# 2016 AAPT Summer Meeting

*July 16–20*

*Sacramento, California*

AAPT
PHYSICS EDUCATION


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Probably Take more Classes.
CHHEANG KHIM
Class of 2018
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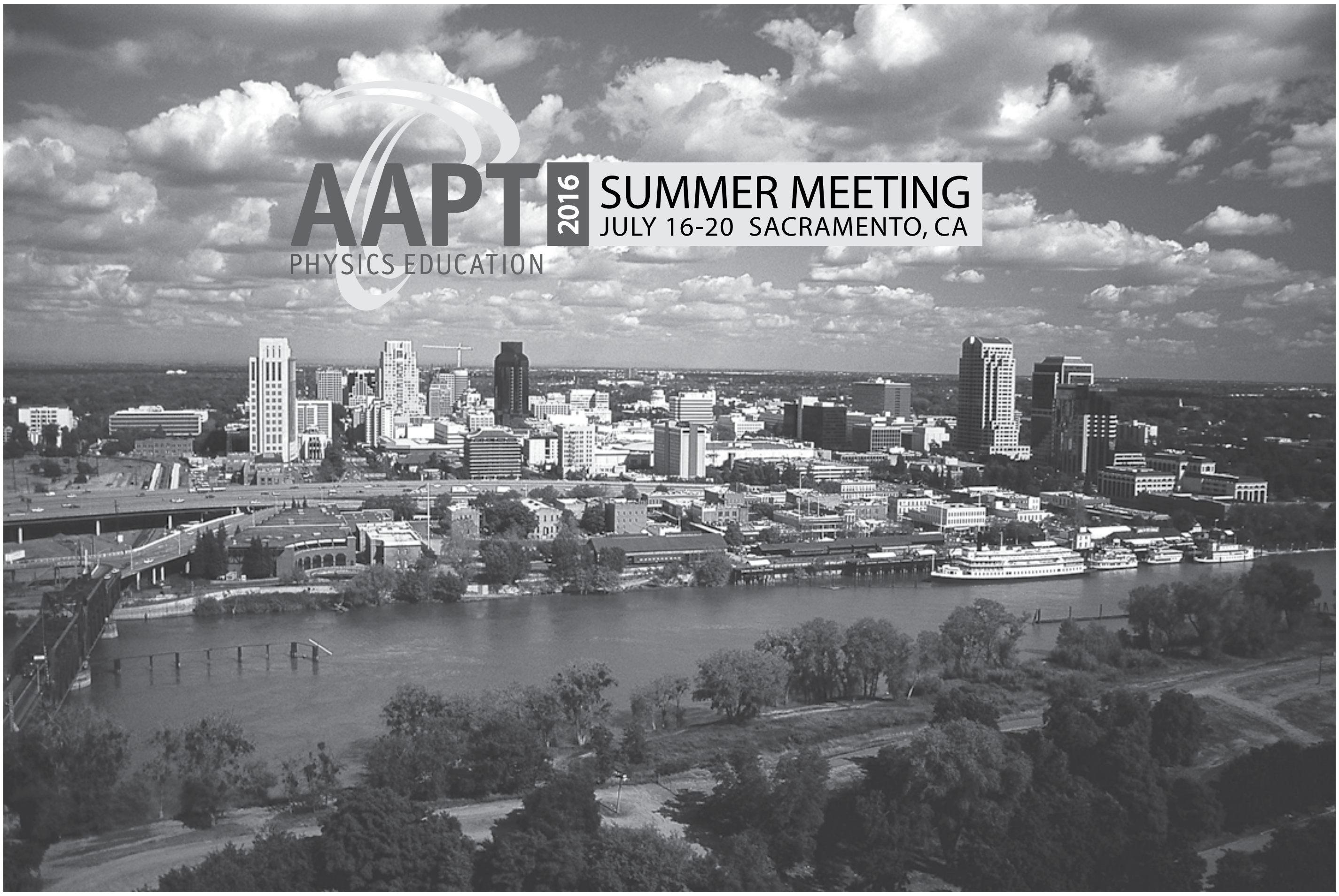


# Sacramento, CA
# July 16–20, 2016

Sacramento Convention Center
Sheraton Grand Sacramento Hotel

AAPT American Association of Physics Teachers

**American Association of Physics Teachers**
One Physics Ellipse
College Park, MD 20740
**301-209-3333**
**www.aapt.org**

# WELCOME FIRST TIME MEETING ATTENDEES AND EARLY CAREER PROFESSIONALS!

We have a day of activities planned for you on Monday, July 18:

First, meet newbies and check out what resources AAPT has to support you during the **First-Timers' Breakfast** from 7:00 - 8:30 AM.

Then, our early career professionals can meet with experienced faculty and teachers at the **Early Career Speed Networking Even**t from 12:00 - 1:30 PM.

Finally, join us for the **Early Career and First Timers' Gathering** from 3:00 -4:00 PM at the Ella dining room and bar. Take this opportunity to get social with other attendees and have some fun!

Not Sure who's new? Spot other First Time Attendees wearing newbie/bee stickers on their badges. Pick your sticker up at the Registration Desk or AAPT Booth 207.

## Thank You to AAPT Sustaining Members

*The American Association of Physics Teachers is extremely grateful to the following companies who have generously supported AAPT over the years:*

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## Facebook/Twitter at Meeting

We will be posting updates to Facebook and Twitter prior to and during the meeting to keep you in the know! Participate in the conversation on Twitter by following us at **twitter.com/AAPTHQ** or search the hashtag **#aaptsm16**. We will also be posting any changes to the schedule, cancellations, and other announcements during the meeting via both Twitter and Facebook. Visit our Pinterest page for suggestions of places to go and things to do in Sacramento. We look forward to connecting with you!

**Facebook**: facebook.com/AAPTHQ
**Twitter**: twitter.com/AAPTHQ
**Pinterest**: pinterest.com/AAPTHQ

**Note: Wireless will be available only in the Exhibit Hall during exhibit hall hours.**

*Network:* **AAPT2016** *Password:* **physics2016**

## Special Thanks

AAPT wishes to thank the following persons for their dedication and selfless contributions to the Summer Meeting:

**William DeGraffenreid**, CSU Sacramento Physics Department Chair, for organizing the workshops

**Tom Scarry**, CSU Sacramento Department Technician/Stockroom Supervisor

***Paper sorters:***

Terry Christensen
Steve Henning
Paul Irving
Mary Ann Klassen
Gordon Ramsey
Ellie Sayre
Shawn Reeves
Sam Sampere
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# First time at an AAPT meeting?

*Welcome to the 2016 AAPT Summer Meeting in Sacramento! Everyone at AAPT hopes you fulfill all the goals you have for attending this meeting. To help you plan your meeting activities, the following information and suggestions have been developed.*

- Being at your first National Meeting can be a lonely experience if you don't know anyone. AAPT members are friendly people, so do not hesitate to introduce yourself to others in sessions and in the hallways. It is fun and rewarding to establish a network of other physics teachers with whom you can talk and share experiences. This is especially true during lunch and dinner.
- Area Committee meetings are not only for members of the committee, but also for friends of the committee. You are welcome to attend any Area Committee meeting. You should be able to find one or two committees that match your interests. Their meeting times are listed on page 11 in this guide. Area Committee meetings are often relatively small and are a great place to meet other people with interests similar to yours.
- Be sure to attend the First Timers' Gathering from **7–8:30 a.m. Monday in Sheraton - Tofanelli**. It is a wonderful way to learn more about the meeting and about AAPT.
- Awards and other plenary sessions have distinguished speakers and are especially recommended. Invited speakers are experts in their fields and will have half an hour or more to discuss their subjects in some depth. Posters will be up all day and presenters will be available during the times indicated in the schedule. Contributed papers summarize work the presenters have been doing. You are encouraged to talk to presenters at the poster sessions or after the contributed paper sessions to gain more information about topics of interest to you. Informal discussion among those interested in the announced topic typically will follow a panel presentation, and Topical Discussions are entirely devoted to such discussions.
- Be sure to make time to visit the exhibits in the Exhibit Hall in the Convention Center Exhibit Hall D. This is a great place to learn what textbooks and equipment are available in physics education.

## Bus Schedule for AAPT Workshops

### Saturday, July 16

Buses departing Convention Center to CSU

- 7:15 a.m.
- 7:25 a.m.
- 12:20 p.m.
- 12:45 p.m.

Buses departing CSU, returning to Convention Cen.

- 12:15 p.m.
- 1:00 p.m.
- 5:15 p.m.
- 5:30 p.m.

### Sunday, July 17

Buses departing Convention Center to CSU

- 7:15 a.m.
- 7:25 a.m.
- 12:20 p.m.
- 12:45 p.m.

Buses departing CSU, returning to Convention Cen.

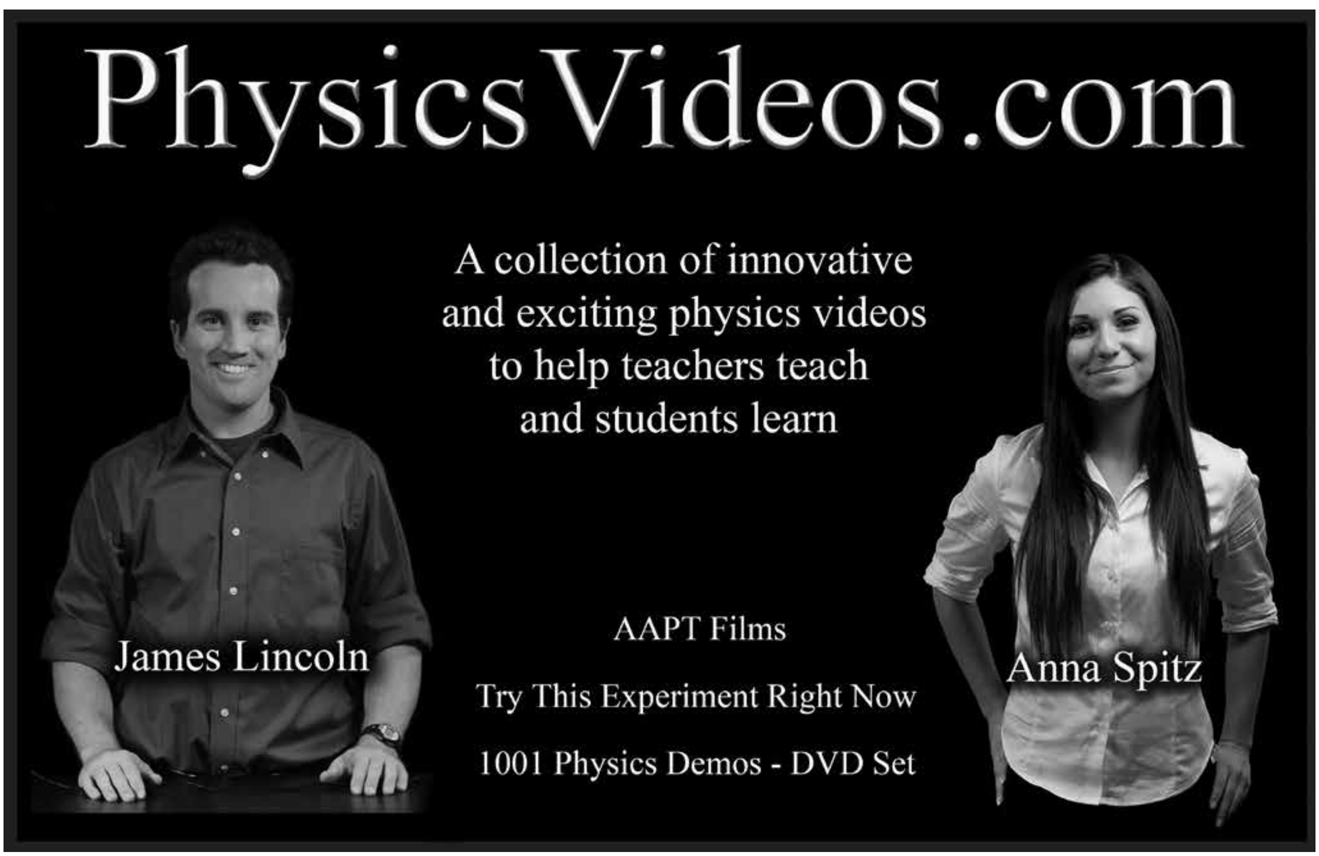
- 12:15 p.m.
- 1:00 p.m.
- 5:15 p.m.
- 5:30 p.m.

***Buses will depart the Convention Center on the J Street side of the building (outside exhibit hall C&D).***

**T01, T02, T03, T04 and T05 will be held at the Convention Center;**
**all other workshops will take place at Cal State Univ., Sacramento.**

Sacramento Convention Center
1400 J St., Sacramento, CA 95814

California State University, Sacramento (CSU)
6000 J St., Sacramento, CA 95819



# Meeting-at-a-Glance

*Meeting-at-a-Glance includes sessions, workshops, committee meetings and other events, including luncheons, Exhibit Hall hours and snacks, plenary sessions, and receptions. All rooms will be in the Sacramento Convention Center (CC) or Sheraton Grand Hotel Sacramento. Workshops on Saturday and Sunday will be at California State University, Sacramento (Tutorials will be held at the convention center).*

**FRIDAY, July 15**

| | | | |
|---|---|---|---|
| **4–7 p.m.** | | **REGISTRATION** | **CC - East Lobby** |

**SATURDAY, July 16**

| | | | |
|---|---|---|---|
| **7 a.m.–4 p.m.** | | **REGISTRATION** | **CC - East Lobby** |
| | | (WORKSHOPS ARE AT CSU-SACRAMENTO, bus schedule, p. 6) | |
| 8 a.m.–12 p.m. | W01 | Teaching Physical Science with the Engineering is Elementary Curriculum | Placer Hall 1006 |
| 8 a.m.–12 p.m. | W02 | Creating Interactive Electronic Books for Computers and Tablets | Placer Hall 1002 |
| 8 a.m.–12 p.m. | W03 | PIRA Lecture Demonstrations I & II Condensed: Selections from the PIRA 200 | Mendocino Hall 1015 |
| 8 a.m.–12 p.m. | W04 | DC Circuits | Sequoia Hall 140 |
| 8 a.m.–12 p.m. | W05 | Interactive Learning with Direct Measurement Video | Sequoia Hall 232 |
| 8 a.m.–12 p.m. | W06 | Impact of Materials on Society – Course Connecting Science & Everyday Life | Mendocino Hall 1026 |
| 8 a.m.–12 p.m. | W07 | Slowing it Down: High Speed Cameras in Lecture and Lab | Sequoia Hall 418 |
| 8 a.m.–12 p.m. | W08 | Making Interactive Video Vignettes and Interactive Web Lectures | Sequoia Hall 246 |
| 8 a.m.–12 p.m. | W45 | Solar Cookers for Learning about Materials, Energy, Sensing, and Society | Sequoia Hall 416 |
| 8 a.m.–5 p.m. | W10 | Developing Inquiry Labs and Activities for AP Physics | Sequoia Hall 236 |
| 8 a.m.–5 p.m. | W11 | Learn Physics While Practicing Science: Introduction to ISLE | Sequoia Hall 242 |
| 10:30 a.m.–4:30 p.m. | | **California Wine Tour** | offsite |
| 1–5 p.m. | W12 | Tools for Teaching Students to Synthesize Concepts | Mendocino Hall 1026 |
| 1–5 p.m. | W13 | Cool NASA Stuff, NGSS, and Cultural Competency | Sequoia Hall 232 |
| 1–5 p.m. | W14 | Computational Modeling in Introductory Physics (vPython and Excel) | Placer Hall 1002 |
| 1–5 p.m. | W15 | Making Physics Videos Using Tablets | Placer Hall 1006 |
| 1–5 p.m. | W17 | Using Kepler Mission Data in the Classroom | Mendocino Hall 1024 |
| 1–5 p.m. | W18 | Fun, Engaging and Effective Labs and Demos with Clickers, Video Analysis | Sequoia Hall 246 |
| 1–5 p.m. | W19 | Introductory Laboratories for Mechanics | Sequoia Hall 428 |
| 1–5 p.m. | W20 | Making the Invisible Visible: Using IR Cameras in Lecture and Lab | Mendocino Hall 2032 |
| 1–5 p.m. | W21 | Submitting Successful Proposals to the NSF S-STEM Program | Mendocino Hall 4000 |
| 6–7:30 p.m. | | Nominating Committee I | Sheraton - Falor |
| 6–9 p.m. | | Board of Directors I | Sheraton - Bataglieri |

**SUNDAY, July 17**

| | | | |
|---|---|---|---|
| **7 a.m.–4 p.m.** | | **REGISTRATION** | **CC - East Lobby** |
| 8–10 a.m. | T01 | Observing the 2017 Solar Eclipse | CC - 309 |
| 8–10 a.m. | T02 | Electrostatics Tutorial | CC - 310 |
| 8–11 a.m. | T03 | An Introduction to Race, Ethnicity, and Equity in Physics Education | CC - 311 |
| 8–10 a.m. | T04 | Using Learning Assistants to Flip Introductory Physics – Part I | CC - 312 |
| 8–10:15 a.m. | | Meetings Committee | Sheraton - Bondi |
| 8–10 a.m. | | Publications Committee | Sheraton - Beavis |
| 8 a.m.– 10 p.m. | | High School Physics Photo Contest Voting and Viewing | CC - East Lobby |
| 8 a.m.–12 p.m. | W22 | How to Implement Collaborative Learning Activities in an IPLS Course | Sequoia Hall 236 |
| 8 a.m.–12 p.m. | W23 | C3PO: Customizable Web-based Computer Coaches to Help Your Students | Mendocino Hall 1026 |
| 8 a.m.–12 p.m. | W24 | Composing Science: A Workshop on Teaching Writing in the Inquiry Classroom | Sequoia Hall 444 |
| 8 a.m.–12 p.m. | W25 | What Every Physics Teacher Should Know About Cognitive Research | Sequoia Hall 418 |
| 8 a.m.–12 p.m. | W26 | Teaching Introductory Astronomy Using Quantitative Reasoning Activities | Mendocino Hall 1024 |
| 8 a.m.–12 p.m. | W27 | Authentic Experimentation in Labs Using Structured Quantitative Inquiry | Sequoia Hall 232 |
| 8 a.m.–12 p.m. | W28 | Integrating Computation into Undergraduate Physics | Sequoia Hall 140 |
| 8 a.m.–12 p.m. | W29 | Waves of Light and Sound: An Exploratorium Workshop | Sequoia Hall 242 |
| 8 a.m.–12 p.m. | W30 | Demo Kit in a Box: Mechanics | Mendocino Hall 4004 |
| 8 a.m.–12 p.m. | W31 | Learner-centered Environment for Algebra-based Physics | Mendocino Hall 2032 |
| 8 a.m.–12 p.m. | W46 | The Physics of Chemistry | Sequoia Hall 416 |
| 8 a.m.–5 p.m. | W33 | Activity-based Physics in the High School Classroom | Sequoia Hall 246 |
| 8 a.m.–5 p.m. | W34 | Research-based Alternatives to Traditional Physics Problems | Mendocino Hall 4000 |
| 8 a.m.–5 p.m. | W35 | Physics of Energy Labs | Sequoia Hall 132 |
| 10:30 a.m.–1:30 p.m. | T05 | Using Learning Assistants to Flip Introductory Physics – Part II | CC - 312 |
| 10:30 a.m.–4 p.m. | | Board of Directors II | Sheraton - Bataglieri |
| 1–5 p.m. | W36 | Learning Activities for Life Science in Introductory Physics | Sequoia Hall 418 |
| 1–5 p.m. | W37 | Strategies to Help Women at All Levels to Succeed in Physics-Related Professions | Mendocino Hall 1026 |
| 1–5 p.m. | W38 | Developing the Next Generation of Physics Assessments | Mendocino Hall 2032 |
| 1–5 p.m. | W39 | Raising Physics to the Surface | Sequoia Hall 232 |
| 1–5 p.m. | W40 | Fun and Engaging Labs | Sequoia Hall 242 |
| 1–5 p.m. | W41 | Intermediate and Advanced Laboratories | Sequoia Hall 428 |
| 1–5 p.m. | W42 | Student Learning in Next Generation Physics and Everyday Thinking | Mendocino Hall 1024 |

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| 1–5 p.m. | W43 | Activities for Teaching About Climate and Climate Change | Sequoia Hall 416 |
| 1–5 p.m. | W44 | Just-in-Time Teaching | Sequoia Hall 236 |
| 4:30–6 p.m. | | PERLOC | Sheraton - Beavis |
| 5–6 p.m. | | AAPT Tweet-up | Sheraton - Bondi |
| 5:30–6:30 p.m. | | Programs Committee I | CC - 311 |
| 5:30–8 p.m. | | Section Officers and Section Representatives | CC - 307 |
| 5:30–9 p.m. | | **REGISTRATION** | **CC - East Lobby** |
| 6:30–8 p.m. | | Laboratories Committee | CC - 316 |
| 6:30–8 p.m. | | History & Philosophy of Physics Committee | CC - 317/318 |
| 6:30–8 p.m. | | Pre-High School Education in Physics Committee | CC - 319 |
| 6:30–8 p.m. | | Research in Physics Education Committee | CC - 301 |
| 6:30–8 p.m. | | Physics in Two-Year Colleges Committee | CC - 302/303 |
| 8–10 p.m. | | **Exhibit Hall Open / Welcome Reception** | **CC - Exhibit Hall D** |
| 8–10 p.m. | | PIRA Resource Room/Apparatus Competition | CC - 104/105 |
| 8–10 p.m. | | SPS Undergraduate Research and Outreach Poster Session | CC - Exhibit Hall D |
| 10 p.m.–12 a.m. | | AAPT Summer Meeting Dance Party | Sheraton - Gardenia |

**MONDAY, July 18**

| | | | |
|---|---|---|---|
| 6:45–7:45 a.m. | | Spin Class at Sheraton | Sheraton - Compagno |
| 7–8:30 a.m. | | Interests of Senior Physicists Committee | Sheraton - Bondi |
| 7–8:30 a.m. | | Teacher Preparation Committee | Sheraton - Beavis |
| 7–8:30 a.m. | | Physics in Undergraduate Education Committee | CC - 302/303 |
| 7–8:30 a.m. | | Women in Physics Committee | CC - 309 |
| 7–8:30 a.m. | | PIRA Business Meeting | CC - 319 |
| 7–8:30 a.m. | | First Timers' Breakfast | Sheraton - Tofanelli |
| 7 a.m.–5 p.m. | | **REGISTRATION** | **CC - East Lobby** |
| 8 a.m.– 10 p.m. | | High School Physics Photo Contest Voting and Viewing | CC - East Lobby |
| 8 a.m.–10 p.m. | | Poster Session I – Posters available for viewing | Sheraton - Gardenia |
| 8:30–9:50 a.m. | AA | Progress in Pedagogy for Introductory Physics for Life Science | CC - 306 |
| 8:30–9:30 a.m. | AB | Frontiers in Astronomy | CC - 307 |
| 8:30–10 a.m. | AC | Effective Practices in Educational Technologies | CC - 308 |
| 8:30–9:20 a.m. | AD | Two Year Colleges | CC - 301 |
| 8:30–10 a.m. | AE | PER: Examining Content Understanding and Reasoning – B | CC - 314 |
| 8:30–10 a.m. | AF | Robert Noyce Scholars in Physics Teacher Preparation | CC - 304/305 |
| 8:30–9:50 a.m. | AG | CIRTL: A Network Model to Transform STEM Education and Prepare Future Faculty | CC - 312 |
| 8:30–10 a.m. | AH | Outreach Demonstrations | CC - 315 |
| 8:30–9:40 a.m. | AI | PER: Exploring Problem Solving Approaches and Skills | CC - 311 |
| 8:30–9:50 a.m. | AJ | Adaptation of Physics Activities to Three Major Components of NGSS | CC - 317/318 |
| 8:30–9:30 a.m. | AK | 30 Demos in 60 Minutes | CC - 313 |
| 8:30–10 a.m. | AL | Computer Modeling and Simulation in Sustainability Courses | CC - 310 |
| 9–10 a.m. | | AAPT Spouse/Guest Gathering | Sheraton - Falor |
| 10 a.m.–5 p.m. | | **Exhibit Hall Open** (a.m. Break 10–10:30 a.m./Raffle 10:20 Amazon Tap) | CC - Exhibit Hall D |
| 10 a.m.–5 p.m. | | PIRA Resource Room/Apparatus Competition | CC - 104/105 |
| 10 a.m.–5 p.m. | | TYC Resource Room Open | CC - East Lobby |
| 10:30 a.m.–12 p.m. | | **AAPT Awards – Teaching / DSCs** | Magnolia/Camellia |
| 12–1 p.m. | | Physics Bowl Advisory Board | Sheraton - Compagno |
| 12–1 p.m. | CW01 | **PASCO: Smart Cart Workshop** | CC - 309 |
| 12–1 p.m. | CW04 | **WebAssign: Code Your Own Questions in WebAssign** | CC - 302/303 |
| 12–1 p.m. | CW06 | **Expert TA: Realigning Homework Grades and Test Scores in Modern Classroom** | CC - 307 |
| 12–1:30 p.m. | | PTRA Advisory Committee | Sheraton - Beavis |
| 12–1:30 p.m. | | Review Board | Sheraton – Bondi |
| 12–1:30 p.m. | CW07 | **Perimeter Institute: Physics in the News** | CC - 316 |
| 12–1:30 p.m. | | Early Career Professionals Speed Networking Event | Sheraton - Bataglieri |
| 12–1:30 p.m. | | High School Teachers Day Luncheon | CC -103 |
| 12–1:30 p.m. | | Retired Physicists Luncheon | Sheraton - Restaurant |
| 12–1:30 p.m. | TOP01 | Celestial Navigation in the Pacific: Polynesian Insights into Old Traditions | Sheraton - Tofanelli |
| 12–1:30 p.m. | TOP02 | Finding Time To Do It: New Lessons in Time Management for Busy Faculty | CC - 319 |
| 12–1:30 p.m. | TOP03 | The Role of the AAPT in preK-8 Physics Education | CC - 317/318 |
| 1:30–3:30 p.m. | BA | Best Practices in Educational Technology | CC - 306 |
| 1:30–3:30 p.m. | BB | PER: Diverse Investigations – B | CC - 307 |
| 1:30–3 p.m. | BC | Art and Science of Teaching | CC - 308 |
| 1:30–3:30 p.m. | BD | PER Advances in Problem Solving | CC - 313 |
| 1:30–3:10 p.m. | BE | Developing Experimental Skills at all Levels | CC - 314 |
| 1:30–3:10 p.m. | BF | Teacher in Residence (TIR) Role in Mentoring | CC - 310 |
| 1:30–3:30 p.m. | BG | Leadership and Other Skills in the Undergraduate Curriculum | CC - 312 |
| 1:30–3:30 p.m. | BH | Integrating Computation into the Curriculum | CC - 315 |
| 1:30–3:30 p.m. | BI | PER in Upper Division | CC - 304/305 |
| 1:30–3:10 p.m. | BJ | Physicists with Disabilities | CC - 311 |
| 1:30–2:20 p.m. | BK | Astronomy Papers | CC - 301 |

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|---|---|---|---|
| 1:30–2:30 p.m. | CW02 | **PASCO: Capstone Workshop** | CC - 309 |
| 1:30–3:30 p.m. | | High School Teacher Lounge | Sheraton - Falor |
| 2:30–4 p.m. | CW08 | **Perimeter Institute: Spicing Up Classical Physics** | CC - 316 |
| 3–4 p.m. | CW03 | **PASCO: Essential Physics Electronic Textbook for Physics** | CC - 309 |
| 3–4 p.m. | | Early Career and First Timers Meetup | Offsite |
| 3:30–4 p.m. | | Afternoon Break in Exhibit Hall (3:50 p.m. Raffle SportShot Action Camera) | Exhibit Hall D |
| 4–5:50 p.m. | CA | Using Popular Media to Teach Astronomy | CC - 306 |
| 4–6 p.m. | CB | PER: Modeling Student Engagement | CC - 307 |
| 4–6 p.m. | CC | Physics and the Maker Movement | CC - 310 |
| 4–5:30 p.m. | CD | Professional Development Opportunities: Participant Perspective on What Works | CC - 311 |
| 4–6 p.m. | CE | Favorite TPT Articles | CC - 308 |
| 4–5:40 p.m. | CF | Introductory Labs/Apparatus | CC - 317/318 |
| 4–5:50 p.m. | CG | PER: Diverse Investigations | CC - 313 |
| 4–6 p.m. | CH | The Physics of the NSF IUSE Program | CC - 312 |
| 4–5:30 p.m. | CI | Searching for Extraterrestrial Intelligence | CC - 304/305 |
| 4–5:30 p.m. | CJ | Comparing World-Class Physics Education Ideologies: A Closer Look at AP, Cambridge | CC - 314 |
| 4–6 p.m. | CK | Preparing and Supporting University Physics Educators | CC - 301 |
| 4–6 p.m. | CL | Modern Physics Demonstrations and Labs | CC - 315 |
| 4–6 p.m. | | High School Teacher Lounge | Sheraton - Falor |
| 6–7:30 p.m. | | National Society of Hispanic Physicists Reception | CC - 103 |
| 6–7:30 p.m. | TOP04 | Graduate Student Topical Discussion | CC - 311 |
| 6–7:30 p.m. | TOP05 | Roundtable on Teaching Physics in High School | CC - 304/305 |
| 6–7:30 p.m. | TOP06 | Solo PER | CC - 306 |
| 6–7:30 p.m. | | SPS Undergraduate Awards Reception | Sheraton - Tofanelli |
| 6:15–7:30 p.m. | | Educational Technologies Committee | CC - 301 |
| 6:15–7:30 p.m. | | Physics in High Schools Committee | CC - 313 |
| 6:15–7:30 p.m. | | Science Education for the Public Committee | CC - 310 |
| 6:15–7:30 p.m. | | Diversity in Physics Committee | Sheraton - Bondi |
| 6:15–7:30 p.m. | | Modern Physics Committee | Sheraton - Beavis |
| 6:15–7:30 p.m. | | Alpha Business Meeting | CC - 312 |
| 7:30–8:30 p.m. | **Awards** | Klopsteg Memorial Lecture Award: Margaret Wertheim | Magnolia/Camellia |
| 8:30–10 p.m. | | Poster Session I, Authors available at posters | Sheraton - Gardenia |
| 8:30–10 p.m. | | High School Share-a-thon | CC - 313 |

**TUESDAY, July 19**

| | | | |
|---|---|---|---|
| 6–8 a.m. | | AAPT Fun Run/Walk | Offsite |
| **7 a.m.–4 p.m.** | | **REGISTRATION** | **CC - East Lobby** |
| 7–8 a.m. | | Venture Fund Review/Bauder Committee | Sheraton - Bondi |
| 7–8 a.m. | | Governance Structure Committee | Sheraton - Compagno |
| 7–8 a.m. | | Executive Programs Committee | Sheraton - Beavis |
| 7–8:30 a.m. | | Two-Year College Breakfast | CC -103 |
| 8 a.m.–6:30 p.m. | | Poster Session II Posters available for viewing | Sheraton - Gardenia |
| 8 a.m.– 10 p.m. | | High School Physics Photo Contest Voting and Viewing | CC - East Lobby |
| 8:30–9:40 a.m. | DA | Interactive Lecture Demonstrations: What's New? ILDs Using Clickers & Video Analysis | CC - 315 |
| 8:30–9:20 a.m. | DB | Upper Division/Graduate Courses | CC - 310 |
| 8:30–9:50 a.m. | DC | Effective Practices in Educational Technologies – I | CC - 311 |
| 8:30–10 a.m. | DD | Leveraging Strengths of Diverse Populations | CC - 312 |
| 8:30–9:40 a.m. | DE | Online Hybrid | CC - 306 |
| 8:30–10 a.m. | DF | AAPT Opportunities for Middle and High School Teachers | CC - 304/305 |
| 8:30–10 a.m. | DG | What Can We Learn From and Do With Science Centers | CC - 301 |
| 8:30–10 a.m. | DH | APS/AAPT Joint Task Force on Undergraduate Education Physics Programs | CC - 313 |
| 8:30–9:20 a.m. | DI | Physicists with Disabilities – A | CC - 308 |
| 8:30–10 a.m. | DJ | Make, Play, Learn | CC - 307 |
| 8:30–9:40 a.m. | DK | Other Papers | CC - 317/318 |
| 8:30–9:30 a.m. | DL | PER Findings Related to Latin American Students | CC - 314 |
| 10 a.m.–4 p.m. | | Exhibit Hall Open (Morning Break 10–10:30 a.m.. Raffle 10:20, $100 AMEX Card) | CC - Exhibit Hall D |
| 10 a.m.–4 p.m. | | PIRA Resource Room/Apparatus Competition | CC - 104/105 |
| 10 a.m.–4 p.m. | | TYC Resource Room Open | CC - East Lobby |
| 10:30 a.m.–12 p.m. | | **Millikan Medal: Stephen M. Pompea** | Magnolia/Camellia |
| 12–1 p.m. | CW05 | **WebAssign: Enrich Your Physics Lecture & Lab Courses with WebAssign Content** | CC - 316 |
| 12–1:15 p.m. | | Apparatus Committee | CC - 310 |
| 12–1:15 p.m. | | Graduate Education in Physics Committee | CC - 311 |
| 12–1:15 p.m. | | International Physics Education Committee | CC - 312 |
| 12–1:15 p.m. | | Professional Concerns Committee | Sheraton - Compagno |
| 12–1:15 p.m. | | Space Science and Astronomy Committee | Sheraton - Bondi |
| 12–1:30 p.m. | | TPT Luncheon | Sheraton - Tofanelli |
| 12–1:30 p.m. | | LGBT Meet-up | Sheraton - Bataglieri |
| 12–1:30 p.m. | CW09 | **Perimeter Institute: What goes into a Black Hole, stays in Black Hole, or does it?** | CC - 309 |
| 12–2 p.m. | CW11 | **Vernier: Experiments and Data Collection with Vernier** | CC - 302/303 |
| 1:30–3:30 p.m. | EA | The History of Accelerator Physics | CC - 306 |

| | | | |
|---|---|---|---|
| 1:30–3:30 p.m. | EB | PER: Evaluating Instructional Strategies | CC - 307 |
| 1:30–2:40 p.m. | EC | Innovative Uses of Technology Enabled Spaces | CC - 304/305 |
| 1:30–3:40 p.m. | ED | Upper Division Undergraduate | CC - 310 |
| 1:30–3 p.m. | EE | Professional Skills for Graduate Students | CC - 311 |
| 1:30–3:30 p.m. | EF | Physics Teaching for Social Justice | CC - 308 |
| 1:30–3:30 p.m. | EG | Addressing Race and Ethnicity | CC - 312 |
| 1:30–3 p.m. | EH | Climate Change | CC - 313 |
| 1:30–3:20 p.m. | EI | Developing Experimental Skills at all Levels I | CC - 314 |
| 1:30–3:10 p.m. | EJ | PER: Examining Content Understanding and Reasoning | CC - 315 |
| 1:30–3 p.m. | EK | Supporting Women in Physics: How Everyone Can Play a Role | CC - 301 |
| 1:30–3:20 p.m. | EL | The Great American Eclipse of 21 August 2017: Preparing for Maximum Impact | CC - 317/318 |
| 1:30–3:30 p.m. | | High School Teacher Lounge | Sheraton – Falor |
| 2–3:30 p.m. | CW10 | **Perimeter Institute: Knowledge in Modern Physics: 21st Century Approach** | CC - 309 |
| 3:30–4 p.m. | | Afternoon Break in Exhibit Hall (Raffle 3:50 p.m., Kindle HD) | CC - Exhibit Hall D |
| 4–5 p.m. | **Plenary** | Neil Gershenfeld, The Center for Bits and Atoms, MIT | Magnolia/Camellia |
| 4–6 p.m. | | High School Teacher Lounge | Sheraton - Falor |
| 5–6:30 p.m. | | Poster Session II, Authors available at posters | Sheraton - Gardenia |
| 6:30–8 p.m. | | AAPT Summer Meeting Picnic at PASCO | Offsite |
| 8–9 p.m. | | Demo Show at PASCO (Transportation to and from the Convention C. provided) | Offsite |

**WEDNESDAY, July 20**

| | | | |
|---|---|---|---|
| 6:45–7:45 a.m. | | Yoga on Sacramento Capitol Lawn | Offsite |
| 7–8 a.m. | | SI Units and Metric Education Committee | Sheraton - Compagno |
| 7–8 a.m. | | Membership and Benefits Committee | Sheraton - Beavis |
| 7–8 a.m. | | Programs II Committee | Sheraton - Bondi |
| 8 a.m.–3 p.m. | | **REGISTRATION** | CC - East Lobby |
| 8 a.m.–4:30 p.m. | | Poster Session III Posters available for viewing | CC - East Lobby |
| 8:30-10 a.m. | FA | PER: Exploring Problem Solving Approaches and Skills – A | CC - 306 |
| 8:30-10:20 a.m. | FB | PER: Examining Content Understanding and Reasoning – A | CC - 307 |
| 8:30-10 a.m. | FC | PER: Evaluating Instructional Strategies – A | CC - 308 |
| 8:30-10:20 a.m. | FD | Computer Modeling and Simulation in the IPLS Course | CC - 315 |
| 8:30-10:10 a.m. | FE | PER: Diverse Investigations – A | CC - 314 |
| 8:30-9:30 a.m. | FF | Lab Guidelines Focus Area 3: Modeling | CC - 304/305 |
| 8:30-9:30 a.m. | FG | High School | CC - 310 |
| 8:30-9:50 a.m. | FH | PhysTEC Teacher Preparation in California | CC - 309 |
| 8:30-10 a.m. | FI | Supporting Hispanic Women Students in Physics | CC - 311 |
| 8:30-10:10 a.m. | FJ | Ardiuno, Teensy, FPGA's et al | CC - 312 |
| 8:30-10:30 a.m. | FK | AP Physics 2 Labs with Java Applets | CC - 301 |
| 10 a.m.–3 p.m. | | TYC Resource Room | CC - East Lobby |
| 10:30–11:30 a.m. | **Plenary** | David Reitze, LIGO Laboratory | Magnolia/Camellia |
| 11:30 a.m.–12 p.m. | | Great Book Giveaway | CC - East Lobby |
| 11:30 a.m.–12:30 p.m. | | Finance Committee | Sheraton - Compagno |
| 11:30 a.m.–1 p.m. | | Awards Committee (Closed) | Sheraton - Beavis |
| 11:30 a.m.–1 p.m. | TOP07 | Web Resources for Teaching Astronomy | CC - 319 |
| 11:30 a.m.–1 p.m. | TOP08 | Work-Life Balance | CC - 316 |
| 12–1 p.m. | | PERTG Town Hall | Magnolia/Camellia |
| 1–2 p.m. | GA | Preparing Pre-service Physics Teachers for the Middle School Classroom | CC - 301 |
| 1–3 p.m. | GB | Particle Physics Investigations by Students | CC - 312 |
| 1–2:10 p.m. | GC | Teacher Training/Enhancement | CC - 310 |
| 1–2:40 p.m. | GD | Introductory Courses | CC - 311 |
| 1–2:10 p.m. | GE | Gender | CC - 304/305 |
| 1–2 p.m. | GF | Technologies | CC - 306 |
| 1–2:30 p.m. | GG | Two Years of New AP Physics 1 and 2 | CC - 307 |
| 1–2:30 p.m. | GH | Mining Data Generated in the Classroom | CC - 308 |
| 1–3 p.m. | GJ | Teaching Physics in High Needs High Schools | CC - 313 |
| 1–2:50 p.m. | GK | Do Try This At Home! | CC - 314 |
| 1–4 p.m. | | High School Teacher Lounge | Sheraton - Falor |
| 2–3 p.m. | PER | PERC Bridging Session | Sheraton - Magnolia |
| 3–4:30 p.m. | | Nominating Committee II | Sheraton - Compagno |
| 3–5:30 p.m. | | Board of Directors III | Sheraton - Bataglieri |
| 3–4:30 p.m. | HA | Post-deadline Papers I | CC - 301 |
| 3–4:20 p.m. | HB | Post-deadline Papers II | CC - 307 |
| 3–4:20 p.m. | HD | Post-deadline Papers IV | CC - 319 |
| 3–4:30 p.m. | PST3A | Post-deadline Poster Session III | CC - East Lobby |




# Committee Meetings

*All interested attendees are invited and encouraged to attend the Committee meetings with asterisks (*).*

## Saturday, July 16

| | | |
|---|---|---|
| Nominating Committee I | 6–7:30 p.m. | Sher. - Falor |
| Board of Directors I | 6–9 p.m. | Sher.- Bataglieri |

## Sunday, July 17

| | | |
|---|---|---|
| Meetings Committee | 8–10:15 a.m. | Sher. - Bondi |
| Publications Committee | 8–10 a.m. | Sher. - Beavis |
| Board of Directors II | 10:30 a.m.–4 p.m. | Sher.- Bataglieri |
| PERLOC | 4:30–6 p.m. | Sher. - Beavis |
| Programs I | 5:30–6:30 p.m. | CC - 311 |
| Section Representative and Officers | 5:30–8 p.m. | CC - 307 |
| Laboratories Committee* | 6:30–8 p.m. | CC - 316 |
| History & Philosophy Committee* | 6:30–8 p.m. | CC - 317/318 |
| Physics in Pre-High School Education* | 6:30–8 p.m. | CC - 319 |
| Research in Physics Education* | 6:30–8 p.m. | CC - 301 |
| Physics in Two-Year Colleges* | 6:30–8 p.m. | CC - 302/303 |

## Monday, July 18

| | | |
|---|---|---|
| Interests of Senior Physicists* | 7–8:30 a.m. | Sher. - Bondi |
| Teacher Preparation* | 7–8:30 a.m. | Sher. - Beavis |
| Physics in Undergraduate Education* | 7–8:30 a.m. | CC - 302/303 |
| Women in Physics* | 7–8:30 a.m. | CC - 309 |
| PIRA Business Meeting | 7–8:30 a.m. | CC - 319 |
| Review Board | 12–1:30 p.m. | Sher. - Bondi |
| Physics Bowl Advisory Committee | 12–1 p.m. | Sher. - Compagno |
| PTRA Advisory Committee | 12–1:30 p.m. | Sher. - Beavis |
| Educational Technologies* | 6:15–7:30 p.m. | CC - 301 |
| Physics in High Schools* | 6:15–7:30 p.m. | CC - 313 |
| Science Education for the Public* | 6:15–7:30 p.m. | CC - 310 |
| Diversity in Physics* | 6:15–7:30 p.m. | Sher. - Bondi |
| Modern Physics* | 6:15–7:30 p.m. | Sher. - Beavis |
| Alpha Business Meeting | 6:15–7:30 p.m. | CC - 312 |

## Tuesday, July 19

| | | |
|---|---|---|
| Venture Fund Review/ Bauder | 7–8 a.m. | Sher. - Bondi |
| Governance Structure | 7–8 a.m. | Sher.- Compagno |
| Executive Programs | 7–8 a.m. | Sher. - Beavis |
| Apparatus Committee* | 12–1:15 p.m. | CC - 310 |
| Graduate Education in Physics* | 12–1:15 p.m. | CC - 311 |
| International Physics Education* | 12–1:15 p.m. | CC - 312 |
| Professional Concerns* | 12–1:15 p.m. | Sher. - Compagno |
| Space Science and Astronomy* | 12–1:15 p.m. | Sher. - Bondi |

## Wednesday, July 20

| | | |
|---|---|---|
| SI Units and Metric Education* | 7–8 a.m. | Sher.- Compagno |
| Membership and Benefits | 7–8 a.m. | Sher. - Beavis |
| Programs II | 7–8 a.m. | Sher. - Bondi |
| Finance Committee | 11:30 a.m.–12:30 p.m. | Sher. - Compagno |
| Awards Committee (closed) | 11:30 a.m.–1 p.m. | Sher. - Beavis |
| Nominating Committee II | 3–4:30 p.m. | Sher. - Compagno |
| Board of Directors III | 3–5:30 p.m. | Sher. - Bataglieri |

**Stephen M. Pompea**
National Optical
Astronomy Observatory
Tucson, AZ

*Knowledge and Wonder: Reflections on Ill-Structured Problem Solving*

**Tuesday, July 19**

**10:30 a.m.–12 p.m.**

**Sheraton - Magnolia/ Camellia**

# Robert A. Millikan Medal 2016

**Stephen M. Pompea** is Observatory Scientist and leads the Department of Education and Public Outreach at the National Optical Astronomy Observatory in Tucson, AZ. He got his BA in Physics, Space Physics, and Astronomy at Rice University, his MAT in Physics at Colorado State University, and his PhD in Astronomy at the University of Arizona. He started his teaching career in 1977 at Air Academy School District in Colorado, where he taught physics, astronomy, and earth science courses. He also was responsible for teaching gifted and talented science classes in summer programs in Nebraska during the time he worked in the aerospace industry.

His professional work on astronomy instrumentation and optical properties of surfaces at Martin Marietta Aerospace, the University of Arizona, and at the Gemini 8-Meter Telescope Project greatly informed his teaching approach which emphasized problem solving and innovative teaching methods. He has consulted widely on the development of science education centers, museum exhibits, and instructional and teacher professional development materials, working with notable institutions such as the NASA Classroom of the Future and the University of California Berkeley's Space Sciences Lab and Lawrence Hall of Science. This collaborative work led to award-winning educational projects such as Astronomy Village: Investigating the Universe (featured in AAPT workshops), Astronomy Village: Investigating the Solar System, and curricular books such as *Invisible Universe: The Electromagnetic Spectrum from Radio Waves to Gamma Rays*. Collaborations with OSA—The Optical Society—and SPIE—the International Society for Optics and Photonics—led to projects like the NSF-funded Hands-On Optics Project for middle school students, which Pompea directed.

Dr. Pompea's colleagues have highlighted some of his efforts: "He has been a leader in physics education developing innovative research experiences for high school teachers such as the NSF-funded Teacher Leaders in Research Based Science Education. Lasting over a decade, this program engaged hundreds of teachers and their students in physics and astronomy research." He was later able to expand these research experiences for teachers and students to integrate teachers and students into research teams with the NASA Spitzer Space Telescope. In the undergraduate outreach and mentoring program he helped start at NOAO, over 35 undergraduate students who have worked on research and outreach programs at the national observatory over the past eight years, two of which have since completed the PhD's in astrophysics, with many others now leading similar outreach efforts.

*The Robert A. Millikan Medal recognizes those who have made notable and intellectually creative contributions to the teaching of physics. The recipient delivers an address at an AAPT Summer Meeting and receives a monetary award, the Millikan Medal, an Award Certificate, and travel expenses to the meeting. The award was established by AAPT in 1962.*

**Margaret Wertheim**
Institute for Figuring
Los Angeles, CA

*Of Corals and the Cosmos: A Story of Hyperbolic Space*

**Monday, July 18**

**7:30–8:30 p.m.**

**Sheraton - Magnolia/ Camellia**

# Klopsteg Memorial Lecture Award 2016

**Margaret Wertheim** is an internationally noted science writer and exhibition curator whose work focuses on relations between science and the wider cultural landscape. She is the author of six books including *The Pearly Gates of Cyberspace*, a groundbreaking exploration of the history of Western concepts of space from Dante to the Internet, and *Pythagoras's Trousers,* a cultural history of physics that also explored the place of women in this field. As a journalist, Wertheim has written for the *New York Times*, *Los Angeles Times*, *The Guardian*, *Washington Post*, *Cabinet* magazine and many other publications.

Wertheim is the founder and director of the Institute For Figuring, a Los Angeles-based organization devoted to creative public engagement with science and mathematics (www.theiff.org). Through the IFF, she has designed exhibitions for galleries and museums around the world, including the Hayward Gallery in London, Science Gallery in Dublin, and the Smithsonian's National Museum of Natural History in Washington, D.C. At the core of the IFF's work is the concept of material play, and a belief that abstract ideas can often be embodied in physical practices.

Throughout her career, Wertheim has been a pioneer in communicating math and science to women. Her "Crochet Coral Reef" project – spearheaded with her twin sister Christine – is now the world's largest participatory science-and-art endeavor, and has been shown at the Andy Warhol Museum (Pittsburgh), Chicago Cultural Center, New York University Abu Dhabi (UAE), and elsewhere. More than 8000 women in a dozen countries have participated in the project, and its exhibitions have been seen by two million visitors.

*Named for Paul E. Klopsteg, a principal founder, a former AAPT President, and a long-time member of AAPT, the Klopsteg Memorial Lecture Award recognizes outstanding communication of the excitement of contemporary physics to the general public. The recipient delivers the Klopsteg Lecture at an AAPT Summer Meeting on a topic of current significance and at a level suitable for a non-specialist audience and receives a monetary award, an Award Certificate, and travel expenses to the meeting. The award was established in 1990.*

## David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching

**Andy Gavrin**
IUPUI
Indianapolis, IN

*Our Students Are Learning!*

**Monday, July 18**

**10:30 a.m. –12 p.m.**

**Sheraton - Magnolia/ Camellia**

The 2016 David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching winner is **Andy Gavrin.** He earned his BS in Physics at the Massachusetts Institute of Technology and his MA and PhD in Physics at The Johns Hopkins University. While at Johns Hopkins, he began his teaching career as a TA and did research in superconductivity and magnetic phase transitions. During his time at Indiana University–Purdue University Indianapolis (IUPUI), Gavrin has been instrumental in improving STEM education in Indiana through a variety of projects funded by the NSF, the NIH, and the Lilly Foundation.

Since arriving at IUPUI in 1995, he has devoted a great deal of effort to creating ways to improve physics teaching, including "Just-in-Time Teaching (JiTT)." This method, developed in collaboration with Gregor Novak (IUPUI), Evelyn Patterson (U.S. Air Force Academy), and Wolfgang Christian (Davidson College) has been highly successful by several different standards. As stated on Gavrin's Physics Education website, "The JiTT method succeeds through a fusion of high-tech and low-tech elements. On the high-tech side, we use the World Wide Web to deliver curricular materials and expand communications among faculty and students. On the low-tech side, we rely on a classroom environment that further stresses interaction among students, faculty and student mentors. The interplay between these elements engages students and promotes learning. The underlying method is to use feedback between the Web and the classroom to increase interactivity, and to allow faculty to make rapid adjustments to address student's problems." This work was published in the influential book *Just-in-Time Teaching: Blending Active Learning and Web Technology* (G.N. Novak, E.T. Patterson, A. Gavrin, and W. Christian, Prentice Hall, Saddle River, NJ (1999).

In addition to his work with JiTT, Gavrin has led efforts focused on increasing the numbers and diversity of students pursuing degrees across the STEM fields. These efforts include the "Bridges to the Baccalaureate in Central Indiana" program. Gavrin has also been active in enhancing undergraduate physics education through his work with the AAPT Committee on Physics in Undergraduate Education, the AAPT Undergraduate Curriculum Task Force, the AAPT Committee on Educational Technologies, and his engagement of undergraduates in research at IUPUI.

*Established as the Excellence in Undergraduate Teaching Award in 1993; it was renamed and substantially endowed in 2010 by John Wiley & Sons. Named for David Halliday and Robert Resnick, authors of a very successful college-level textbook in introductory physics, the award recognizes outstanding achievement in teaching undergraduate physics.*

## Paul W. Zitzewitz Award for Excellence in K-12 Physics Teaching

**Tom Erekson**
Lone Peak High School,
Highland, UT

*Physics is for Everyone!*

**Monday, July 18**

**10:30 a.m. –12 p.m.**

**Sheraton - Magnolia/ Camellia**

The 2016 Paul Zitzewitz Excellence in Pre-College Physics Teaching Award winner is **Tom Erekson**, a physics teacher from Lone Peak High School, Highland UT. This award is in recognition of contributions to pre-college physics teaching and awardees are chosen for their extraordinary accomplishments in communicating the excitement of physics to their students.

Mr. Erekson earned his BA in Physics from Brigham Young University and MEd in Instructional Technology at Utah State University in Logan, UT. He has a Utah Professional Educator Level 2 License with endorsements in Physics, Physical Science and Mathematics, Level III. He participated in the Physics Modeling Workshop at Arizona State University during the summers of 1997 and 1998. He started his career at Pleasant Grove High School as an Intern Teacher and in 1997 began teaching at Lone Peak High School.

Erekson was one of the authors of the Utah Physics Core Curriculum, and was an item writer for Utah end of level physics exams. He serves as Science Department chairman and leads the physics collaboration team on improving student learning. As a result of his leadership, Lone Peak High School teaches more physics classes than any other high school in Utah (27 sections). He has been a presenter at the NSTA Western Area Conference and Utah Science Teacher Association annual conferences. He sets the tone for teacher dedication and student achievement. He works diligently to assist his students and ensure comprehension and knowledge retention.

People who work with Erekson say, "He is a phenomenal educator and with great influence on both students and fellow faculty members. His students consistently rave about his engaging teaching practices and high expectations for their success. He guides and involves his students in a process of hands-on learning, where through their own experimentation they explore solutions and gain first-hand knowledge of physics concepts. As a testimony of his student's admiration for and motivation by him, his classroom is generally full of student activity during lunch and after school." He has been honored with "Teacher of the Year," and various other school, community, district, and state school recognitions for his service to students.

*Established as the Excellence in Pre-College Teaching Award in 1993 then renamed and endowed in 2010 by Paul W. and Barbara S. Zitzewitz, the Paul W. Zitzewitz Award for Excellence in Pre-College Physics Teaching recognizes outstanding achievement in teaching pre-college physics.*

# Homer L. Dodge Citations for Distinguished Service to AAPT

**Monday, July 18 • 10:30 a.m.–12 p.m. • Sheraton - Magnolia/Camellia**

**Kathleen Falconer**

## Kathleen A. Falconer

**Kathleen Falconer**, Buffalo State College, Buffalo, NY, is recognized for her work at the national level. She has been active in several Area Committees. She has been a member and Chair of the Committee on Minorities in Physics, a member, Vice-Chair, and Chair of the Committee on Physics in Pre-High School Education and the Committee on Physics in Undergraduate Education, a member of the Committee on Women in Physics, and a member of the Programs Committee. She has also been a friend of the Committee on Laboratories as well as the Committee on Physics in Two-Year Colleges and has been active in the SEES Program which provides low-socioeconomic students with the opportunity to engage in hands-on science activities.

**Steve Kanim**

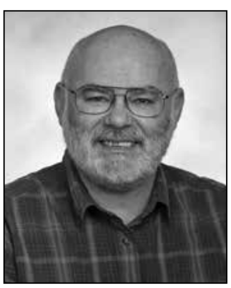
## Stephen Kanim

**Steve Kanim,** New Mexico State University, Las Cruces, NM, emeritus, received his bachelor's degree in electrical engineering from UCLA in 1981. After spending a few years designing microwave amplifiers, he decided to try teaching instead. He obtained his teaching certification from San Jose State University and taught high school physics in Palo Alto, CA, and in Las Cruces, NM. While teaching, he became more and more curious about the physics ideas expressed by his students, and decided to pursue a career doing physics education research. He received his PhD in physics from the University of Washington in 1999, and returned to Las Cruces to teach in the physics department at New Mexico State University. Kanim's primary research focus has been on how students use conceptual understanding to help solve physics problems and how they use mathematics in physics.

**Kevin Lee**

## Kevin M. Lee

**Kevin Lee** is Research Associate Professor at the University of Nebraska-Lincoln Center for Science, Mathematics, and Computer Education and the Department of Physics and Astronomy, Lincoln, NE. He earned his BS in Astronomy at the University of Michigan. He got his MS at Central Michigan University, and his PhD in Physics and Astronomy at the University of Nebraska. As a longtime AAPT member and 2-year chair of the AAPT Committee on Space Science and Astronomy (CSSA), he elevated the role of research and teaching of astronomy for the sessions/talks sponsored by CSSA. Lee's work in astronomy education has been remarkable and innovative. His accomplishments include the development of numerous simulations and peer instruction questions, resulting in many workshops. His two seminal works, to date, are The Nebraska Astronomy Applet Project and ClassAction, the clicker question database which is designed to help make large lecture-format astronomy courses more interactive. He freely shares these materials on his web site http://astro.unl.edu.



**Dan MacIsaac**

## Daniel L. MacIsaac

**Dan MacIsaac,** Buffalo State College, Buffalo, NY, is recognized for his work at the section and national level. He was active in the Arizona Section of AAPT from 1998-2000 as a Section Representative. He has also served as the Indiana Section Representative. He served as a member of several AAPT Area Committees including: the Committee on International Physics Education, the Committee on Research in Physics Education, the Committee on Laboratories, the Committee on Professional Concerns, and the Committee on Teacher Preparation. He has also been a member of the AAPT Programs Committee and active as a Column Editor for *The Physics Teacher* from 2004–present. Outside of AAPT, MacIsaac has been a member the AIP Committee on Publishing Policy and the AIP Subcommittee on Serials. MacIsaac earned his BSc in Physics at Mount Allison University and his PhD at Purdue University in West Lafayette, Indiana. He begin his career as a full-time teacher at Ebb and Flow School, Ebb and Flow Indian Reserve #52, Frontier School Division #48, Manitoba.

**Mel Sabella**

## Mel S. Sabella

**Mel Sabella,** Chicago State University, Chicago, IL, earned his BS in Physics at Binghamton University (SUNY) and his PhD in Physics at the University of Maryland in College Park, MD. He worked as a Postdoctoral Research Associate at the University of Washington in the Physics Education Group before his current appointment at Chicago State University—a majority African American institution on Chicago's south side. Sabella has been a reviewer for numerous publications including: *Science Education, Physics Education Research Supplement, Physics Education Research Conference proceedings, Physical Review: Special Topics, Sessions of 2004 American Education Research Association Conference, The Physics Teacher,* and *The American Journal of Physics.* He has been an active member of the Chicago Section of AAPT, a member of the Physics Education Research Leadership Organizing Council, a member of AAPT's Research in Physics Education Committee and Committee on Diversity.

*The Homer L. Dodge Citation for Distinguished Service to AAPT was established in 1953, was renamed in 2012 to recognize the foundational service and contributions of Homer Levi Dodge, AAPT's first president. The Homer L. Dodge Citation for Distinguished Service to AAPT recognizes AAPT members for their exceptional contributions to the association at the national, section, or local level.*

# #AAPTSM16

## JOIN US FOR A TWEET-UP
## SUNDAY, JULY 17 5:00 - 6:00 PM
## SHERATON BONDI

Gather with attendees and Tweet about the highlights of the meeting, Then, visit AAPT's booth in the exhibit hall afterwards ( booth 207) and show us that you've tweeted using the Hashtag #AAPTSM16 to be entered into a free raffle!

**Neil Gershenfeld**
Massachusetts
Institute of Technology

## From Bits to Atoms

### *by Neil Gershenfeld*

**Tuesday, July 19 • 4–5 p.m. • Sheraton - Magnolia/Camellia**

**Prof. Neil Gershenfeld** is the director of MIT's Center for Bits and Atoms. His unique laboratory is breaking down boundaries between the digital and physical worlds, from creating molecular quantum computers to virtuosic musical instruments. Technology from his lab has been seen and used in settings including New York's Museum of Modern Art and rural Indian villages, the White House and the World Economic Forum, inner-city community centers and automobile safety systems, Las Vegas shows and Sami herds. He is the author of numerous technical publications, patents, and books including Fab, When Things Start To Think, The Nature of Mathematical Modeling, and The Physics of Information Technology, and has been featured in media such as The New York Times, The Economist, NPR, CNN, and PBS. He is a Fellow of the American Physical Society, has been named one of Scientific American's 50 leaders in science and technology, as one of 40 Modern-Day Leonardos by the Museum of Science and Industry, one of Popular Mechanic's 25 Makers, has been selected as a CNN/Time/Fortune Principal Voice, and by Prospect/Foreign Policy as one of the top 100 public intellectuals. Dr. Gershenfeld has a BA in Physics with High Honors from Swarthmore College, a PhD in Applied Physics from Cornell University, honorary doctorates from Swarthmore College, Strathclyde University and the University of Antwerp, was a Junior Fellow of the Harvard University Society of Fellows, and a member of the research staff at Bell Labs.

**David Reitze**
LIGO Laboratory,
California Institute of
Technology

## Colliding Black Holes & Convulsions in Space-time: The First Observation of Gravitational Waves by LIGO

### *by David Reitze*

**Wednesday, July 20 • 10:30–11:30 a.m. • Sheraton - Magnolia/Camellia**

**David Reitze** holds joint positions as the Executive Director of the LIGO (Laser Interferometer Gravitational-wave Observatory) Laboratory at the California Institute of Technology and a Professor of Physics at the University of Florida. He received a PhD in Physics from the University of Texas at Austin in ultrafast laser spectroscopy in 1990 and has worked extensively in the area of experimental gravitational-wave detection since the mid-1990s. He has authored or co-authored over 250 peer-reviewed publications, and is a Fellow of the American Physical Society and the Optical Society of America.

AAPT American Association of Physics Teachers

# Connections Matter Winner!


**Douglas Wick, science teacher at the Branson School, Ross, CA, won AAPT's Connections Matter contest by referring new members to AAPT. He won the grand prize of an all-expenses paid trip to Sacramento for the 2016 Summer Meeting.**

**"Second Place winners received an AAPT Messenger Bag.** ***You can purchase your own bag at the AAPT Booth in the Exhibit Hall!***

# Free Commercial Workshops

## CW01: PASCO: Smart Cart Workshop

**Location:** CC - 309
**Date:** Monday, July 18
**Time:** 12–1 p.m.
**Sponsor:** PASCO

*Leader: Brett Sackett*

Get hands on with the wireless Smart Cart, and see how much physics you can do with this amazing low-friction dynamics cart from PASCO! The PASCO Smart Cart has on-board sensors that measure position, velocity, acceleration, force, plus an additional 3-axis accelerometer and 3-axis gyroscope. Six lucky attendees will win their own Smart Cart!

## CW02: PASCO: Capstone Workshop

**Location:** CC - 309
**Date:** Monday, July 18
**Time:** 1:30–2:30 p.m.
**Sponsor:** PASCO

*Leader: Brett Sackett*

Come learn about Capstone, an incredibly powerful data collection and analysis software for physics. See how to create customized lab pages, set start and stop conditions, analyze video data and add component vectors to the tracked object. See how easy it is to graph manually entered data, replay your experimental data, create calculations, and linearize your data. Bring all your Capstone questions, and provide your feedback directly to PASCO software developers.

## CW03: PASCO: Essential Physics Electronic Textbook for Physics

**Location:** CC - 309
**Date:** Monday, July 18
**Time:** 3–4 p.m.
**Sponsor:** PASCO

*Leader: Brett Sackett*

Meet *Essential Physics* author Dr. Tom Hsu and see how this interactive electronic physics textbook is the ultimate complement to your program. Features include interactive equations, simulations, the Infinite Test Bank with built-in assessment, and hands-on ErgoBot lab activities. Runs on a browser on Mac®, Windows®, Android™, iPad®, and Chromebook™.

## CW04: WebAssign: Code Your Own Questions in WebAssign

**Location:** CC - 302/303
**Date:** Monday, July 18
**Time:** 12–1 p.m.
**Sponsor:** WebAssign

*Leader: Matthew White*

Interested in adding your own questions to WebAssign? Whether you are new to coding in WebAssign or an experienced question coder, join our WebAssign question coding workshop to learn how easy it is to code your own questions. Bring questions about your own coding challenges, or just come to learn how to enrich your courses with your own coded questions.

## CW05: WebAssign: Enrich Your Physics Lecture and Lab Courses with WebAssign Content

**Location:** CC - 316
**Date:** Tuesday, July 19
**Time:** 12–1 p.m.
**Sponsor:** WebAssign

*Leader: Matthew White*

Since 1997, WebAssign has been the online homework and assessment system of choice for introductory physics lecture courses. Many veteran instructors already know that WebAssign supports over 150 introductory physics textbooks with precoded, assignable questions and advanced learning tools. In this presentation, we will focus on the wide array of WebAssign content you can use to enhance both your lecture course and your lab sections. WebAssign offers great resources for physics instruction, many of which can be adopted to supplement publisher offerings for no additional charge to your students. These include original question collections with feedback, solutions, and tutorials paired to some of the most popular textbooks; direct measurement videos that help students connect physics to real-world scenarios; and conceptual question collections authored by experienced educators and designed around physics education research principles. WebAssign also offers ready-to-use lab solutions, designed and tested at major universities, that you can adopt and customize to fit your needs. In some cases we can even build custom lab programs based on your specific lab materials and setup. This workshop is intended for current WebAssign users, but newcomers are welcome to join.

## CW06: Expert TA: Realigning Homework Grades and Test Scores in the Modern Classroom

**Location:** CC - 307
**Date:** Monday, July 18
**Time:** 12–1 p.m.
**Sponsor:** Expert TA

*Leader: Jeremy Morton*

The gap between students' homework grades and test scores is a concern we share with you. In order to study this, in 2012 Expert TA launched its Analytics platform and entered into the arena of "Big Data." Using this platform, we worked with instructors to do an intense analysis of data from 125 classes from the 2013-2014 AY; cross-referencing an aggregate data set involving approximately 1200 assignments and 2.4 million submitted answers. We identified three major factors causing these gaps: access to immediate and meaningful feedback, practice on symbolic questions, and a minimized ability to find problem solutions online. Knowing this, we have worked to develop the largest available library of "symbolic" questions and we use Analytics to data mine every incorrect answer ever submitted, in order to continually improve our feedback for these questions. We have also established very effective strategies to guard our problem solutions. The ultimate goal is to keep students focused on the physics; and then as they are working problems to provide them with meaningful, Socratic feedback that helps resolve misconceptions. Please join us and learn how other instructors are using Expert TA to reduce cost to students, increase academic integrity, and improve overall outcomes.

## CW07: Perimeter Institute: Physics in the News

**Location:** CC - 316
**Date:** Monday, July 18
**Time:** 12–1:30 p.m.
**Sponsor:** Perimeter Institute

*Leaders: Damian Pope, Stephanie Keating*

What's new in physics? From quantum mechanics to cosmology, we'll summarize all the coolest discoveries and highlight what to watch for. This session will explore cutting-edge physics for teachers that are looking for current, real-world science connections in their classroom. We'll discuss the big breakthroughs from this past year that your students are talking about and show you how you can incorporate it in your class.

## CW08: Perimeter Institute: Spicing Up Classical Physics

**Location:** CC - 316
**Date:** Monday, July 18
**Time:** 2:30–4 p.m.
**Sponsor:** Perimeter Institute

*Leaders: Damian Pope, Glenn Wagner*

Are YOU tired of using the same examples to illustrate concepts in classical physics every year? Looking for ways to expose your students to modern physics without taking up extra time? This session will show you that what you do every day in class can easily be applied to new, interesting concepts in modern physics. We will show you how to use dark matter in your lessons about circular motion, how to do nuclear physics using electric fields, and how to detect sub-atomic particles using conservation of momentum. Come and see how modern physics can be explored within classical curriculum in these easy-to-adapt activities for your classroom.

## CW09: Perimeter Institute: What Goes into a Black Hole, Stays in a Black Hole… or Does it?

**Location:** CC - 309
**Date:** Tuesday, July 19
**Time:** 12–1:30 p.m.
**Sponsor:** Perimeter Institute

*Leaders: Damian Pope, Glenn Wagner*

Black holes are arguably the most fascinating objects in the universe and they never fail to captivate students. But how can you incorporate black holes into your senior high school physics class? This session will explore the key properties of Black Holes via inquiry-based, hands-on student activities, and show how you can apply black hole physics to core curriculum topics including force, gravity, orbits, and escape velocity. Participants will receive a copy of the workshop activities.

## CW10: Perimeter Institute: Knowledge in Modern Physics: 21st Century Approach to Learning

**Location:** CC - 309
**Date:** Tuesday, July 19
**Time:** 2–3:30 p.m.
**Sponsor:** Perimeter Institute

*Leaders: Damian Pope, Stephanie Keating*

Will the Big Bang ever stop? Does the universe have an edge? Can we quantum teleport a person? Is 'absolute nothing' possible? These and other student-generated questions form the foundation of a new approach to teaching and learning about modern physics called Knowledge Building. In this learning environment, students form like-minded communities who share the same interest in a field of modern physics. Students then work as a community to develop and share knowledge through researching authoritative sources, asking questions, and building upon the ideas of others in their community. The result is a rich body of conceptual knowledge constructed entirely by student inquiry. The teacher does not need to be the 'expert' in this learning environment. Instead, the teacher plays a supporting role by providing learning opportunities through laboratory investigations, guest speakers and just-in-time teaching. This workshop will explain how Knowledge Building works and how knowledge building communities can be formed for learning in your classroom. Provide your students the freedom to be curious, collaborate, and explore cutting-edge topics in modern physics.

## CW11: Vernier: Experiments and Data Collection with Vernier

**Location:** CC - 302/303
**Date:** Tuesday, July 19
**Time:** 12–2 p.m.
**Sponsor:** Vernier

*Leaders: David Vernier, Fran Poodry, John Gastineau*

Attend this hands-on workshop to learn about physics experiments and data collection with Vernier. We will start with an interactive presentation to show you how Vernier data collection works on a variety of platforms, including Chromebooks. Then you may explore a variety of physics apparatus using your own device or one of ours. • Use the LabQuest 2 interface as a stand-alone device or as an interface to a computer or Chromebook • Collect data directly to an iPAD or Android tablet with LabQuest Stream • Collect and analyze data using an iPad, Android tablet, or Chromebook—ours or yours • Test the Vernier Motion Encoder System, and see just how good dynamics cart data can be • Try out the new Vernier Structures and Materials Tester with our sample beams and bridges • Explore thermal imaging with the FLIR ONE camera and Vernier's Thermal Analysis app • Explore the new Vernier Circuit Board 2 with optional breadboard • Do video analysis using Vernier Video Physics on an iPad • Experiment with Vernier Sensors connected to Arduino-compatible microcontroller boards.

## AAPT Publications

**Booth #306**
**One Physics Ellipse**
**College Park, MD 20740**
**301-209-3300**
**mgardner@aapt.org**
**www.aapt.org**

Drop by for information on how you can become part of the AAPT Publications program. Learn why you should submit articles for publication, consider becoming a reviewer, and make sure your physics department subscribes to *American Journal of Physics* and *The Physics Teacher*. It is rumored that it may be possible to catch up with journal editors and other members of the Publications Committee during your visit. If you are an online only member, you'll get a chance to see the print copies and reconsider your choice. If you aren't yet an AAPT member, we will do our best to help you decide which option is best for you.

## American 3B Scientific

**Booth #109**
**2189 Flintstone Drive**
**Tucker, GA 30084**
**678-405-5612**
**andrea.quinlan@a3bs.com**
**www.A3BS.com**

Visit 3B Scientific's booth for innovative physics products designed to inspire students, release their creative spirits, and challenge their critical thinking skills. Come check out our STEM focused experiments, alternative energy products, and 3B's unrivaled line of Teltron® electron tubes and atomic spin resonance devices. Go one step further... and find what you're looking for!

## American Association of Physics Teachers

**Booth #207**
**One Physics Ellipse**
**College Park, MD 20740**
**301-209-3300**
**swills@aapt.org**
**www.aapt.org**

Welcome to Sacramento! Join us at the AAPT booth and spin the wheel for your chance to win awesome prizes. This year, try out our new interactive demos based on lesson plans created from *The Physics Teacher*! We will also have a large selection of educational resources available to meet the needs of everyone from students to faculty. Show us you've tweeted using the hashtag #AAPTSM16 or liked us on Facebook to be entered into a free raffle, and don't forget to pick up your raffle ticket for the Great Book Giveaway!

## American Physical Society

**Booth #108**
**One Physics Ellipse**
**College Park, MD 20740**
**301-209-3206**
**thompson@aps.org**
**www.aps.org**

The American Physical Society's Public Outreach Department aims to bring the excitement of physics to all. Stop by to grab our new retro poster series, your copy of Spectra's Quantum leap or hear more about www.physicscentral.com. We will also be demoing our new comic book app as well as SpectraSnapp for android.

## Arbor Scientific

**Booth #206**
**PO Box 2750**
**Ann Arbor, MI 48106**
**800-367-6695**
**peter@arborsci.com**
**www.arborsci.com**

For 25 years, Arbor Scientific has worked with physics and physical science teachers to develop educational science supplies, science instruments, and physics lab equipment that make learning fun for students in elementary grades through college. Stop by our Booth and try the most fascinating, dynamic, hands-on methods that demonstrate key concepts and principles of physics and chemistry. We find the cool stuff!

## Expert TA

**Booth #203**
**624 South Boston Avenue**
**Tulsa, OK 74119**
**877-572-0734**
**main@theexpertta.com**
**www.theexpertta.com**

The Expert TA is an online homework and tutorial system for introductory physics courses. Expert TA's proprietary math engine performs partial credit grading of the most complex problems. It analyzes the steps used to solve equations, identifies detailed mistakes and deducts the appropriate points. This method allows instructors to accurately evaluate the mastery of student knowledge and provides students with consistent grading and quality feedback on their work. Stop by Booth 203 for a demonstration.

## Freeman/Sapling/Macmillan Learning

**Booth #303**
**41 Madison Avenue**
**New York, NY 10010**
**theresa.elise.moynahan@gmail.com**
**www.whfreeman.com/physics**

Macmillan Learning strives to support and enhance the Physics and Astronomy teaching and learning experience. Come by Booth 303 to learn more about how we are partnering with thought leaders in Physics and Physics education to change the landscape in Physics offerings, like iOLab (from Mats Selen and Tim Stelzer) and innovative books on Biological Physics by Philip Nelson. Interact with FlipItPhysics and Sapling Learning to learn how to best engage students from pre-lecture animations to robust post-lecture assignments with targeted feedback and unparalleled service. Browse our catalog to learn more and to view physics and astronomy titles from prominent authors, like Roger Freedman: www.macmillanlearning.com.

## iFLY Indoor Skydiving

**Booth #314**
**31310 Alvarado-Niles Road**
**Union City, CA 94587**
**510-401-5190**
**iflyworld.com**
**jboyce@iflyworld.com**

Teachers, come fly with us in our 200 mph 1000 horsepower vertical wind tunnel. See up close how we use our technology to teach physics with a unique combination of formal learning, kinesthetic experience plus a huge amount of fun! You will fly in the tunnel with an instructor, and will experience STEM activities just as your students would on a field trip. Come find out what your terminal velocity is (hint: it will be > 100 mph)!

## Klinger Educational Products Corp.

**Booth #313, 315**
**112-19 14th Road**
**College Point, NY 11356**
**718-461-1822**
**klinger_ed@prodigy.net**
**www.KlingerEducational.com**

This year KLINGER will be introducing new products that cover a wider range of topics and levels to teach physics. In addition to advanced physics teaching equipment, we will also have a selection of items for the high school and middle school teachers. Come visit and see the capabilities of a ballistics car and lab kits that demonstrate topics such as predicting trajectories, circular motion, a simple pendulum, accelerated motion, and much more. Also being demonstrated will be the LEYBOLD x-ray apparatus and tomography module. Both now have a locking, storage drawer that fits directly under the main units as well as a HD upgrade for the goniometer, enabling a 10X higher resolution achieved through narrower apertures and software. X-rays are detected with an end-window counter or an energy detector. Additionally we will be exhibiting our dependable Electron Diffraction tube and a Ne Franck-Hertz experiment. We look forward to seeing current and new members of the AAPT to say hello and catch up on events happening in the field of physics teaching.

## Laser Classroom

**Booth #214**
**1419 Main Street NE**
**Minneapolis, MN 55413**
**763-234-0692**
**colette@laserclassroom.com**
**www.laserclassroom.com**

Laser Classroom creates resources, partnerships, and products to make teaching and learning about Light, Lasers and Optics clear, easy, and affordable. Home of LASER Blox, the stackable laser designed just for teaching and learning.

## Merlan Scientific

**Booth #301**
**234 Matheson Blvd.**
**Mississauga, Ontario, Canada**
**1-800-387-2474**
**genie@merlanusa.com**
**merlanusa.com**

Merlan Scientific Booth #301 – Your source for Quality Optics/Physics teaching equipment. For over 45 years, Merlan Scientific has provided quality Science teaching resources. We are proud to introduce our premium Optics/Physics range. Great institutions such as CUNY endorse our Optics/Physics range, and we think you will be very impressed too. Much of our equipment is made in Europe and 'the accuracy and quality is unrivalled' (CUNY). Join us at Booth 301 to view some of our equipment including our new mecca table, thermal imager, wind tunnel, and much more. We will be happy to answer any questions you have and we also have great giveaways and offers including a coupon giving you a huge 15% off your first order with Merlan USA. www.merlanusa.com; 1800-387-2474; info@merlanusa.com.

## Modus Medical Devices

**Booth #212**
**1570 North Routledge Park**
**London, Ontario, Canada**
**519-438-2409**
**padams@modusqa.com**
**www.deskcat.com**

DeskCAT™ is an interactive multi-slice optical CT scanner that performs real-time acquisition, reconstruction, and display of 3D CT images. Designed by and for science educators as a safe and hands-on approach to teaching Computed Tomography, DeskCAT™ comes complete with 20 hours of lab exercises, phantoms, and an unlimited software license.

## Northern Kentucky CVB

**Booth #114**
**50 East RiverCenter Blvd.**
**Covington, KY 41011**
**859-261-4677**
**CQuercioli@meetnky.com**
**www.meenky.com**

As a true gateway to the South and part of a dynamic riverfront region known as CincinnatiUSA, Northern Kentucky boasts a sassy fusion of big-city fun & amenities and an array of authentic experiences you won't find elsewhere. As the region's destination specialists, we are quick to share our excitement about NKY's sumptuous culinary scene, boutique shopping enclaves and engaging attractions, which offer visitors the authentic & immersive experiences they crave. Customers tell us the unique assets in NKY are a key factor in promoting and growing their meeting attendance. In NKY, attendees find outstanding value and convenient access whether traveling by car or air. Whether you're a frequent visitor or a first-time guest, we invite you to spend some time with us in NKY. Our entire meetNKY team will do everything possible to ensure that your group enjoys a successful, memorable and value-rich meeting experience.

## OpenStax

**Booth #215**
**6100 Main Street**
**Houston, TX 77005**
**713-348-3674**
**jva7@rice.edu**
**www.openstaxcollege.org**

OpenStax is a nonprofit based at Rice University, and our mission is to improve access to education. Our free, peer-reviewed college textbooks have been used by nearly 700,000 students, and we're piloting adaptive, personalized learning technology that improves student learning. Through philanthropic partnerships, OpenStax is empowering students and instructors to succeed.

## PASCO scientific

**Booths #101,103,200,202**
**10101 Foothills Blvd.**
**Roseville, CA 95747**
**800-772-8700**
**tstout@pasco.com**
**www.pasco.com**

PASCO scientific transforms science education and student learning with innovative wireless probeware and software, promoting science inquiry and 21st century readiness skills for the global marketplace. Today teachers and students in more than 100 countries use PASCO solutions for physics, biology, chemistry, and earth and environmental science classes.

## Pearson

**Booths #208**
**1 Lake Street**
**Upper Saddle River, NJ 07458**
**201-236-5885**
**lauren.lopez@pearson.com**
**www.pearsonhighered.com**

Every learning moment builds character, shapes dreams, guides futures, and strengthens communities. At Pearson, your learning gives us purpose. We are devoted to creating effective, accessible solutions that provide boundless opportunities for learners at every stage of the learning journey. For more information, visit www.pearsoned.com.

## Perimeter Institute for Theoretical Physics

**Booth #307**
**31 Caroline Street N.**
**Waterloo, Ontario, Canada**
**519-569-7600**
**twilliams@perimeterinstitute.ca**
**www.perimeterinstitute.ca**

Perimeter Institute for Theoretical Physics is an independent, non-profit charity, research institute whose mission is to make breakthroughs in our understanding of our universe and the forces that govern it. Such breakthroughs drive advances across the sciences and the development of transformative new technologies. Located in Waterloo, Ontario, Canada, Perimeter also provides a wide array of research, training and educational outreach activities to nurture scientific talent and share the importance of discovery and innovation.

## Andrews University Physics Enterprises

**Booth #312**
**4260 Administration Drive**
**Berrien Springs, MI 49104**
**269-471-3503**
**rhoda@andrews.edu**
**www.physicsenterprises.com**

Physics Enterprises designs and manufactures high-quality teaching equipment for science classes. Our products are mainly represented by Vernier Software & Technology, PASCO scientific, VWR, American 3B Scientific, and TEL-Atomic. Visit our Booth to see our latest projects and share your ideas of what your class needs. More information at https://www.andrews.edu/services/physicsenterprises/.

## PhysicsVideos.com

**Booth #104**
**P.O. Box 11032**
**Irvine, CA 92658**
**949-285-9546**
**lincolnphysics@gmail.com**
**www.physicsvideos.com**

Physics Videos is a collection of high quality Physics Demonstrations videos for teachers and student. Our featured product is our DVD set of hundreds of physics demos organized by subject. Written and directed by James Lincoln, and performed by James Lincoln and Anna Spitz, these demonstrations are filmed in HD and explained with clear, concise language. We are also the creators of AAPT Films and the "Try This Experiment Right Now" video series.

## PhysTEC

**One Physics Ellipse**
**College Park, MD 20740**
**301-209-3206**
**sargent@aps.org**
**www.aps.org**

The American Physical Society has resources for every physics educator! Faculty can learn about APS education and diversity programs. Teachers can register for our middle school science adventure, adopt physicists for your high school class, pick up free posters, and much more.

## Quantum Design

**Booth #309**
**6325 Lusk Blvd.**
**San Diego, CA 92121**
**858-481-4400**
**melissa@qdusa.com**
**www.qdusa.com**

Quantum Design manufactures automated material characterization systems to further the research and education of physics, chemistry, and material science. These systems and associated curricula provide essential tools for engaging students and assisting teachers by providing hands-on instruction and experience using fundamental science principles. The VersaLab is a portable, cryogen-free cryocooler-based material characterization platform. With a temperature range of 50 – 400K, this 3 tesla platform is perfect for accomplishing many types of materials characterization in a limited space. A fully-automated system with a user-friendly interface, the VersaLab utilizes Quantum Design's PPMS platform measurement options.

## Quantum Experience Ltd.

**Booth #113**
**Haprat 2**
**Yavne, Israel 9122702**
**www.quantumlevitation.com**
**Tel: 972522559178**
**Contact: Boaz Almog**
**boazal@quantumlevitation.com**

Stimulate and encourage students to learn PHYSICS by teaching them the amazing phenomenon of Quantum Levitation. Quantum Experience develops educational programs using superconductors and quantum levitation. Our experimental kits and supporting material allow students to study Quantum Levitation, experience in a research process of learning and develop important scientific learning skills.

## CSU Sacramento

**Booth #112**
**6000 J Street**
**Sacramento, CA 95819**
**916-278-6011**
**degraff@csus.edu**
**http://www.csus.edu/physics/**

The Department of Physics and Astronomy at CSU Sacramento has been preparing students for graduate school, teaching careers, and industrial employment for over 40 years. Based in Sequoia Hall, overlooking the American River, our students interact closely with faculty members in and out of the classroom. Educators of the highest quality and excellent laboratory facilities have led Sac State Physics Alumni to graduate programs at institutions such as MIT, Berkeley, Stanford, Princeton, and Harvard not to mention wonderful careers in government, private industry, and education.

## Science First

**Booth #102**
**86475 Gene Lasserre Blvd.**
**Yulee, FL 32097**
**904-225-5558**
**info@sciencefirst.com**
**www.sciencefirst.com**

Science First® specializes in the design, manufacturing, marketing and distribution of high quality, hands on science products. Scientific equipment and experiments from PHYWE and Daedalon® are especially designed and built to meet the teaching requirements of the higher education market. Our product program covers 100% of the experimental courses of the Bachelor of Science in Physics curriculum.

## Society of Physics Students

**Booth #110**
**One Physics Ellipse**
**College Park, MD 20740**
**301-209-3008**
**lquijada@aip.org**
**www.spsnational.org**

The Society of Physics Students (SPS), along with Sigma Pi Sigma, the national physics honor society, are chapter-based organizations housed within the American Institute of Physics. SPS strives to serve all undergraduate physics students and their mentors with a chapter in nearly every physics program in the country and several international chapters. Sigma Pi Sigma, with over 95,000 historical members, recognizes high achievement among outstanding students and physics professionals. SPS and Sigma Pi Sigma programs demonstrate a long-term commitment to service both within the physics community and throughout society as a whole through outreach and public engagement. Partnerships with AIP member societies introduce SPS student members to the professional culture of physics and convey the importance of participation in a professional society. SPS and Sigma Pi Sigma support scholarships, internships, research awards, physics project awards, outreach/service awards, and a job site for summer and permanent bachelor's level physics opportunities (jobs.spsnational.org).

## Spectrum Techniques

**Booth #213**
**106 Union Valley Road**
**Oak Ridge, TN 37830**
**865-482-9937**
**sales@spectrumtechniques.com**
**www.spectrumtechniques.com**

Spectrum Techniques, the leading supplier of nuclear GM counting equipment, Exempt Quantity radioisotopes, and nuclear spectrometers is now showcasing a wifi enabled radiation counter with standard ethernet and USB.

## Turning Technologies

**Booth #115**
**255 West Federal Street**
**Youngstown, OH 44503**
**330-746-3015**
**kcastaneda@turningtechnologies.com**
**TurningTechnologies.com**

Increase engagement and understanding with Turning Technologies' learning solutions. TurningPoint Cloud is a desktop polling application that offers secure collection of data. Seamlessly poll with PowerPoint®, over any application or conduct self-paced assessments. Gather detailed reports with clickers or any web-enabled device.

## UC Davis

**Booth #100**
**Dept. of Mechanical and Aerospace Engineering**
**One Shields Road**
**Davis, CA 95616**
**217-819-7221**
**mae.ucdavis.edu**
**fmjan@ucdavis.edu**

We are a mechanical and aerospace engineering team from UC Davis. We developed an educational approach using a simple and affordable water table setup to demonstrate the theory of design, manufacturing, and testing of airplane wings. Our learning innovation includes an in-house water table, relevant wing models, and educational material. Our approach offers a very cost-effective and easy experiment based on the hydraulic analogy to transfer experimental results from models moving in water to models moving in air. By using our approach, students will gain hands-on experience to understand sophisticated engineering concepts such as shock wave and expansion fans.

## Vernier Software and Technology

**Booth #300, 302**
**13979 SW Millikan Way**
**Beaverton, OR 97005**
**888-837-6437**
**aharr@vernier.com**
**www.vernier.com**

Vernier Software & Technology is the leading worldwide innovator of real-time data-collection, graphing, and analysis tools for science education. Visit our booth to see our newly redesigned Dynamics Cart and Track System and demo our free Thermal Analysis app. Enter to win a FLIR ONE™ Thermal Camera for iOS!

## Ward's Science

**Booth #107**
**P. O. Box 92912**
**Rochester, NY 14692**
**800-962-2660**
**michael_jachles@vwr.com**
**www.wardsci.com**

All you need to turn science lessons into science connections. Ward's Science is the exclusive distributor for all Cenco Physics products, connecting you to the same world-class quality and innovative physics apparatus and experiments you know from Cenco, plus a wide selection of additional physics related activities, kits, and supplies.

## WebAssign

**Booth #201**
**1791 Varsity Drive**
**Raleigh, NC 27606**
**919-829-8181**
**aknight@webassign.net**
**www.webassign.net**

WebAssign has been delivering powerful online instructional solutions since 1997. A vital partner in physics education, WebAssign provides extensive content, instant assessment, and superior support. Educators appreciate our additional question collections, customizable labs, and free resources. Stop by Booth 201 to learn more.

**Booth #209, 308**
***Cyber Lounge and Charging station***

New this year! Now you can relax and recharge during your time in the exhibit hall. Plug in your devices or pop onto one of our provided laptops. Sit back, grab some refreshments and relax in our comfortable seating area.

## Shared Book Exhibit

**Springer:**
- Mark A. Cunningham, *Neoclassical Physics*

**Bitingduck Press:**
- Nadeau, Cohen, Sauerwine, *Truly Tricky Graduate Physics Problems*
- Susy Gage, *A Slow Cold Death*

**Insight Press:**
- Lewis Carroll Epstein, *Thinking Physics*

**Basic Books:**
- Stephon Alexander, *The Jazz of Physics*
- Author Benjamin, *The Magic of Math*

# Monday, July 18 – Session Schedule

**Poster Session 1: 8:30–10 p.m. Sheraton – Gardenia Ballroom**

| | CC - 306 | CC - 307 | CC - 308 | CC - 301 | CC - 314 | CC - 304/305 | CC - 312 | CC - 315 | CC - 311 | CC - 317/318 | CC - 313 | CC - 310 | CC - 319 | Sheraton Magnolia/ Camellia |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8:30 a.m. | **AA:** Progress in Pedagogy for Intro. Physics for Life Science | **AB:** Frontiers in Astronomy | **AC:** Effective Practices in Educational Technologies | **AD:** Two Year Colleges | **AE:** PER: Examining Content Understanding and Reasoning B | **AF:** Robert Noyce Scholars in Physics Teacher Preparation | **AG:** CIRTL: A Network Model to Transform STEM Edu. and Prepare Future Faculty | **AH:** Outreach Demonstrations | **AI:** PER: Exploring Problem Solving Approaches and Skills | **AJ:** Adaptaton of Physics Activities to 3 Major Components of NGSS | **AK:** 30 Demos in 60 Minutes | **AL:** Computer Modeling and Simulation in Sustainability Courses | | |
| 9:00 | | | | | | | | | | | | | | |
| 9:30 | | | | | | | | | | | | | | |
| 10:00 | | | | | | | | | | | | | | |
| 10:30 | | | | | | | | | | | | | | **Awards Session:** AAPT Teaching Awards AAPT DSCs |
| 11:00 | | | | | | | | | | | | | | |
| 11:30 | | | | | | | | | | | | | | |
| 12:00 p.m. | | | | | | | | | | **TOP03:** Role of AAPT in preK-8 Physics Edu: What Can We Do to Support Teachers? | | | **TOP02:** Finding Time To Do It: New Lessons in Time Management for Busy Faculty | |
| 12:30 | | | | | | | | | | | | | | |
| 1:00 | | | | | | | | | | | | | | |
| 1:30 | **BA:** Best Practices in Educational Technology | **BB:** PER: Diverse Investigations - B | **BC:** Art and Science of Teaching | **BK:** Astronomy Papers | **BE:** Developing Experimental Skills at all Levels | **BI:** PER in Upper Division | **BG:** Leadership and Other Skills in the Undergraduate Curriculum | **BH:** Integrating Computation into the Curriculum | **BJ:** Physicists with Disabilities | | **BD:** PER Advances in Problem Solving | **BF:** Teacher in Residence (TIR) Role in Mentoring | | |
| 2:00 | | | | | | | | | | | | | | |
| 2:30 | | | | | | | | | | | | | | |
| 3:00 | | | | | | | | | | | | | | |
| 3:30 | | | | | | | | | | | | | | |
| 4:00 | **CA:** Using Popular Media to Teach Astronomy | **CB:** PER: Modeling Student Engagement | **CE:** Favorite TPT Articles | **CK:** Preparing and Supporting University Physics Educators | **CJ:** Comparing World-Class Physics Education Ideologies: A Closer Look at AP, Cambridge, and IB Programs | **CI:** Searching for Extraterrestrial Intelligence | **CH:** The Physics of the NSF IUSE Program | **CL:** Modern Physics Demonstrations and Labs | **CD:** Professional Development Opportunities: Participant Perspective on What Works | **CF:** Introductory Labs/Apparatus | **CG:** PER: Diverse Investigations | **CC:** Physics and the Maker Movement | | |
| 4:30 | | | | | | | | | | | | | | |
| 5:00 | | | | | | | | | | | | | | |
| 5:30 | | | | | | | | | | | | | | |
| 6:00 | **TOP06:** Solo PER | | | | | **TOP05:** Roundtable on Teaching Physics in High School | | | **TOP04:** Graduate Student Topical Discussion | | | | | |
| 6:30 | | | | | | | | | | | | | | |
| 7:00 | | | | | | | | | | | | | | |
| 7:30 | | | | | | | | | | | | | | **Klopsteg Memorial Lecture:** Margaret Wertheim |
| 8:00 | | | | | | | | | | | | | | |
| 8:30 | | | | | | | | | | | | | | |

**Building Key:** **CC** = Convention Center **Sheraton** = Sheraton Grand Hotel

# Tuesday, July 19 – Session Schedule

**Poster Session 2: 5–6:30 p.m. Sheraton – Gardenia Ballroom**

| | CC - 306 | CC - 307 | CC - 308 | CC - 301 | CC - 314 | CC - 304/305 | CC - 312 | CC - 315 | CC - 311 | CC - 317/318 | CC - 313 | CC - 310 | CC - 319 | Sheraton Magnolia/ Camellia |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8:30 a.m. | **DE:** Onlline Hybrid | **DJ:** Make, Play, Learn | **DI:** Physicists with Disabilities - (Panel) | **DG:** What Can We Learn From and Do With Science Centers | **DL:** PER Findings Related To Latin American Students | **DF:** AAPT Opportunities for Middle and High School Teachers | **DD:** Leveraging Strengths of Diverse Populations | **DA:** Interactive Lecture Demonstrations: What's New? | **DC:** Effective Practices in Educational Technologies - I | **DK:** Other Papers | **DH:** APS/ AAPT Joint Task Force on Undergraduate Education | **DB:** Upper Division/Graduate Courses | **DE:** Finding Resources in History of Physics Suitable for Classroom Use | |
| 9:00 | | | | | | | | | | | | | | |
| 9:30 | | | | | | | | | | | | | | |
| 10:00 | | | | | | | | | | | | | | |
| 10:30 | | | | | | | | | | | | | | **Awards Session:** Millikan Medal: Stephen M. Pompea |
| 11:00 | | | | | | | | | | | | | | |
| 11:30 | | | | | | | | | | | | | | |
| 12:00 p.m. | | | | | | | | | | | | | | |
| 12:30 | | | | | | | | | | | | | | |
| 1:00 | | | | | | | | | | | | | | |
| 1:30 | **EA:** The History of Accelerator Physics | **EB:** PER: Evaluating Instructional Strategies | **EF:** Physics Teaching for Social Justice | **EK:** Supporting Women in Physics: How Everyone Can Play a Role | **EI:** Developing Experimental Skills at all Levels I | **EC:** Innovative Uses of Technology Enabled Spaces | **EG**: Addressing Race and Ethnicity | **EJ:** PER: Examining Content Understanding and Reasoning | **EE:** Professional Skills for Graduate Students | **EL:** The Great American Eclipse of 21 August 2017: Preparing for Maximum Impact | **EH:** Climate Change | **ED:** Upper Division Undergraduate | | |
| 2:00 | | | | | | | | | | | | | | |
| 2:30 | | | | | | | | | | | | | | |
| 3:00 | | | | | | | | | | | | | | |
| 3:30 | | | | | | | | | | | | | | |
| 4:00 | | | | | | | | | | | | | | **Plenary I:** Neil Gershenfeld |
| 4:30 | | | | | | | | | | | | | | |
| 5:00 | | | | | | | | | | | | | | |
| 5:30 | | | | | | | | | | | | | | |

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# Wednesday, July 20 – Session Schedule

**Poster Session 3: 3–4:30 p.m. CC - East Lobby**

| | CC - 306 | CC - 307 | CC - 308 | CC - 301 | CC - 314 | CC - 304/305 | CC - 312 | CC - 315 | CC - 311 | CC - 316 | CC - 313 | CC - 310 | CC - 319 | CC - 309 | Sheraton Magnolia Ballroom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8:30 a.m. | **FA:** PER: Exploring Problem Solving Approaches and Skills - A | **FB:** PER: Examining Content Understanding and Reasoning - A | **FC**: PER: Evaluating Instructional Strategies - A | **FK:** AP Physics 2 Labs with Java Applets | **FE:** PER: Diverse Investigations - A | **FF:** Lab Guidelines Focus Area 3: Modeling | **FJ:** Ardiuno, Teensy, FPGA's et al | **FD:** Computer Modeling and Simulation in the IPLS Course | **FI:** Supporting Hispanic Women Students in Physics | | | **FG:** High School | | **FH:** PhysTEC Teacher Preparation in California | |
| 9:00 | | | | | | | | | | | | | | | |
| 9:30 | | | | | | | | | | | | | | | |
| 10:00 | | | | | | | | | | | | | | | |
| 10:30 | | | | | | | | | | | | | | | **Plenary Session:** David Reitze |
| 11:00 | | | | | | | | | | | | | | | |
| 11:30 | | | | | | | | | | **TOP08:** Work Life Balance (Sheraton Bataglieri) | | | **TOP07:** Web Resources | | |
| 12:00 p.m. | | | | | | | | | | | | | | | |
| 12:30 | | | | | | | | | | | | | | | |
| 1:00 | **GF:** Technologies | **GG**: Two Years of New AP Physics 1 and 2 | **GH:** Mining Data Generated in the Classroom | **GA:** Preparing Pre-service Physics Teachers | **GK**: Do Try This at Home! | **GE:** Gender | **GB:** Particle Physics Investigations by Students | **GF:** Retention and Representation Programs | **GD:** Introductory Courses | | **GJ**: Teaching Physics in High Needs High Schools | **GC:** Teacher Training/Enhancement | | | |
| 1:30 | | | | | | | | | | | | | | | |
| 2:00 | | | | | | | | | | | | | | | |
| 2:30 | | | | | | | | | | | | | | | **PERC:** Bridging Session |
| 3:00 | | **HB:** Post-deadline Papers II | | **HA**: Post-deadline Papers I | | | | | | | | | **HD**: Post-deadline Papers IV | | |
| 3:30 | | | | | | | | | | | | | | | |
| 4:00 | | | | | | | | | | | | | | | |
| 4:30 | | | | | | | | | | | | | | | |
| 5:00 | | | | | | | | | | | | | | | |
| 5:30 | | | | | | | | | | | | | | | |

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# Workshops – Saturday, July 16

Transportation between the Sheraton Grand Hotel and California State University, Sacramento will be provided. Sunday morning tutorials (T01, T02, T03, T04, and T05) will be held at the Convention Center.

## W01: Teaching Physical Science with the Engineering is Elementary Curriculum

**Sponsor:** Committee on Physics in Pre-High School Education
**Time:** 8 a.m.– 12 p.m. Saturday
**Member Price:** $65 **Non-Member Price:** $90
**Location:** Placer Hall 1006

*Araceli Martinez Ortiz, Department of Curriculum & Instruction, Texas State University, 601 University Dr., San Marcos, TX 78666; araceli@txstate.edu*

*Eleanor W. Close*

Meet the original concept creator and curriculum developer of the popular story-book based Engineering is Elementary curriculum (EiE character, "Javier's" Mom!). Learn about EiE's design goal of integrating science and engineering, review a snapshot of the research and implementation progress of the last 10 years and examine how the NGSS Science and Engineering Practices can be supported through the use of this curriculum. The science and engineering practices describe behaviors that scientists engage in as they investigate and build models and theories about the natural world and the key set of engineering practices that engineers use as they design and build models and systems and integrate important scientific process standards in science along with science content knowledge while using the engineering design process. Select physical science-related EiE units developed by the Boston Museum of Science will be presented and participants will have an opportunity to explore colorful EiE stories, EiE web-based resources, and roll-up their sleeves to try several of the EiE uniquely packaged design challenges.

## W02: Creating Interactive Electronic Books for Computers and Tablets

**Sponsor:** Committee on Educational Technologies
**Time:** 8 a.m.–12 p.m. Saturday
**Member Price:** $60 **Non-Member Price:** $85
**Location:** Placer Hall 1002

*Mario Belloni, Physics Department, Davidson College, Davidson, NC 28036; mabelloni@davidson.edu*

*Wolfgang Christian, Bruce Mason*

With the rise of tablets, such as the iPad, the past few years has seen an increase in the demand for quality electronic textbooks. Unfortunately, most of the current offerings do not exploit the accessibility and interactivity that electronic books can deliver. In this half-day workshop we will describe the pedagogy and technology necessary to use, modify, and create an interactive electronic book in AAPT/ComPADRE (http://www.compadre.org) and as a stand-alone interactive book using EjsS. Participants will create an AAPT/ComPADRE account and filing cabinet of material and convert this material into the new books format (for example: http://www.compadre.org/books/WavesIntTut). We will also introduce the EjsS tool (freely available on ComPADRE) and lead participants through creating simple eBook with an existing JavaScript simulation. Participants are encouraged to bring laptops to install and run the EJS desktop tool. No previous experience with electronic books is necessary.

## W03: PIRA Lecture Demonstrations I & II Condensed: Selections from the PIRA 200

**Sponsor:** Committee on Apparatus
**Time:** 8 a.m.–12 p.m. Saturday
**Member Price:** $95 **Non-Member Price:** $120
**Location:** Mendocino Hall 1015

*Dale E. Stille, Rm 58 Van Allen Hall, Dept. of Physics and Astronomy, Univ. of Iowa, Iowa City, IA 52242; dale-stille@uiowa.edu*

*Sam Sampere*

During this ½ day workshop, we will introduce you to the Physics Resource Instructional Association (PIRA) and the PIRA 200. Almost every demonstration one can think of has a catalog number within the Demonstration Classification System (DCS); we will introduce you to this system and the comprehensive bibliography that details journal articles and demonstration manuals for construction and use in the classroom. The PIRA 200 are the specific 200 most important and necessary demonstrations needed to teach an introductory physics course. We will also show a subset of approximately 50 demonstrations explaining use, construction, acquisition of materials, and answer any questions in this highly interactive and dynamic environment. Ideas for organizing and building your demonstration collection will be presented. We especially invite faculty members teaching introductory physics to attend. *NOTE* that this is a paperless workshop. All information and materials will be distributed on a USB thumb drive. A computer, tablet, or other device capable of reading a USB will be needed for note taking, or you can bring your own paper.

## W04: DC Circuits

**Sponsor:** Committee on Physics in High Schools
**Time:** 8 a.m.–12 p.m. Saturday
**Member Price:** $80 **Non-Member Price:** $105
**Location:** Sequoia Hall 140

*Ann Brandon, 1544 Edgewood Ave., Chicago Heights, Il 60411; brandon3912@wowway.com*

*Deborah Lojkutzu*

A system of 10 to 12 activities and labs with integrated worksheets/home works. It starts with the basics, resistance, voltage, currents and how to use the digital multimeter in series, parallel, and combination circuits. The grand finale is Ohm's law. This workshop is suitable for a wide range of courses from basic intro to Advanced Placement Physics 1 and 2. The participants will receive one digital multimeter as well as permission to reproduce all of the materials.

## W05: Interactive Learning with Direct Measurement Video

**Sponsor:** Committee on Educational Technologies
**Co-Sponsor:** Committee on Graduate Education in Physics
**Time:** 8 a.m.–12 p.m. Saturday
**Member Price:** $60 **Non-Member Price:** $85
**Location:** Sequoia Hall 232

*Peter Bohacek, 14675 Afton Blvd., Afton, MN 55001; peter.bohacek@isd197.org*

*Matthew Vonk*

New Direct Measurement Videos allow students to explore by changing parameters such as mass, angles, and distances, and then measure the outcome. This allows open-ended inquiry learning. In this workshop, we'll use Direct Measurement Videos to show how students can discover mathematical relationships, make and test predictions, and apply physics models to new situations. We'll use whiteboards and discourse as our teaching methods, showing how Direct Measurement Videos can facilitate interactive learning.

## W06: Impact of Materials on Society – An Interdisciplinary Course Connecting Science and Everyday Life

**Sponsor:** Committee on Physics in Two-Year Colleges
**Time:** 8 a.m.–12 p.m. Saturday
**Member Price:** $30 **Non-Member Price:** $55
**Location:** Mendocino Hall 1026

*Kevin S. Jones, University of Florida; kjones@eng.ufl.edu*

*Pamela Hupp, Sophia Krzys Acord*

The Impact of Materials on Society (IMOS) is an interdisciplinary humanities/science course that examines how humans have used materials to change the world from human prehistory into our future. It increases both the technical literacy of the non-engineer and the social literacy of the pre-engineering student. The flexible curriculum can be used for both 4-year and 2-year institutions. This workshop will provide the information necessary to implement the class, including: learning outcomes, curriculum materials, lectures and films, flipped classroom activities, exams, and open source textbook etc. All information is available in a central location and is free to the instructors. The workshop will also address methods to attract student enrollment and best practices on how to nucleate teaching collaborations across disciplines. This course meets a timely need to help tomorrow's engineers understand how society influences their innovations and it helps the non-engineer understand the role of engineering in society.

## W07: Slowing it Down: High-Speed Cameras in Lecture and Lab

**Sponsor:** Committee on Apparatus
**Co-Sponsor:** Committee on Educational Technologies
**Time:** 8 a.m.–12 p.m. Saturday
**Member Price:** $65 **Non-Member Price:** $90
**Location:** Sequoia Hall 418

*Paul Nord, 1610 Campus Drive, Neils Science Center; paul.nord@valpo.edu*

Participants will explore the use of inexpensive high-speed cameras for lecture demonstration and lab experiments. We'll look at the limitations of these devices for phenomenological observation and data collection. Cameras from GoPro and the new iPhones provide up to 240 frames per second. Nikon 1 cameras can take video at 1200 frames per second. A few cameras will be available for shared use. Participants are welcome to bring their own cameras. Topics discussed will include: lighting, mounting, geometry of the setup, optimizing camera settings, data transfer, correcting for fish-eye lens distortions, and the use of simple editing tools.

## W08: Making Interactive Video Vignettes and Interactive Web Lectures*

**Sponsor:** Committee on Educational Technologies
**Time:** 8 a.m.–12 p.m. Saturday
**Member Price:** $60 **Non-Member Price:** $85
**Location:** Sequoia Hall 246

*Bob Teese, 1268 Carlson Hall, Rochester Institute of Technology, 54 Lomb Drive, Rochester, NY 14623; rbtsps@rit.edu*

*Priscilla W. Laws, Patrick J. Cooney, Kathleen Koenig, Maxine C. Willis*

The LivePhoto Physics Project is creating online activities that combine narrative videos with interactive, hands-on elements for the user including video analysis or making predictions based on replaying a short video (http://www.compadre.org/ivv). They can contain branching questions, where the user's answer affects the sequence of elements that follow. They are delivered over the Internet and run in a normal browser on the user's device. The same software runs both short Interactive Video Vignettes and Interactive Web Lectures for flipped classrooms or online courses. You will learn how to make vignettes and interactive web lectures using a free Java application. We will demonstrate the impact of select online activities on student learning. You need access to a web server to host your activities. Visit http://ivv.rit.edu/workshop to see detailed requirements for the web server and video equipment you will need.

*Supported by NSF grants DUE-1122828 and DUE-1123118.

## W45: Solar Cookers for Learning about Materials, Energy, Sensing, and Society

**Sponsor:** Committee on Science Education for the Public
**Time:** 8 a.m.–12 p.m. Saturday
**Member Price:** $60 **Non-Member Price:** $85
**Location:** Sequoia Hall 416

*Shawn Reeves, 1559 Beacon St. Apt 1, Brookline, MA 02446; shawn@energyteachers.org*

Sacramento is the home of Solar Cookers International, a longstanding research and advocacy organization that has been disseminating designs and practices for solar cooking. EnergyTeachers.org is a network of educators interested in energy production and use, started by physics teachers. Workshop participants will learn about how SCI researches and teaches about solar cookers and how educators from EnergyTeachers.org have been teaching physics with the cookers. Participants will build a cooker, use electronic sensors, cook something in the sun, and take the cookers and sensors home. Activities and concepts will include data-logging, digital and analog, automatic and manual; selective materials, examined in multiple wavelengths; infrared thermography; heat capacity; power; engineering design; pasteurization; replacing cooking fuels; diverse cooking methods for diverse situations; curriculum scope and sequence; and attitudes about women's work and about engineering to 'save the world'.

## W10: Developing Inquiry Labs and Activities for AP Physics

**Sponsor:** Committee on Teacher Preparation
**Co-Sponsor:** Committee on Physics in High Schools
**Time:** 8 a.m.–5 p.m. Saturday
**Member Price:** $95 **Non-Member Price:** $120
**Location:** Sequoia Hall 236

*Connie Wells, 2413 West 71st Str., Prairie Village, KS 66208; cwells@pembrokehill.org*

Physics education research, along with recent changes in AP Physics curriculum, encourages significant laboratory work and inquiry-based learning to foster in students a deeper conceptual understanding of physics concepts. In this workshop, participants planning to teach AP Physics will gain practical experience with laboratory experiments and the process of inquiry-based teaching that support the new curriculum design. Those who teach physics but are not involved in the AP program will gather ideas for inquiry labs and hands-on classroom activities to add to their existing programs. Teacher-team lab discussions, sharing of ideas, and construction of items for classroom use will be an invaluable part of the day.

## W11: Learn Physics While Practicing Science: Introduction to ISLE*

**Sponsor:** Committee on Physics in Undergraduate Education
**Co-Sponsor:** Committee on Research in Physics Education
**Time:** 8 a.m.–5 p.m. Saturday
**Member Price:** $82 **Non-Member Price:** $107
**Location:** Sequoia Hall 242

*Eugenia Etkina, 10 Seminary Place; eugenia.etkina@gse.rutgers.edu*

*David Brookes and Gorazd Planinsic*

Participants will learn how to modify introductory physics courses to help students acquire a good conceptual foundation, apply this knowledge in problem solving, and engage them in science practices. The framework for these modifications is Investigative Science Learning Environment (ISLE). We provide tested curriculum materials including: (a) *The College Physics Textbook* by Etkina, Gentile and Van Heuvelen, the Physics Active Learning Guide and the Instructor Guide; (b) a website with over 200 videotaped experiments and questions for use in the classroom, laboratories, and homework; (c) a set of innovative labs in which students design their own experiments, and (d) newly developed curriculum materials that use LEDs to help students learn physics. During the workshop the participants will learn how to use the materials in college and high school physics courses to help their students learn physics by practicing it. We will focus on the connections of our materials with the NGSS and revised AP curriculum, specifically on the interplay of science practices and crosscutting concepts.

*Please bring your own laptop to the workshop if you own one. Make sure it has Quicktime installed. If you do not own a computer, you will be paired with somebody who does.

## W12: Tools for Teaching Students to Synthesize Concepts

**Sponsor:** Committee on High Schools
**Co-Sponsor:** Committee on Teacher Preparation
**Time:** 1–5 p.m. Saturday
**Member Price:** $60 **Non-Member Price:** $85
**Location:** Mendocino Hall 1026

*Kelly O'Shea, 40 Charlton St., New York, NY 10014; kellyoshea@gmail.com*

*Peter Bohacek*

The Next Generation Science Standards Science Practices require that students learn to synthesize models to make predictions and show relationships. But how do teachers create opportunities for students to synthesize ideas? This workshop will focus on sharing and practicing student-centered activities that give students the opportunity to develop synthesis and that can be easily adapted to many physics classrooms. Activities in this interactive workshop will include concept maps, goal-less (open-ended) problems, a variety of whiteboarding modes, and direct measurement videos.

## W13: Cool NASA Stuff, NGSS, and Cultural Competency

**Sponsor:** Committee on Teacher Preparation
**Co-Sponsor:** Committee on Physics in Pre-High School Education
**Time:** 1–5 p.m. Saturday
**Member Price:** $65 **Non-Member Price:** $90
**Location:** Sequoia Hall 232

*Eleanor Close, Department of Physics, Texas State University, 601 University Dr., San Marcos, TX 78666; eclose@txstate.edu*

*Araceli Martinez Ortiz*

This discussion and hands-on workshop will encourage the exploration of equity issues driven by the recurring question: "How can culturally responsive teaching be operationalized in the Science, Technology, Engineering and Mathematics (STEM) classroom?" Culturally responsive instructional practices and cool NASA curricular resources aligned to NGSS will be presented. A culturally responsive curriculum validates students, integrates school-based knowledge with cultural-based knowledge, encourages differentiation of instruction and contributes to reducing student misunderstanding and demotivation. By focusing on NGSS science and engineering practices such as "Obtaining, Evaluating, and Communicating Information," students and teachers can find relevant approaches for critiquing and communicating ideas individually and in groups in more effective ways. Select NASA Educator Professional Development resources will highlight NASA inquiry-based lesson plans, web-based applications, primary data sources, and countless digital media resources that can be used in culturally congruent ways to enhance student learning.

## W14: Computational Modeling in Introductory Physics (vPython and Excel)

**Sponsor:** Committee on Physics in Two-Year Colleges
**Time:** 1–5 p.m. Saturday
**Member Price:** $60 **Non-Member Price:** $85
**Location:** Placer Hall 1002

*Tom Okuma, Lee College Physics, P.O. Box 818, Baytown, TX 77522-0818; tokuma@Lee.Edu*

*Dwain M. Desbien, David Weaver*

Over the last few years, we have implemented a number of different computational modeling activities in our introductory physics courses. These activities use either VPtyhon (http://vpython.org) or Microsoft Excel. Several of these activities have been developed in conjunction with a series of workshops done as part of the ATE Physics Workshop Project. Participants will work activities used in a typical two-semester introductory physics course ranging from conceptual level to calculus-based level. In this workshop, participants will work with some of these activities and develop their own. Participants are asked to bring their own laptops with VPython and Excel already downloaded on your laptop.

## W15: Making Physics Videos Using Tablets

**Sponsor:** Committee on Professional Concerns
**Co-Sponsor:** Committee on International Physics Education
**Time:** 1–5 p.m. Saturday
**Member Price:** $65 **Non-Member Price:** $90
**Location:** Placer Hall 1006

*Dan MacIsaac, SUNY Buffalo State College, Physics 462, SCIE 1300 Elmwood Ave., Buffalo, NY 14222; danmacisaac@gmail.com, jeremias.weber@uni-koeln.de*

*Jeremias Weber*

Recently ubiquitous iOS and Android tablets can be used to record high-quality stills and video, measure object motion, produce slow- motion sequences, stop-motion animation and cartoons, add subtitles, edit video sequences, and provide voiceover for short video vignettes. We will describe the use of tablets by students for the production of simple physics vignettes in introductory physics laboratories and in courses for the preparation of physics teachers with examples. Participants will learn to shoot and edit simple videos and practice using (low cost or free) commercial tablet software, using our provided iPads or their own tablets.

## W17: Using Kepler Mission Data in the Classroom

**Sponsor:** Committee on Space Science and Astronomy
**Time:** 1–5 p.m. Saturday
**Member Price:** $90 **Non-Member Price:** $115
**Location:** Mendocino Hall 1024

*Gary Nakagiri, SETI Institute, 189 Bernardo Ave., Suite 100, Mountain View, CA 94043; gnakagiri@seti.org*

*Gary Nakagiri, Susan Thompson*

NASA's Kepler Mission, launched in March 2009, has discovered exoplanets via the transit method of detection. We will explain how scientists have used the light curve data and Kepler's laws to calculate the orbital radii and sizes of many discovered exoplanets. An overview of the Kepler Mission findings, including the search for Earth-like planets, and the current K2 Mission, will be included. A simple light curve simulation will be demonstrated, using a classroom planetary system model, the orrery, a light sensor probe, and graphic interface software. This system collects data in real time and creates graphs similar in form to the actual light curve graphs. Participants will then use several simplified light curves and the mathematical formula (Kepler's third law) to determine the size and orbit of these unknown exoplanets. This process is quite similar to what has been done by Kepler scientists and will be explained in greater detail by our Kepler scientist co-presenter. She will also demonstrate how to access and use the publicly available large exoplanet data sets for classroom use and will offer some advanced exoplanet-related problems for high school honors and collegiate courses. NASA-published materials and resources will be shared.

## W18: Fun, Engaging, and Effective Labs and Demos with Clickers, Video Analysis, and Computer-based Tools

**Sponsor:** Committee on Educational Technologies

**Co-Sponsor: Committee on Research in Physics Education**
**Time: 1–5 p.m. Saturday**
**Member Price: $75 Non-Member Price: $100**
**Location: Sequoia Hall 246**

*David Sokoloff, Department of Physics 1274, University of Oregon, Eugene, OR 97403-1274; sokoloff@uoregon.edu*

*Ronald Thornton, Tufts University Priscilla Laws, Dickinson College*

RealTime Physics and Interactive Lecture Demonstrations have been available for over 15 years—so what's new? Participants in this workshop will have hands-on experience with some of the new activities in RTP and ILD using clickers, video analysis, and computer-based tools. The topics will be mechanics and optics. These active learning approaches for lectures, labs, and recitations (tutorials) are fun, engaging, and validated by physics education research (PER). Research results demonstrating the effectiveness of these curricula will be presented. These materials are also available for high schools in the Activity Based Physics High School e-dition. The following will be distributed: Modules from the Third Edition of RTP, the ILD book, the Physics with Video Analysis book and CD, and *Teaching Physics with the Physics* Suite by E.F. Redish.

## W19: Introductory Laboratories for Mechanics

**Sponsor: Committee on Laboratories**
**Time: 1–5 p.m. Saturday**
**Member Price: $72 Non-Member Price: $97**
**Location: Sequoia Hall 428**

*Mary Ann Klassen, Dept. of Physics & Astronomy, Swarthmore College, 500 College Ave., Swarthmore, PA 19081; mklasse1@swarthmore.edu*

*David Haley, Kenneth Lonnquist*

Whether your lab curriculum is ripe for an overhaul or well-established, this workshop will provide new ideas to bring home to your institution. Presenters from colleges and universities across the United States will each demonstrate their approach to a favorite introductory lab exercise. This year's workshop will focus on labs for mechanics. Attendees will have the opportunity to work with each apparatus. Documentation will be provided for each experiment, with lab manuals, sample data, equipment lists, and construction or purchase information. This workshop is appropriate primarily for college and university instructional laboratory developers.

## W20: Making the Invisible Visible: Using IR Cameras in Lecture and Lab

**Sponsor: Committee on Apparatus**
**Time: 1–5 p.m. Saturday**
**Member Price: $60 Non-Member Price: $85**
**Location: Mendocino Hall 2032**

*James Lincoln, SCAAPT, PO Box 11032, Newport Beach, CA 92660; lincolnphysics@gmail.com*

*Sam Sampere*

In this workshop, learn how to see invisible light, both with normal digital cameras and modern thermographic cameras. We will teach you to perform experiments and demonstrations that will make the invisible visible. Learn also the fundamentals of infrared photography, and the physics of near, intermediate, and far infrared light. Experienced physics demonstrators give you a hands-on experience with the cameras and equipment that are available.

## W21: Submitting Successful Proposals to the NSF S-STEM Program

**Sponsor: AAPT**
**Time: 1–5 p.m. Saturday**
**Member Price: $60 Non-Member Price: $85**
**Location: Mendocino Hall 4000**

*Kevin Lee, Program Director, National Science Foundation, 4201 Wilson Blvd., Arlington, VA 22230; KELEE@nsf.gov*

This workshop will focus on the National Science Foundation's Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) Program. This program makes awards to institutions to allocate scholarships to low-income students with demonstrated financial need who are academically talented. Its overarching motivation is to improve the STEM workforce of the United States to ensure our competitiveness in the global marketplace. I will describe the defining characteristics of the program as well as some prominent awards in the S-STEM portfolio. Program characteristics that have evolved recently and the motivations for these changes will get special emphasis. Guidance will be provided on potential areas of confusion including: the role of diversity, motivations underlying the strand structure, adapting versus creating materials for support structures, and the need for all projects to be knowledge-based and knowledge-generating. Note that participants will be asked to prepare for the workshop beforehand. This preparation will include reading the currently active S-STEM solicitation, reading an S-STEM proposal, and writing a review of the proposal in preparation for participating in a mock NSF panel exercise. Registrants should be proactive in contacting the workshop organizer to obtain the needed materials.

# Workshops – Sunday, July 17

## T01: Observing the 2017 Solar Eclipse

**Sponsor: Committee on Space Science and Astronomy**
**Time: 8–10 a.m. Sunday**
**Member Price: $50 Non-Member Price: $75**
**Location: CC - 309**

*Shannon Willoughby, Montana State University, EPS 264; willoughby@physics.montana.edu*

*Toby Dittrich*

The total solar eclipse occurring on Aug. 21, 2017, has a path of totality from Oregon to South Carolina. It is partial from the Canadian Arctic to Brazil. This eclipse will capture the attention of millions of students everywhere! Are you ready to pique your students' interest with unique curricular knowledge and activities? Do you plan to perform research during totality? This workshop gives you answers to these questions. The workshop focuses first on experts explaining: what happens during an eclipse, safe observation, the Sun/Moon, historical perspectives and student activities. Secondly, the American EclipseProject.org intends to engage undergraduates in the recreation of Eddington's 20th Century experiment verifying Einstein's relativistic theory of gravitational lensing of light. This experiment will be explained operationally for the use of telescopes and associated equipment necessary to take CCD images of the deflection of stars during totality. Fifteen student groups nationally will be selected for data acquisition for this project, and an unlimited number of data analysis teams will undertake measurements and calculations needed to draw final conclusions and publish the results. The workshop will prepare you to apply to be a team leader for this fabulous STEM research opportunity for both professors and students.

## T02: Electrostatics Tutorial

**Sponsor: Committee on Physics in High Schools**
**Time: 8–10 a.m. Sunday**
**Member Price: $50 Non-Member Price: $75**
**Location: CC - 310**

*Robert Morse, 5530 Nevada Ave., NW, Washington, DC 20015; ramorse@rcn.com*

With inexpensive equipment, students can carry out activities to build a conceptual understanding of electrostatic phenomena. In this short tutorial we will build the equipment and learn to carry out experiments patterned after those from William Gilbert to Alessandro Volta, including charge detection, electric field patterns, and electrostatic induction.

## T03: An Introduction to Race, Ethnicity, and Equity in Physics Education

**Sponsor:** Committee on Diversity in Physics
**Co-Sponsor:** Committee on Research in Physics Education
**Time:** 8–11 a.m. Sunday
**Member Price:** $50 **Non-Member Price:** $75
**Location:** CC - 311

*Angie Little; angie.little@gmail.com*

*Vashti Sawtelle, Chandra Turpen*

This workshop focuses on race, ethnicity, and equity in the context of physics education. We especially encourage those who may feel novice in talking about race and ethnicity to attend, but welcome everyone who is interested in exploring this area as well. We will support participants to examine educational spaces through the lenses of race and ethnicity. We will also consider how race and ethnicity play a role in systemic issues affecting physics education more broadly. Topics to be explored will be guided by participant input and may include, but are not limited to: identity, culture, privilege, microaggressions, implicit bias, and colorblind rhetoric. We will engage in group conversations, self-reflection, and explore possibilities for action within our own institutional contexts.

## T04: Using Learning Assistants to Flip Introductory Physics – Part I

**Sponsor:** AAPT
**Time:** 8–10 a.m. Sunday
**Member Price:** $25 **Non-Member Price:** $50
**Location:** CC - 312

*Vera Margoniner, Physics and Astronomy Department, California State University, Sacramento Office: SQU 436; vera.margoniner@gmail.com*

In this first half-day workshop we introduce participants to the concepts of a flipped classroom, Just in Time Teaching, Team-Based Learning, and to the Learning Assistant program. We will demonstrate how the model we developed at Sacramento State works in a large (90 students) introductory physics class, and present evidence of improved learning for students of all backgrounds. We will also discuss other benefits to students, LAs, and faculty associated with this modality of instruction such as improved study skills for students and LAs, and the organic development of a (interdisciplinary) faculty learning community. Next, we will start to discuss aspects related to student, LAs, and faculty preparation that are essential to running such a class successfully. LAs will be present to share their experiences

## T05: Using Learning Assistants to Flip Introductory Physics – Part II

**Sponsor:** AAPT
**Time:** 10:30 a.m.–1:30 p.m. Sunday
**Member Price:** $25 **Non-Member Price:** $50
**Location:** CC - 312

*Vera Margoniner, Physics and Astronomy Department, California State University, Sacramento Office: SQU 436; vera.margoniner@gmail.com*

In the second half-day workshop we will talk about the practicalities and help you get started. The goal is for you to leave the workshop with a better understanding of how to implement the program in a way that makes sense to your specific situation. We will help you think about ways to flip your classroom; start (and maintain) an LA program at your institution; get your students to buy into this modality of instruction; and manage it all without going crazy.

## W46: The Physics of Chemistry

**Sponsor:** Committee on Physics in High Schools
**Time:** 8 a.m.–12 p.m. Sunday
**Member Price:** $70 **Non-Member Price:** $95
**Location:** Sequoia Hall 416

*Jan Mader, 2223 5th Ave. SW, Great Falls, MT 59404; jan_mader@gfps.k12.mt.us*

*Karen Jo Matsler, Elaine Gwinn, Evelyn Restivo, Tommie Holsenbeck*

Very few high school physics teachers have the luxury of only teaching physics. This workshop will integrate chemistry and physics topics that are parallel in concepts but often deleted in one or the other classes due to limited instructional time frames.

## W22: How to Implement Collaborative Learning Activities in an IPLS Course

**Sponsor:** Committee Research in Physics Education
**Co-Sponsor:** Committee on Laboratories
**Time:** 8 a.m.–12 p.m. Sunday
**Member Price:** $125 **Non-Member Price:** $150
**Location:** Sequoia Hall 236

*David Smith, Department of Physics and Astronomy, University of North Carolina at Chapel Hill, Chapel Hill, NC, 27599; smithd4@email.unc.edu*

*Alice D. Churukian, Colin S. Wallace, Duane L. Deardorff, Laurie E. McNeil*

Physics instructors are increasingly being asked to reform their teaching practices and use evidence-based instructional strategies to actively and intellectually engage their students. In this workshop, participants will gain firsthand experience implementing multiple collaborative learning activities that have been specifically designed for use in introductory physics for life science (IPLS) courses. Examples will include content from mechanics, electricity, magnetism, and optics, with each activity grounded in real-world applications to biological phenomena and/or medical practices. Participants will also gain a better understanding of student difficulties in IPLS-focused topics and be introduced to teaching methods aimed at addressing such issues.

## W23: C3PO: Customizable Web-based Computer Coaches to Help Your Students Improve their Problem Solving

**Sponsor:** Committee on Research in Physics Education
**Co-Sponsor:** Committee on Educational Technologies
**Time:** 8 a.m.–12 p.m. Sunday
**Member Price:** $60 **Non-Member Price:** $85
**Location:** Mendocino Hall 1026

*Leon Hsu; lhsu@umn.edu*

*Bijaya Aryal, Tom Carter, Evan Frodermann, Andrew Heckler, Ken Heller, Koblar Alan Jackson, Sue Kasahara, Andy Pawl, Jie Yang*

This workshop will introduce participants to C3PO, a software system for creating and modifying computer interactions designed to help students develop expertise in solving problems in introductory physics. Delivered via the web so that students can use them at their convenience or in class, these computer coaches provide students with practice using the decision-making processes necessary to succeed in solving problems. In addition, C3PO allows instructors, with no programming background, to modify the coaches to be compatible with their teaching methods and build their own coaches. We will discuss the motivation behind and possible uses of C3PO and coach participants in making their own modifications to the coaches. Participants should bring their own laptops to access the coaches so they can practice modifying existing coaches to suit their teaching and the needs of their students. Participants will also be able to give feedback to the developers about how the functionality of C3PO could be improved to make the coaches more useful to them. A selection of working coaches will be available to workshop participants to use, modify, serve as a basis for building their own coaches, and incorporate into their teaching.

## W24: Composing Science: A Workshop on Teaching Writing in the Inquiry Classroom*

**Sponsor:** Committee Research in Physics Education
**Co-Sponsor:** Committee on Teacher Preparation

**Time:** 8 a.m.–12 p.m. Sunday
**Member Price:** $60 **Non-Member Price:** $85
**Location:** Sequoia Hall 444

*Leslie Atkins, 400 W. 1st St., Dept of Science Education; leslieatkins@boisestate.edu*

*Kim Jaxon*

Faculty who teach physics, biology, and English at California State University, Chico, have collaborated to develop a suite of materials to aid science faculty in improving writing in their science courses. In this workshop, we will familiarize participants with research from the field of composition, and share how findings from composition studies can be used to improve writing instruction in science courses. We will then walk participants through a range of ways in which we embed writing instruction in our courses—from the informal (whiteboards and lab notebooks) to the formal (term papers and exams)—with examples from our own courses. Participants will receive a set of lesson plans and activities they can use in science courses. Appropriate for high school and college/university instructors, suitable for non-science majors.
*Funding by NSF # 1140860.

## W25: What Every Physics Teacher Should Know About Cognitive Research

**Sponsor:** Committee Research in Physics Education
**Co-Sponsor:** Committee on International Physics Education
**Time:** 8 a.m.–12 p.m. Sunday
**Member Price:** $60 **Non-Member Price:** $85
**Location:** Sequoia Hall 418

*Chandralekha Singh, 4421 Schenley Farms Terrace; clsingh@pitt.edu*

In the past few decades, cognitive research has made significant progress in understanding how people learn. The understanding of cognition that has emerged from this research can be particularly useful for physics instruction. We will discuss and explore, in a language accessible to everybody, how the main findings of cognitive research can be applied to physics teaching and assessment.

## W26: Teaching Introductory Astronomy Using Quantitative Reasoning Activities

**Sponsor:** Committee on Space Science and Astronomy
**Time:** 8 a.m.–12 p.m. Sunday
**Member Price:** $68 **Non-Member Price:** $93
**Location:** Mendocino Hall 1024

*Stephanie Slater, CAPER Ctr for Astro & Phys Educ Research - ATT, Slater, 604 S 26th St., Laramie, WY 82070; sslaterwyo@gmail.com*

*Windsor Morgan, Dickinson College*

In this half-day, participatory workshop specially designed for college introductory astronomy faculty and high school teachers, participants will learn how to use active learning tutorials to develop and enhance students' quantitative reasoning skills. It has long been recognized that many astronomy students are terrified of courses requiring them to perform what they perceive as being tedious arithmetical calculations. At the same time, few materials exist across the broader astronomy education community to help students overcome their reluctance to engage in mathematical thinking and enjoy success at doing astronomy. Created by teaching-experts affiliated with the CAPER Center for Astronomy & Physics Education Research Team, these active learning tutorials are purposefully designed to support students in learning challenging astronomy concepts by introducing short and highly structured quantitative reasoning intervals where students collaboratively wrestle with how to think of astronomy in novel settings. Astronomy education research consistently demonstrates that students significantly increase their understanding of astronomy through the use of collaborative learning materials and that teachers find them easy to implement. Classroom-ready materials will be provided to all participants.

## W27: Authentic Experimentation in Labs Using Structured Quantitative Inquiry

**Sponsor:** Committee on Laboratories
**Co-Sponsor:** Committee on Research in Physics Education
**Time:** 8 a.m.–12 p.m. Sunday
**Member Price:** $70 **Non-Member Price:** $95
**Location:** Sequoia Hall 232

*Natasha Holmes; ngholmes@stanford.edu*

*Joss Ives*

The Structured Quantitative Inquiry Labs (SQILabs) are a new pedagogy for teaching data analysis, modeling, and critical thinking in physics labs. In this workshop, participants will learn about the SQILabs structure and work through sample experiments and activities in groups. Participants will explore quantitative tools students can use to compare measurements with uncertainty and use those tools to make decisions about the experiment. These are used to promote iterative experimentation cycles, where students reflect on comparisons and iterate to improve measurements. Several examples of these cycles will be applied to specific experiments and participants will also reflect on their own teaching labs and adapt the SQILabs structure to an experiment of their choice. Participants can expect to learn about a new pedagogical approach to physics labs and leave the workshop with tools, ideas, and structure to implement the approach in their own courses, whether or not labs are attached to lecture or lecture content. To learn more about SQILabs, visit http://sqilabs.phas.ubc.ca/.

## W28: Integrating Computation into Undergraduate Physics*

**Sponsor: Committee on Educational Technologies**
**Co-Sponsor: Committee on Physics in Undergraduate Education**
**Time: 8 a.m.–12 p.m. Sunday**
**Member Price: $20 Non-Member Price: $45**
**Location: Sequoia Hall 140**

*Larry Englehardt, PO Box 100547, Florence, SC 29506; LEngelhardt@fmarion.edu*

*Marie Lopez del Puerto, Kelly Roos, Danny Caballero*

In this workshop we will discuss the importance of integrating computation into the physics curriculum and will guide participants in discussing and planning how they would integrate computation into their courses. The PICUP partnership has developed materials for a variety of physics courses in a variety of platforms including Python/VPython, C/C++, Fortran, MATLAB/Octave, Java, and Mathematica. Participants will receive information on the computational materials that have been developed, will discuss ways to tailor the materials to their own classes, and will learn about opportunities that are available to receive additional support through the PICUP partnership. PLEASE BRING A LAPTOP COMPUTER WITH THE PLATFORM OF YOUR CHOICE INSTALLED.

*This workshop is funded by the National Science Foundation under DUE IUSE grants 1524128, 1524493, 1524963, 1525062, and 1525525. To learn more about SQILabs, visit http://sqilabs.phas.ubc.ca/.

## W29: Waves of Light and Sound: An Exploratorium Workshop

**Sponsor: Committee on Physics in Pre-High School Education**
**Co-Sponsor: Committee on Science Education for the Public**
**Time: 8 a.m.–12 p.m. Sunday**
**Member Price: $60 Non-Member Price: $85**
**Location: Sequoia Hall 242**

*Kathy Holt, 19100 LIGO Lane, P.O. Box 940, Livingston, LA 70754; kholt@ligo-la.caltech.edu*

*Paul Doherty*

Join us as we explore waves of light and sound using explorations created by the Exploratorium Teacher Institute. We'll look at colors in soap films and oil slicks and model what's going on by using waves drawn on index cards. We'll listen to sounds made in air-filled tubes and by aluminum rods and model the vibrations creating the sounds by modeling them in a dance. We'll also provide links to videos of the activities and to free Exploratorium apps on color and sound.

## W30: Demo Kit in a Box: Mechanics

**Sponsor: Committee on Apparatus**
**Co-Sponsor: Committee on Science Education for the Public**
**Time: 8 a.m.–12 p.m. Sunday**
**Member Price: $70 Non-Member Price: $95**
**Location: Mendocino Hall 4004**

*Steve Lindass, Dept. of Physics and Astronomy, MN State University Moorhead, 1104 7th Ave. South, Moorhead MN 56563; lindaas@mnstate.edu*

*Adam Beehler*

Are you looking for easy ways to infuse inquiry into your classroom? Don't have a demo manager? We will help you establish having several small demos conveniently packed into one box, ready for the classroom at any moment. You may bring your box to your class and use the demos to highlight lecture points, or use them when a student asks a question. Use a "Just-In-Time" teaching approach but with a demo twist! We will show you how to pack small demo kit boxes that pack a large instructional punch. The demo focus this summer is mechanics (toys are likely to be involved). Participants will leave with lots of demos!

## W31: Learner-centered Environment for Algebra-based Physics*

**Sponsor: Committee on Research in Physics Education**
**Co-Sponsor: Committee on Physics in High Schools**
**Time: 8 a.m.–12 p.m. Sunday**
**Member Price: $60 Non-Member Price: $85**
**Location: Mendocino Hall 2032**

*Paula Engelhardt, Tennessee Technological University, 110 University Drive, Bruner 227, Cookeville, TN 38505; engelhar@tntech.edu*

*Steve Robinson*

The Learner-centered Environment for Algebra-based Physics (LEAP) is a two-semester physics curriculum for algebra-based physics appropriate for both university and high school settings. The pedagogy and activity sequence is guided by research on student learning of physics and builds on the work of the NSF-supported project, Physics for Everyday Thinking (PET). Students work in groups to develop their understanding of various physics phenomena including forces, energy, electricity and magnetism, light and optics. Students utilize hands-on experiments and computer simulations to provide evidence to support their conceptual understanding. Traditional problem solving is scaffolded by using the S.E.N.S.E. problem solving strategy. During this workshop, participants will be introduced to the LEAP curriculum and S.E.N.S.E. problem solving strategy, will examine and work through a sample of the types of activities students do including Java- and Flash-based simulations.

*Supported in part by NSF CCLI grant #DUE-0737324 and NSF TUES grant #1245684.

## W33: Activity-based Physics in the High School Classroom

**Sponsor: Committee on Physics in High Schools**
**Co-Sponsor: Committee on Educational Technologies**
**Time: 8 a.m.–5 p.m. Sunday**
**Member Price: $80 Non-Member Price: $105**
**Location: Sequoia Hall 246**

*Steve Henning, 52 Dick Dr., Worcester, MA 01609; physfsh@gmail.com*

*Maxine Willis, Priscilla Laws*

This hands-on workshop is designed for teachers in advanced physics classes such as AP, International Baccalaureate, and honors physics. Teachers attending should be interested in enabling their students to master physics concepts in mechanics by engaging in inquiry-based active learning. Participants will work with classroom-tested curricular materials drawn from the Activity Based Physics Suite materials. These curricula make creative use of flexible computer tools available from Vernier and PASCO. These materials have been developed in accordance with the outcomes of physics education research. Affordable access to the Suite materials for secondary school use is now available and will be discussed.

## W34: Research-based Alternatives to Traditional Physics Problems

**Sponsor: Committee on Research in Physics Education**
**Co-Sponsor: Committee on Professional Concerns**
**Time: 8 a.m.–5 p.m. Sunday**
**Member Price: $80 Non-Member Price: $105**
**Location: Mendocino Hall 4000**

*Kathy Harper, Engineering Education Innovation Center, The Ohio State University, 244 Hitchcock Hall, 2070 Neil Ave., Columbus, OH 43210; harper.217@osu.edu*

*Thomas M. Foster, David P. Maloney*

Accumulating research on problem solving in physics clearly indicates that traditional, end-of-chapter exercises in physics texts are not useful and may actually hinder students' learning of important physics concepts. The research also raises questions about the efficacy of such tasks for helping students develop "problem solving skills." In light of these results the question is: What alternative tasks can we use to help students develop problem solving skills and a conceptual understanding? This workshop will review the research and then provide examples of several alternative tasks and their use. Participants will also get practice writing alternative problems in a variety of formats for use in their own classrooms.

## W35: Physics of Energy Labs

**Sponsor: Committee on Laboratories**
**Time: 8 a.m.–5 p.m. Sunday**
**Member Price: $105 Non-Member Price: $130**
**Location: Sequoia Hall 132**

*Abigail Mechtenberg, University of Notre Dame, Department of Physics, 313 Jordan Hall of Science, University of Notre Dame, Notre Dame, IN 46556; Abigail.R.Mechtenberg.3@nd.edu*

*Regina Barrera, Patricia White*

AAPT educators embrace this Physics of Energy Labs workshop for experimental (laboratories) and theoretical (simulations) curricula. The academic level is set for undergraduate engineers and physicists; however, the astute teacher can easily apply this to other students and we will have explanations of labs used in high schools. During the experimental-part of the workshop, laboratories will be executed in groups (starting with cookbook and moving to inquiry-based pedagogies through a novel experimental design approach). During the theoretical part of the workshop, Homer Energy microgrid activities will be executed. All participants will leave with a USB of resources. Together the workshop will weave a coherent common thread for our Physics of Energy from mechanical to electrical energy, thermal to electrical, solar to electrical, and chemical to electrical energy. Whether motivated by energy security or environmental stability, physicists at all levels must play an active role in the scientific literacy of energy integrated coherently and systematically without personal bias. Participant's are encouraged to bring their own laptops.

## W36: Learning Activities for Life Science in Introductory Physics

**Sponsor: Committee on Physics in Undergraduate Education**
**Time: 1–5 p.m. Sunday**
**Member Price: $75 Non-Member Price: $100**
**Location: Sequoia Hall 418**

*Nancy Beverly, Mercy College, 555 Broadway, Dobbs Ferry, NY 10522; Nbeverly@mercy.edu*

Experience hands-on activities for the health or life science student in introductory physics. A group representing a variety of institutions will provide lab and other hands-on activities with varying pedagogical strategies, which all have a biological or health context. Get ideas about different approaches and activities that would fit your students' needs with your institution's resources and faculty investment time constraints. A focus will be tying together what you would like to do with how you can do it.

## W37: Strategies to Help Women at All Levels to Succeed in Physics-Related Professions

**Sponsor: Committee on Women in Physics**
**Co-Sponsor: Committee on Graduate Education in Physics**
**Time: 1–5 p.m. Sunday**
**Member Price: $60 Non-Member Price: $85**
**Location: Mendocino Hall 1026**

*Chandralekha Singh, 4421 Schenley Farms Terrace; clsingh@pitt.edu*

Women are severely underrepresented in physics-related professions. This workshop will explore strategies to help women understand and overcome barriers to their advancement in careers related to physics. A major focus of the workshop will be on strategies for navigating effectively in different situations in order to succeed despite the gender schema, stereotypes, and subtle biases against women in physics. We will also examine case studies and learn effective strategies by role playing.

## W38: Developing the Next Generation of Physics Assessments

**Sponsor: Committee on Research in Physics Education**
**Time: 1–5 p.m. Sunday**
**Member Price: $20 Non-Member Price: $45**
**Location: Mendocino Hall 2032**

*James T. Laverty, 620 Farm Lane, Erickson Hall, Room 115; laverty1@msu.edu*

*Marcos D. Caballero*

Want to write assessments that will tell you what your students are able to do with their physics knowledge? If so, then this is the workshop for you. Participants will learn how to use the recently developed Three-Dimensional Learning Assessment Protocol (3D-LAP) to develop homework and exam problems that engage students in both the process and content of physics. This instrument was developed to help assessment authors at all levels (K-16) generate questions that include scientific practices, crosscutting concepts, and disciplinary core ideas, the three dimensions used to develop the Next Generation Science Standards. Join us to learn how to create the next generation of physics assessments.

## W39: Raising Physics to the Surface

**Sponsor: Committee on Research in Physics Education**
**Co-Sponsor: Committee on Physics in Two-Year Colleges**
**Time: 1–5 p.m. Sunday**
**Member Price: $60 Non-Member Price: $85**
**Location: Sequoia Hall 232**

*Aaron Wangberg, 322 Gildemeister Hall, Department of Mathematics and Statistics, Winona State University, Winona, MN 55987; awangberg@winona.edu*

*Elizabeth Gire, Robyn Wangberg*

Visualization and geometric reasoning are key components of solving physics problems. These skills are particularly difficult for students when reasoning about multivariable functions. "Raising Physics to the Surface" helps students discover the geometric relationships behind such ideas as partial derivatives, gradient, level curves, and integrals used in the middle-level and upper-division undergraduate physics curriculum. The project utilizes dry-erase surface manipulatives and contour maps, letting students draw, measure, and grasp concepts geometrically. Participants in this workshop will have an opportunity to play, draw, and make measurements on the surface manipulatives. We will explore how these surface manipulatives could be utilized in classical mechanics, E&M, and thermal physics or in a math methods course.

## W40: Fun and Engaging Labs

**Sponsor: Committee on Teacher Preparation**
**Co-Sponsor: Committee on Physics in High Schools**
**Time: 1–5 p.m. Sunday**
**Member Price: $60 Non-Member Price: $85**
**Location: Sequoia Hall 242**

*Wendy Adams, University of Northern Colorado, Greeley, CO 80639; wendy.adams@unco.edu*

*Duane Merrell*

In this workshop we will share many labs that are suitable for both high school and introductory college physics. The labs are challenging but not too difficult and, leave plenty of room for creativity! We have found success by limiting the goals for the labs to: 1) Fun and engaging, 2) Built-in student choice, and 3) Related to this week's material. The labs are effective at engaging the students in problem solving and conceptual understanding. Merrell used this type of lab as a high school teacher and physics quickly became one of the most popular classes in the school. Adams, inspired by Merrell, has found that her college students no longer rush to leave, and in some cases stay to see how other groups do even after they've turned in their lab write up for the day! This workshop will allow you to try out these labs for yourself.

## W41: Intermediate and Advanced Laboratories

**Sponsor:** Committee on Laboratories
**Time:** 1–5 p.m. Sunday
**Member Price: $85** **Non-Member Price: $110**
**Location: Sequoia Hall 428**

*Jeremiah Williams, Physics Department, Wittenberg University, PO Box 720, Springfield, OH 45504; jwilliams@wittenberg.edu*

This workshop is appropriate for college and university instructional laboratory developers. At each of five stations, presenters will demonstrate an approach to an intermediate or advanced laboratory exercise. Each presenter will show and discuss the apparatus and techniques used. Attendees will cycle through the stations and have an opportunity to use each apparatus. Documentation will be provided for each experiment, with sample data, equipment lists, and construction or purchase information.

## W42: Student Learning in Next Generation Physics and Everyday Thinking

**Sponsor:** Committee on Physics in Undergraduate Education
**Co-Sponsor:** Committee on Teacher Preparation
**Time:** 1–5 p.m. Sunday
**Member Price: $65** **Non-Member Price: $90**
**Location: Mendocino Hall 1024**

*Fred Goldberg, San Diego State University, 6475 Alvarado Rd., Set 206, San Diego, CA 92120; fgoldberg@mail.sdsu.edu*

*Stephen Robinson, Edward Price*

The "Next Generation Physics and Everyday Thinking" set of curricular materials[1] has been adapted from previous curricula (PET, PSET and others) to make the materials more aligned with the Next Generation Science Standards and more flexible in its implementation. Like the previous curricula, the conceptual and pedagogical design of Next Gen PET builds on students' prior knowledge and lends itself to making students' thinking visible to both other students and to the instructor. In this workshop we will work through some sample activities, view and discuss corresponding classroom video clips as a means of focusing on student learning, and examine features of the new web-based faculty resources that support instructors in their implementation.

1. Major support for the development of Next Gen PET has come from the Chevron Foundation and the National Science Foundation grant 1044172.

## W43: Activities for Teaching About Climate and Climate Change

**Sponsor:** Committee on Science Education for the Public
**Time:** 1–5 p.m. Sunday
**Member Price: $60** **Non-Member Price: $85**
**Location: Sequoia Hall 416**

*Brian Jones, Physics Department, 1875 Campus Delivery, Colorado State University, Fort Collins, CO 80523; physicsjones@gmail.com*

During the day, the Earth is warmed by sunlight that shines on it. This is something that your students can see, something that they can feel. But, over the course of a day, the surface of the Earth receives more radiant energy from the bottoms of clouds and the lower atmosphere than it does from the Sun. This influence of thermal radiation is critically important for an understanding of the Earth's climate and how it is changing. In this workshop we'll share activities that make this invisible form of energy transfer tangible. We'll also share activities that illuminate other important but complex concepts, such as how climate models work, how feedbacks—both positive and negative—affect the climate. Our goal is to give you a set of tools to give your students a real understanding of the Earth's climate and how scientists predict its development in the future.

## W44: Just-in-Time Teaching

**Sponsor:** Committee on Physics in Undergraduate Education
**Co-Sponsor:** Committee on Educational Technologies
**Time:** 1–5 p.m. Sunday
**Member Price: $20** **Non-Member Price: $45**
**Location: Sequoia Hall 236**

*Andrew Gavrin, IUPUI, Dept. of Physics, LD154, 402 N. Blackford St., Indianapolis, IN 46202; agavrin@iupui.edu*

For more than 15 years, faculty members in physics, math, engineering and many other fields have used Just-in-Time Teaching, also known as "JiTT." By creating a short time scale feedback loop between homework and the classroom, JiTT improves students' engagement with the course, promotes active learning in the classroom, and helps students to stay caught up in the class. JiTT also provides faculty with greater insight to their students' thinking about the subject. This workshop will introduce JiTT methods, and show how they can be implemented in a variety of educational settings. Participants will learn to implement JiTT using their LMS or free technology, and will be introduced to an online library of assignments that they can use or adapt. By the end of the session, participants will have several JiTT assignments usable in their own classes. We will also discuss tips and tricks for a successful implementation.

## Session SPS: SPS Undergraduate Research and Outreach Posters

**Location:** CC - Exhibit Hall D
**Sponsor:** SPS
**Date:** Sunday, July 17
**Time:** 8–10 p.m.

*Presider: Brad Conrad*

### SPS01: 8-10 p.m. Electromagnetic Field Duality in Light Polarization Using Geometric Algebra

*Poster – Elijah C. Ryan,* Yakima Valley Community College, S. 16th Ave. and Nob Hill Blvd. Yakima, WA 98907-2520; srodrigue@yvcc.edu*

*Stephen M. Rodrigue, Yakima Valley Community College*

In the Clifford Algebra of Spacetime, dubbed the Spacetime Algebra, the duality of vectors to trivectors and bivectors to bivectors provides a simple language to formulate the duality of the Electric and Magnetic Fields. The equations of Maxwell that describe these classical fields can, by using Geometric Algebra, be placed in the form of a single field equation in the pseudo-Euclidean four-space of the Spacetime Algebra in place of the two distinct Classical Field Equations formed by the derivatives of the Faraday Tensor and its dual. The duality of bivectors in the four-space can be used to show the orthogonality of the Electromagnetic Field, with specific application in the polarization of light. The Geometric Algebra developed by David Hestenes is applied to take advantage of the directional qualities and simplicity of the Geometric Product in the Spacetime Metric.

*Sponsored by Stephen M. Rodrigue

### SPS02: 8-10 p.m. High-Resolution Measurement of Lattice Spacing of a Sodium Chloride Monocrystal Using X-Ray Diffraction

*Poster – Misganaw Getaneh, University of Tennessee at Martin, 115 Stephenson Rd., Martin, TN 38237; mgetaneh@utm.edu*

*Jordan Johnson, University of Tennessee at Martin*

High-energy electrons that are stopped at a Molybdenum surface produce two types of x-rays. These are bremsstrahlung x-rays produced through deceleration of electrons and material characteristic x-rays, K-alpha and K-beta emission lines, produced by transitions in the Molybdenum atoms when high-energy electrons hit the surface. A small portion of the x-rays produced at the source goes through a collimator and is scattered by a NaCl monocrystal target. Data of count rate versus target angles was collected for the scattered x-rays for electron accelerating voltage of 35 kV. Analysis of the scattered K-alpha and K-beta lines gives d=280±4 p.m. for lattice spacing, which is consistent with the literature value d=282.01 p.m.. The measurement was repeated using a much higher resolution accessory. This gave a much more resolved image of the scattered x-rays. This resulted in lattice spacing d=281.54±1.60 p.m..

### SPS04: 8-10 p.m. Modeling Acoustic Landmine Detection Using a Soil-Plate Oscillator

*Poster – Joshua M. Lewis, Department of Physics, U.S. Naval Academy, 572 C Holloway Road, Chauvenet Hall Room CH295, Annapolis, MD 21402, korman@usna.edu*

*Miahanna K. Nguyen, Murray S. Korman, U.S. Naval Academy*

In laboratory acoustic landmine detection experiments a plastic cylindrical drum-like simulant is buried in a soil tank. Sound (generated from subwoofers located above the soil) drives the soil particles causing subsequent particle vibration over the compliant top plate of the simulant. Measurements of surface particle velocity vibration vs. frequency were recorded for various scan locations across the surface in an effort to profile the buried simulant. Resonant behavior can be modeled using a soil-plate-oscillator (SPO) apparatus, which involves a thick-walled cylindrical column of granular material (sand or light density edible materials) supported by a circular acrylic plate clamped to the bottom of the column. A small accelerometer on the granular surface measures tuning curve results across the surface using a sweep spectrum analyzer. Landmine simulant and SPO results are compared to help analyze the behavior of the resonant tuning curves.

### SPS05: 8-10 p.m. Newton's Second Law

*Poster – Vincent Coletta, Loyola Marymount University, 1 LMU Drive, Los Angeles, CA 90045-1373; vcoletta@lmu.edu*

*Josh Bernardin, Daniel Pascoe, Loyola Marymount University*

Students pull each other on carts, sheets of plywood that roll on low friction, rollerblade wheels. One student pulls the cart on which a second student is seated as the cart moves down the hall. The cart is pulled with a rope and spring scale, so that the student who is pulling can monitor the force during the motion. The riding student uses a metronome and marks the floor at one second interval so that the distance traveled as a function of time can be measured. This experiment serves to develop both students' understanding of Newton's second law and also their facility with handling multiple variables and their relationships.

### SPS06: 8-10 p.m. Nonlinear Vibration Experiment: Clamped Elastic Plate with Granular Material Loading

*Poster – Emily V. Santos, Department of Physics, U.S. Naval Academy 572 C Holloway Road, Chauvenet Hall Room Ch295, Annapolis, MD 21402; korman@usna.edu*

*Murray S. Korman, U.S. Naval Academy*

Experiments using soil-plate-oscillators (SPO) involve a cylindrical column of granular media (masonry sand, glass spheres, uncooked brown rice, un-popped popcorn kernels, or "Toasty Oats" ™ cereal) supported by a circular elastic acrylic plate (20.3 cm diam, 3.2 mm thick) clamped to the bottom of the tube. An AC coil driven by a swept sinusoidal chirp drives a magnet fastened to the underside center of the plate. A spectrum analyzer measures the accelerometer vibration amplitude vs. frequency. The resonant frequency decreases with increasing amplitude—representing softening in the nonlinear system. Experiments involving fixed amplitude resonant frequency vs. mass loading were performed.

### SPS07: 8-10 p.m. Particle Physics and Minecraft

*Poster – Amanda Depoian, Siena College, 515 Loudon Rd., Coram, NY 11727; al17depo@siena.edu*

*Michele McColgan, Siena College*

At Siena College, the physics department runs a program on Saturdays for inner city middle school students to come to campus and learn about science and the arts. A class was developed for middle school students to learn about particle physics. Hands-on activities, videos, and Minecraft worlds were developed where the students learned about quarks, the makeup of atoms, particle detectors, and particle accelerators. These activities along with the results of a pre- and post-test assessment that measures how well the students learned and retained about particle physics will be presented.

### SPS08: 8-10 p.m. Use of Facebook-like Instrument to Teach Photovoltaic Theory Under the Theoretical Framework of Instrumental Genesis

*Poster – Mario Humberto Ramirez Diaz, CICATA IPN Av. Legaria 694, Mexico, MEX 11500 Mexico; mramirezd@ipn.mx*

*Mario Rodriguez Castillo, CICATA-IPN*

Facebook is the most popular social network among college students. Its significance has transcended beyond its purpose to the point where is presumed to be able to support a learning environment for teaching physics. The purpose of this research was to investigate if Facebook offers a useful and meaningful educational environment able to support, enhance or strengthen the learning of physics in college students. The research will conduct an experiment in which observable throw achieve identify the concept of students about the use of Facebook as a virtual environment that facilitates learning of physics, identify instrumentative elements developed by students during the use of Facebook as a learning environment in the subject of photovoltaic theory, and identify the significant difference in learning of a group of 40 students in their first year of college. All this under the theoretical framework of Instrumental Genesis.

### SPS10: 8-10 p.m. Vibration Experiments: Clamped Elastic Plate with Edible Granular Material Loading

*Poster – Ebonie S. Smith, Department of Physics, U.S. Naval Academy, 572 C Holloway Road, Chauvenet Hall Room Ch295, Annapolis, MD 21402; korman@usna.edu*

*Blair E. Lewis, Murray S. Korman, U.S. Naval Academy*

A soil-plate oscillator (SPO), apparatus, studies flexural vibrations of a soil loaded acrylic plate (8 inch diam, 1/8 inch thick) clamped below a cylindrical tube supporting granular material. An accelerometer attached to a small magnet (below the plate) is used to detect the plate's vibration. The plate is driven from below by an AC coil using an amplified swept sinusoidal current. The accelerometer signal is measured vs. frequency using a spectrum analyzer. Experiments were performed with uncooked rice, instant oats, popcorn kernels, and pretzel gold fish. Resonant frequency decreases then increases with added granular media due to the material's stiffness.

### SPS11: 8-10 p.m. A Demonstration of Polarization Using a Mach-zehnder Interferometer

*Poster – Adam T. McKinley*, 120 Menlo Way, Chico, CA 95926; amckinley3@mail.csuchico.edu*

The Mach-Zehnder interferometer is a sensitive diagnostic and measurement instrument that makes it ideal for use to measure how temperature changes in gas affect the density and pressure of the gas, and variation of an objects index of refraction. It has additional practical applications in the classroom as a specialized interferometer that has a beam split into two beams with equal amplitude and later recombines before hitting a screen where an interference pattern is observed. However by adding a linear polarizing lens in the path of each beam changes the phase difference between the two respective beams and in turn changes the phase difference of the two beams causing different fringe pattern when observed on a screen and can cause the interference pattern to disappear; however with the use of a third polarizer placed at the output of the Mach-Zehnder interferometer the pattern can be made to reappear.

*Sponsored by Eric Ayars

### SPS12: 8-10 p.m. A Soil-Plate-Oscillator Apparatus for Research Projects and Student Demonstrations

*Poster – Melissa Pineda Brown, Department of Physics, U.S. Naval Academy, 572 C Holloway Road, Chauvenet Hall Room Ch295, Annapolis, MD 21402; korman@usna.edu*

*Brianna D. Taliaferro, Murray S. Korman, U.S. Naval Academy*

A model apparatus called the "soil-plate-oscillator" is useful in understanding resonant vibration behavior. It is an open column of granular medium supported by a circular clamped plate. A sleeve keeps the soil in the column. The plate is driven from below by a coil located below a magnet (underneath the plate). An amplified swept sinusoidal chirp drives the coil. An accelerometer signal is fed into a spectrum analyzer. Results for masonry sand and glass spheres are compared. Here, the resonant frequency vs. granular mass loading decreases, then increases with further loading due to granular flexural stiffness overcoming the loading effects.

### SPS13: 8-10 p.m. Analysis of the Effectiveness of Heat Exchangers on Backpacking Pots

*Poster – Jessalyn E. Ayars*, Chico High School, 1866 Lodge Pine Lane, Chico, CA 95926; jessalyn@ayars.org*

Is a backpacking pot with an attached heat exchanger worth the extra weight? After testing the efficiency of a common design it was found that the weight of fuel saved is greater than the weight of the heat exchanger if the trip is above a certain length. For shorter trips there was no advantage other than shorter cooking times.

*Sponsored by Eric Ayars

### SPS15: 8-10 p.m. Between Nature of the Things, Representations and Mathematical Object: The Case of the Scalar and Vector Fields

*Poster – Mario Ramirez Diaz, CICATA IPN Legaria 694, México City Mexico, MEX 11500 México; mramirezd@ipn.mx*

*Eduardo Chávez Lima, ESCOM-IPN*

*Miguel Olvera Aldana, ESCOM-IPN*

Considering physics like a general science, and thus isolating the individual sciences, we sometimes forget interpreting the phenomena by their representations available to the human being. If possible, we sometimes give an explanation of the nature of the "thing," -- to develop a mathematical model that gives formalizing but, How is geometric interpretation? How is described in the regular language? How was made the modeling of phenomena? A fundamental element is how to learn and link these three elements in a regular class, even more if we used it like a mediator tool the technology. In this proposal, we made proofs using an APP in a mobile device to integrate these three elements to teach and learn scalar and vector fields.

### SPS16: 8-10 p.m. Between the Nature of the Things, Representations and Mathematical Object: A Case Study, Scalar and Vector Fields

*Poster – Eduardo Chávez Lima, ESCOM-IPN Juan de Dios Batiz esq. Miguel Othón de Mendizabal Mexico, México; echavezl@ipn.mx*

*Miguel Olvera Aldana, ESCOM-IPN*

*Mario Ramírez Díaz, CICATA-IPN*

When considering physics like a general science with universal validity, and therefore isolating the idiographic sciences (or single sciences), we sometimes do not take on account interpreting of the phenomena by their representations affordable to human being. If it's possible, is given an explanation of the nature of the "thing," is built a mathematical model that formalizing it, but, how is interpreted geometrically? How is described the phenomena in regular language? How is the model made? And a fundamental element is How is it learned and linked thee three elements in class? Even more taking the technology like the mediator element in the learning. In this proposal we made proofs with an APP in a mobile device to integrate this three elements to teach Scalar and Vector fields, evaluating the conceptual gain with Hake's factor.

### SPS18: 8-10 p.m. Charged Particle Irradiation of Stainless Steel 316L

*Poster – Benjamin D. Hunt, Glenbrook North High School, 2300 Shermer Rd., Northbrook, IL 60062; bdhunt16@gmail.com*

*Alyssa N. Blumstein, Robert A. Grosulescu, Michael D. Zhang, Glenbrook North High School*

*Yaal G. Dryer*

Stainless Steel 316L (SST-316L) was irradiated in a charged particle beam, and analyzed using atomic force microscopy and scanning electron microscopy to compare surface defects to conventionally irradiated SST-316L nuclear cladding material. The density of these dislocations from the charged particle irradiated SST-316L were compared to that of the dislocation density of the traditionally irradiated cladding material. Analysis of these dislocations was the primary method used to compare the results of this process to the results of the test-reactor irradiation process.

### SPS19: 8-10 p.m. Cheap and Eye-Catching Demo of Young's Double Slit

*Poster – John Avallone, Math for America and Stuyvesant High School, 345 Chambers St., New York, NY 10282; john.avallone@gmail.com*

Many images that represent the double-slit interference phenomenon are opaque and indecipherable to those who do not already understand the concept. This extremely simply, hand-made device gives the teacher and the student a way to work through the problem and come to an understanding of the topic that goes beyond the equations and then makes the equations more sensible.

### SPS20: 8-10 p.m. Chemically Synthesized Nanostructures Based Solar Cell

*Poster – Gen Long, St. John's University, 8000 Utopia Pkwy., Jamaica, NY 11439-0001; longg@stjohns.edu*

*Michael Beattie, Kenneth Sabalo, Mostafa Sadoqi, St. John's University*

We fabricate heterojunction solar cell devices using chemically synthesized nanostructures such as nanoparticles and nanowires. The heterojunction solar cell was fabricated with home-made nanostructures, including chemically synthesized narrow gap, IV-VI group semiconductor nanoparticles (PbS or PbSe) of 3~6 nm diameter, wide gap semiconductors such as TiO2 nanoparticles (~20nm) or hydrothermally grown ZnO nanowires (of 500 nm~1 ?m length and 30~50 nm diameter), and gold nanoparticles (~5 nm to 50 nm), by spin-coating (~10cycles) onto FTO/ITO glasses, in ambient conditions (25C, 1atm). The synthesized nanostructures were characterized by XRD, UV-VIS-NIR spectrometer, SEM, AFM, TEM, solar simulator, etc. Nanostructures of variant sizes were integrated into the heterojunction devices to study the effects on photocurrent and solar cell performance. The sizes, lengths, thicknesses of nanostructures were studied. The effects of fabrication conditions (such as growth temperature, growth time, anneal temperature, ligand treatments, in air or in N2, etc.) on device performance were also studied. We have demonstrated that the heterojunction devices with a combination of wide gap and narrow gap semiconductor nanostructures can function for photovoltaic applications. The key challenges are to minimize the trap states and optimize the interface of nanostructures.

### SPS21: 8-10 p.m. Interference or Diffraction, Start from LED Decoration Film*

*Poster – Mingchen Sun, The true light middle school in Guangzhou No.17, Peizhen Road, Baihedong, Liwan District Guangzhou, GD 510275 China ,1273035372@qq.com*

*Botao Wei, The middle school attached to Sun Yat-sen University*

*Long Song Jingrui, education, Guangzhou*

Interference and diffraction are the two concepts in our high school physics course. In the course we have only the opportunity to discuss the Yang's double slit interference and Fresnel diffraction. But in our daily life these two concepts are often entangled together so that we cannot distinguish which play the main role. For example, from a series of LED decoration products called decoration film we cannot judge whether it originates from interference or diffraction. Such complicated behaviors motivate us to explore the interference behaviors and the diffraction ones. The talk will focus on the wave optics phenomena and give a step further analysis to various illumination patterns with Virtual Lab software as well as the short but clear principle deduction.

*Thank for the support of the outreach program from SPS Chapter of Sun Yat-sen University, China

### SPS22: 8-10 p.m. How to Make a Stone Skip More

*Poster – Xing Guo Chien-Shiung, Wu College, Southeast University, Southeast University, Jiulonghu campus NanJing, Jiangsu 211111 China; higuoxing@outlook.com*

*Zhiang Li Chien-Shiung, Zhihao Niu Chien-Shiung, Wu College, Southeast University*

It is generally known that the stone with a correct incidence angle and an accurate velocity could bounce many times on water. Previous works mainly focus on how to make a flat stone skip more times on water. In this paper, we investigate a new type stone with a curved bottom which can bounce more times and can be more robust during its collision. Analytical model for the motion of the stone is presented. Experiments are conducted at the same time by using an effective stone skipping facility. The minimum skipping velocity indicating the efficiency of a stone is measured by this experiment setup. With the help of this experiment setup, the best stone for skipping on water can be found.

### SPS23: 8-10 p.m. Classroom Tools – Vpython

*Poster – Zakary T. Noel,* Lee College, SPS 5005, Tamarach Drive Baytown, TX 77521; zaktnoel@aol.com*

Making use of modern computing techniques, members of Lee College SPS (newly formed in early 2016) have been working to expand the usability of the programming language Vpython in order to introduce a new type of lab environment to the physics classroom. Vpython is an easy to learn 3D programing tool that bridges principal building blocks of physics together such as calculations, vectors, 3-dimensional space, and derived behaviors. Efforts of the Lee College SPS center on incorporating visual and interactive aids into the program that can be used to better understand how the simple mathematics and relationships coded by students work together to simulate real physical systems. Some applicable subjects include kinematics, electricity and magnetism, waves, and relativity.

*Sponsored by Tom O'Kuma, Lee College

### SPS24: 8-10 p.m. Mechanical Response of Figure-Eight Knots as Physical Parameters Change

*Poster – Shazhiyuan Li Chien-Shiung, Wu College, Southeast University, No.2 Dongnandaxue Road, Jiangning Development Zone,Nanjing 211111,P.R.China Nanjing, Jiangsu 211111 China; 915560950@qq.com*

*Junhong Chen Chien-Shiung, Qi Gu Chien-Shiung, Wu College, Southeast University*

Previous works indicate that the equilibrium shape of the knot is governed by interaction of topology, friction, and bending. We propose a new experiment to study the mechanics of figure-eight knots. Our experiments discover the regularity of the pulling force in response to the increase of crossing numbers and our results do not coincide with former theory of crossing numbers. Our results show universality of many kinds of materials. Different from overhand knots, the figure-eight knots have a new type of mechanical response as the physical and topological parameters change.

### SPS25: 8-10 p.m. Mechanical Analysis of the Falling Chimney

*Poster – Zhiang Li, No.2 Dongnandaxue Road, Jiangning Development Zone Nanjing, Jiangsu 211189 China Chee-Uh_Lee@outlook.com*

*Xing Guo Chien-Shiung, Zhihao Niu Chien-Shiung Wu College, Southeast University*

It is generally known that chimneys might break at a certain place before they hit the ground during a demolition blasting. However, previous models have assumed that the mass distribution of the chimney is uniform. The chimney model analyzed in this paper is a more realistic one with non-uniform mass distribution. Furthermore, clay miniatures are used to reproduce the falling process of a chimney. The experiment result is in good agreement with our outlined theory.

### SPS26: 8-10 p.m. Compact Model Solutions for HfO2-based RRAM Including Random Telegraph Noise

*Poster – Bochen Guan, Sun Yat-sen University, No. 135, Xingang Xi Road Guangzhou, 510275 China; guanboch@mail2.sysu.edu.cn*

*Jing Li, University of Wisconsin, Madison*

Read instability in resistive random access memory (RRAM) devices, mainly caused by random telegraph noise (RTN), needs to be fully addressed before its wide commercial adoption. To fulfill the increasing need for circuit level reliability study, it is desirable to develop a compact model to account for RTN effect. In prior art, several analytical compact models have been developed to simulate resistive switching behavior [2]. However, none of them are capable of capturing current fluctuation caused by RTN. In this paper, we develop a RRAM compact model for circuit simulation, which for the first time takes into account the RTN effect. The model is validated using different sets of experimental data. Our simulation fits well with measurements both in high resistance state (HRS) and low resistance state (LRS).

### SPS27: 8-10 p.m. Undergraduate Research on Paint-based Organic Solar Cells

*Poster – Kausiksankar Das, University of Maryland Eastern Shore, Princess Anne, MD 21853-1299 kdas@umes.edu*

*Benjamin Barnes, University of Maryland Eastern Shore*

In this work, a range of dye-sensitized solar cells (DSSCs) were made from anthocyanin-containing biological pigments, synthetic dyes and perovskite materials. The results and efficiency are compared under various solar illumination conditions. Almost 70% of global energy produced is derived from fossil fuel materials such as coal and oil. The transportation and combustion of coal releases a range of harmful agents such as sulfur and nitrogen oxides as well as carbon nanoparticles. Moreover, carbon emission from the combustion process leads to global warming and climate change. Because of these non-ideal properties, new energy generating technologies have lately been the center of much research. The focus of this research has been on reducing the production costs while simultaneously increasing power conversion efficiency of emerging technologies to a level competitive with fossil fuels. One of the many successful technologies to emerge from this research are high performance solar cells constructed from novel materials. Unfortunately, the power conversion efficiency of established types of solar cells has plateaued while costs continue to rise due to natural resource demand. In response to this, two new generations of solar cells have emerged recently: dye-sensitized solar cells (DSSCs) constructed from inexpensive semiconductor material and readily available organic dyes, and perovskite solar cells made from Earth-abundant minerals. This work investigates the relative efficiency of DSSCs constructed with a variety of biological, synthetic dye based, and perovskite solar cells.

### SPS28: 8-10 p.m. Designing and Building a Motorized Gimbal for Space Debris Research

*Poster – Miles Moser,* Drury University, 729 N Drury Lane, Springfield, MO 65802; mmoser@drury.edu*

*Greg Ojakangas*

Space debris is a growing global threat to space and telecommunications industries. Medium to large pieces of space debris are difficult to analyze because they have complex rotational properties. On top of that, they're small and fast, making them hard to see. Our device is a motorized, three-axis gimbal system that can simulate any rotational state through the use of a PID controller, and our project is to suspend actual debris collected from space in the center of the three rings and collect reflection data as it rotates. This will enable us to develop a catalog of light reflection patterns corresponding to different orientations, so ambiguous light patterns observed in a telescope can be associated with distinct rotational states. We built the first prototype of the robot and developed a working PID system to control velocity or position this spring, and will start collecting reflection data in the fall.

*Sponsored by Brant E. Hinrichs

# Monday, July 18 Highlights

**Spin Class**
6:45–7:45 a.m.
Sheraton - Compagno

**First Timers' Breakfast**
7–8:30 a.m.
Sheraton - Tofanelli

**Exhibit Hall Open**
10 a.m.–5 p.m.
CC Exhibit Hall D

**Exhibit Hall Amazon Tap Raffle**
10:20 a.m.

**Spouse/Guest Gathering**
9–10 a.m.
Sheraton - Falor

**AWARDS – Teaching Awards and DSCs**
10:30 a.m.–12 p.m.,
Sheraton - Magnolia/Camellia

**High School Teachers Day Luncheon**
12–1:30 p.m., CC - 103

**Early Career Professional Speed Networking**
12–1:30 p.m., Sheraton - Bataglieri

**Free Commercial Workshops**
CW01: **PASCO**: Smart Cart Workshop
12–1 p.m. – CC - 309

CW02: **PASCO**: Capstone Workshop
1:30–2:30 p.m. – CC - 309

CW04: **WebAssign:** Code Your Own Questions in WebAssign
12–1 p.m. – CC - 302/303

CW06: **Expert TA:** Realigning Homework Grades and Test Scores in the Modern Classroom
12–1 p.m. – CC - 307

CW07: **Perimeter Institute:** Physics in the News
12–1:30 p.m., 2:30–4 p.m. – CC - 316

**High School Teacher Lounge**
1:30–3:30 p.m.; 4–6 p.m.
Sheraton - Falor

**Committees, 7–8:30 a.m.**

| | |
|---|---|
| Interests of Senior Physicists | Bondi |
| Undergraduate Education | CC - 302/303 |
| Teacher Preparation | Beavis |
| Women in Physics | CC - 309 |

**Exhibit Hall SportShot Camera Raffle**
3:50 p.m., Exhibit Hall D

**Committees, 6:15–7:30 p.m.**

| | |
|---|---|
| Educationational Technologies | CC - 301 |
| Science Educ. for Public | CC - 310 |
| Physics in High Schools | CC - 313 |
| Diversity in Physics | Bondi |
| Modern Physics | Beavis |

**AWARDS – Klopsteg Memorial Lecture Award**
7:30–8:30 p.m., **Margaret Wertheim**
Sheraton - Magnolia/Camellia

**High School Share-a-thon**
8:30–10 p.m., CC - 313

## Session AA: Progress in Pedagogy for Introductory Physics for Life Science

**Location:** CC - Room 306
**Sponsor:** Committee on Research in Physics Education
**Co-Sponsor:** Committee on Physics in Undergraduate Education
**Date:** Monday, July 18
**Time:** 8:30–9:50 a.m.

*Presider: Nancy Beverly*

### AA01: 8:30-8:40 a.m. Impact of Mindset and Awareness on Life Sciences Students

*Contributed – Claudia De Grandi, Yale University, Dept. of Physics, P.O. Box 208120, New Haven, CT 06520; claudia.degrandi@yale.edu*

*Simon Mochrie, Rona Ramos, Yale University*

We analyze the impact of different pedagogical interventions in a two-semester sequence of an introductory physics course for the Life Sciences. The course has been taught in two parallel sections: one in a TEAL classroom (a technologically innovative classroom where students sit at round tables of 8-10 people) and one in a traditional lecture hall. Performance and attitude in the two classrooms are compared. Motivation and awareness of personal learning were prompted by reflections on: mindset (fixed versus growth) and consequences of multitasking, by additionally banning the use of laptops and cell phones in class. Students were also offered optional choices such as: sharing weekly anonymous feedback on the class and lectures, and resubmitting revisions of their midterm exams in order to gain partial credits on missed points. We'll discuss students' responses to these different class variables and highlight the successes and failures towards increasing engagement and performance.

### AA02: 8:40-8:50 a.m. The Source of Student Engagement in IPLS

*Contributed – Benjamin Geller, Swarthmore College, 500 College Ave., Swarthmore, PA 19081; bgeller1@swarthmore.edu*

*Chandra Turpen, University of Maryland, College Park*

*Catherine Crouch, Swarthmore College*

Effectively teaching an Introductory Physics for the Life Sciences (IPLS) course means engaging life science students in a subject matter for which they may not have considerable preexisting interest. While we have found that the inclusion of topical examples of relevance to life-science students can help to engage students whose initial interest in physics is less developed, we have found that the inclusion of biological content is just one of several dimensions supporting student engagement in IPLS. When describing what is salient to them about their IPLS experiences, students are just as quick to cite particular pedagogical structures and supports as they are to cite issues relating directly to content choices. In this talk we begin to unpack this complex interplay of content and pedagogy in fostering student engagement in the IPLS classroom. We also describe the role that explicit messaging around disciplinary coherence may play in students' experiences.

### AA03: 8:50-9 a.m. NEXUS/Physics: Open-ended Design and Peer Review in IPLS*

*Contributed – Kimberly A. Moore, University of Maryland, 6525 Roosevelt St., Falls Church, VA 22043; MoorePhysics@gmail.com*

UMd-PERG's NEXUS/Physics for Life Sciences laboratory curriculum, piloted in 2012-2013 in small test classes, has been implemented in large-enrollment environments at UMD in 2013-present, and adopted at several institutions beginning in 2014. These labs address physical issues at biological scales using microscopy, image and video analysis, electrophoresis, and spectroscopy in an open, non-protocol-driven environment. In the 2015-16 iteration, we have added peer review elements to the second semester course. We have collected a wealth of data (surveys, video analysis, etc.) that enables us to get a sense of the students' responses to this curriculum at UMD. In this talk, we will provide a brief overview of what we have learned and a discussion of the challenges in integrating simultaneous interdisciplinary and pedagogical reforms.

*This work is supported by funding from HHMI and the NSF.

### AA04: 9-9:10 a.m. Incorporating Research-based, Biologically Authentic Physics Problems in IPLS

*Contributed – Deborah Hemingway, University of Maryland, College Park, 1322 John S. Toll Physics Building, College Park, MD 20742-2421; deb.hemingway@gmail.com*

*Wolfgang Losert, Edward F. Redish, University of Maryland, College Park*

Prior research has shown that when life-science students perceive physics problems as providing authentic insight into biological phenomena, they achieve more expert-like ways of knowing in physics. This work discusses the incorporation of biologically authentic, research-based physics problems into a reformed introductory physics for the life sciences course (IPLS) that is part of the National Experiment in Undergraduate Education (NEXUS/Physics) at the University of Maryland, College Park (UMD). The problem set combines an ongoing collaborative research project between labs at UMD and the National Institutes of Health (NIH) that examines the biophysical properties of collective cell migration with modern biophysical research methods. More specifically, this work focuses on the determination of cellular biomechanical properties during micropipette aspiration and the application of mathematical modeling in the posterior lateral line primordium migration during the embryonic development of danio rerio.

### AA05: 9:10-9:20 a.m. Incorporating Student Ideas and Interests

*Contributed – Brian Jones, Colorado State University, Physics Department, 1875, Fort Collins, CO 80523; brian.jones@colostate.edu*

The General Physics course at Colorado State University is largely populated by students in the life sciences. Most of these students are juniors and seniors with a wealth of background in the fields whose content we seek to integrate. We have started holding regular sessions with students to brainstorm possible topic areas for lecture and lab exercises. This has provided pedagogical benefits that go far beyond the identification and development of topic areas and has provided ideas for new strategies for the course.

### AA06: 9:20-9:30 a.m. Student Self-Assessment of Learning Outcomes in the IPLS Course

*Contributed – Nancy Beverly, Mercy College, 555 Broadway, Dobbs Ferry, NY 10522; nbeverly@mercy.edu*

The students enrolled in the Physics for Life Science course sequence at Mercy College consist primarily of those preparing for futures in medicine or other health fields. Learning outcomes for this course were chosen to align with the physics competencies most supportive of the health professions. To improve student competence in these areas and to reorient their mind-set away from grades and towards learning itself, assignment rubrics aligned to the learning outcomes were used, and the course grade is now largely dependent on achievement of these learning outcomes. This year, to help students focus on these learning skills and monitor their own progress, assignment self-assessment checklists, also aligned with the course learning outcomes, were required with submission of each major assignment. An analysis is ongoing comparing the competencies displayed in the semester-long student projects this year and the previous two years.

### AA07: 9:30-9:40 a.m. Teach Poiseuille First: Call for a Fluid Dynamics Paradigm Shift

*Contributed – Bradley S. Moser, University of New England, 11 Hills Beach Rd., Biddeford, ME 04005-9988; bmoser@une.edu*

*James Vesenka; University of New England*

Blood pressure rises in arterial expansions and airplanes lift due to the Bernoulli principle; so states the standard approach to fluid flow in textbooks and lesson plans. These promote Bernoulli first, then Poiseuille's law second (if at all). Yet it is known that lift is a complex phenomenon, invoking multiple conservation principles. Detailed study of the human circulatory system shows that blood pressure steadily drops as blood flows through the system. Regretfully, the two approaches to fluid dynamics are kept entirely separate: either Bernoulli applies (often misapplied) OR Poiseuille. In this talk, the presenter will review the growing evidence against pure Bernoulli descriptions and discuss contradictory results from a circulatory system model we developed,[1] which support a Poiseuille first approach to teaching fluid dynamics. The growing emphasis on life science applications heightens the need to shift focus toward more realistic viscous and turbulent fluid properties.

1. http://dx.doi.org/10.1119/perc.2015.pr.085

### AA08: 9:40-9:50 a.m. A New IPLS Course: From Design to Dissemination*

*Contributed – Alice D. Churukian, The University of North Carolina at Chapel Hill, Department of Physics and Astronomy, Chapel Hill, NC 27517; adchuruk@physics.unc.edu*

*Duane L. Deardorff, David P. Smith, Colin S. Wallace, Laurie E. McNeil, The University of North Carolina at Chapel Hill*

At the University of North Carolina at Chapel Hill, we have finished the complete transformation of our large-enrollment two-course sequence of introductory physics for life science majors. Both courses are now taught in the integrated lecture/studio format and use biological phenomena to motivate the physics. Across both courses, we have created a suite of 54 active-engagement modules, each consisting of studio activities, an interactive lecture, and assessment questions, all of which have been developed using the findings and best practices from PER. This suite includes materials for many topics that are important for life science majors, but are not part of the traditional introductory physics curriculum, including stress and strain, diffusion, chemical energy, and life at low Reynolds numbers. In this talk, we will provide an overview of what these two courses now look like, how we implement our curricula, the challenges we overcame during the development process, and our plans for dissemination. *This work is partially funded by NSF DUE-1323008 and AAU Undergraduate STEM Education Initiative

*This work is partially funded by NSF DUE-1323008 and AAU Undergraduate STEM Education Initiative

## Session AB: Frontiers in Astronomy

**Location:** CC – Room 307
**Sponsor:** Committee on Space Science and Astronomy
**Date:** Monday, July 18
**Time:** 8:30-9:30 a.m.

*Presider: Tim Slater*

### AB01: 8:30-9 a.m. Discovering Cosmic Simplicity: The 350-year Journey to the Standard Cosmological Model

*Invited – Lloyd E. Knox,* UC Davis, One Shields Ave., Davis, CA 95616; lknox@ucdavis.edu*

Starting from Newton's discovery of universal gravitation, through Einstein's discovery of general relativity, and on to the latest results from cosmological surveys, I will tell a story of how we came to our current understanding of the cosmos and its origins. The story emphasizes the remarkable simplicity and universality of natural laws, and the extraordinary power of human thought, experimentation, and observation to reveal them.

*Sponsored by Tim Slater

### AB02: 9-9:30 a.m. Dark Matter in Galaxy Clusters: Past, Present, and Future

*Invited – David Wittman, University of California, Davis, Physics 529, One Shields Ave., Davis, CA 95616-5270; dwittman@physics.ucdavis.edu*

Dark matter makes a wonderful case study in the nature of science. What should astronomers do when they see orbits that apparently conflict with the known law of gravity? Two competing explanations always arise: dark matter (unseen mass influencing the orbit according to the known law of gravity) and modified gravity. I will briefly review two historical examples—one in which dark matter turned out to be the correct explanation and one in which modified gravity turned out to be correct—to set the stage for the modern conception of dark matter. Turning to the present, I will explain how merging clusters of galaxies prove the case for dark matter despite its apparently extravagant violation of Occam's razor. Looking to the future, I will show how the latest observations of merging clusters could tell us something surprising about dark matter.



## Session AC: Effective Practices in Educational Technologies

**Location:** CC – Room 308
**Sponsor:** Committee on Educational Technologies
**Date:** Monday, July 18
**Time:** 8:30-10 a.m.

*Presider: Andy Gavrin*

### AC01: 8:30-8:40 a.m. Vignette Studio Software for Interactive Online Teaching*

*Contributed – Robert B. Teese, Rochester Institute of Technology, 54 Lomb Dr., Rochester, NY 14623; rbtsps@rit.edu*

*Thomas J. Reichlmayr, Rochester Institute of Technology*

Vignette Studio is a cross-platform application for creating online activities that contain narrative videos as well as interactive elements such as video analysis, prediction questions and branching. It is being used to develop assignments for introductory physics, advanced physics labs and introductory biology. The software that powers the activities is delivered over the Internet and runs in a normal browser on the user's device. It can be used to make short, single-topic Interactive Video Vignettes, pre-lab exercises, or Interactive Online Lectures for flipped classrooms, online learning and MOOCs. New features added in the past year include text, checkbox, and data table inputs, menus, completion certificates, multi-language closed captioning and bar graphs. The software will be demonstrated and plans for its future development will be described. Vignette Studio is available for download at http://compadre.org/ivv/ .

*Supported by NSF grants DUE 1432286, 1245147, 1122828 and 1123118.

### AC02: 8:40-8:50 a.m. An Interactive Video Vignette on Fall Rates for Different Masses

*Contributed – Priscilla W. Laws, Dickinson College, 28 North College St.,Carlisle, PA 17013; lawsp@dickinson.edu*

*Patrick J. Cooney, Millersville University*

*David P. Jackson, Dickinson College*

Several years ago members of the LivePhoto Physics Group received collaborative NSF grants* to create short, single-topic, online activities that invite introductory physics students to make and test individual predictions about a phenomenon though video observations or analysis. Each Interactive Video Vignette is designed for web delivery as: (1) an ungraded homework assignment or (2) an exercise to prepare for a class or tutorial session. Sample IVVs are available at the ComPADRE website http://www.compadre.org/ivv/. A new vignette on free fall made at Dickinson College using Vignette Studio software will be presented. Using normal and high-speed videos, this vignette is designed to help students understand that both light and massive objects fall with the same acceleration. Finally, research on the impact of some of our vignettes on student learning will be discussed.

*NSF #1122828 (Dickinson College) & NSF #1123118 (Rochester Institute of Technology)

### AC03: 8:50-9 a.m. Creating Learning Communities with Web Technology in Professional Development Programs

*Contributed – Andrew W. Dougherty, The Ohio State University, 191 West Woodruff Ave.,Columbus, OH 43210-1117; dougherty.63@osu.edu*

*Bruce R. Patton, The Ohio State University*

The School Year Based Inquiry Learning Program (SYBIL) is a large Mathematics and Science Partnership (MSP) Program that works with a number of school districts throughout central Ohio. K-12 teachers participate in a year-long professional development program that uses active inquiry-based learning to improve participant teacher and student science and math content gains. Teachers incorporate inquiry methods into their classrooms, and development inquiry-based lesson modules with accompanying pre/post formative assessments. SYBIL staff support teachers throughout the process and maintain contact with the teachers in subsequent school years, in order to further the incorporation if inquiry techniques into as many classrooms as possible. In order to maximize contact with participants, and to foster a learning community among participant teachers spread throughout many buildings and districts, SYBIL has begun leveraging web technologies to improve communication and access to inquiry materials. A brief summary of capabilities useful for a PD program is presented.

### AC04: 9-9:10 a.m. Lab Away From Lab: The IOLab's Potential for Avoiding the Space and Equipment Constraints of the Traditional General Physics Lab

*Contributed – Stephen Mecca, Providence College, Dept. of Engineering-Physics-Systems, 1 Cunningham Square, Providence, RI 02908; smecca@providence.edu*

*Seth Ashman, Nicole Boyd, Kerry McIntyr, Providence College*

Commercial and open-source multi-sensor instruments have become common in the marketplace. Some of these, for example the basic tablet or smartphone, can be inexpensive but may lack features such as adequate sample rates for basic motion experiments. Commercial products from PASCO and Vernier are being introduced with Bluetooth capability allowing a laptop, tablet or hybrid logger to acquire data wirelessly. These products and the open-source IOLab device offer the opportunity to accomplish particular lessons of the general physics laboratory without the need for a physical laboratory and without an expensive inventory of lab equipment. This paper presents the authors' use of the IOLAB with a minimal set of additional components to replicate or slightly modify the existing General Physics laboratory exercises in our two semester sequence in the Department of Engineering-Physics-Systems at Providence College. The potential of this approach to laboratory instruction in traditional laboratory curricula, for distance learning or for resource constrained environments, such as rural schools in the developing world is discussed.

### AC05: 9:10-9:20 a.m. Update on the Development of Distance Learning Labs for Introductory Physics Using IOLab

*Contributed – David R. Sokoloff, University of Oregon and Portland State University, Department of Physics, Eugene, OR 97403-1274; sokoloff@uoregon.edu*

*Erik Bodegom, Portland State University*

*Erik Jensen, Chemeketa Community College*

In January, we presented a preliminary report on our project to develop and research the effectiveness of distance learning (DL) introductory laboratories based on the IOLab, a versatile, relatively inexpensive data acquisition device developed by Mats Selen and his colleagues at University of Illinois (2). With a cost of around $100, students can purchase their own individual IOLab, and can—in theory—use it to do hands-on laboratory experiments at home. The labs we have developed for IOLab are based on RealTime Physics (3), (4). Thus far, testing of these labs has been done in supervised laboratory environments at Portland State University and Chemeketa Community College, with research on conceptual learning and student attitudes carried out using the FMCE (5) and ECLASS (6), respectively. We will report on these preliminary results, and how they have guided us in our first round of testing the labs in a DL environment that is taking place at Chemeketa this Summer.

(1) Funded under NSF DUE – 1505086, July 1, 2015-June 30, 2017. (2) See http://www.iolab.science/ (3) David R. Sokoloff, Ronald K. Thornton and Priscilla W. Laws, "RealTime Physics: Active Learning Labs Transforming the Introductory Laboratory," Eur. J. of Phys. 28 (2007), S83-S94. (4) David R. Sokoloff, Ronald K. Thornton and Priscilla W. Laws, RealTime Physics: Active Learning Laboratories, Module 1: Mechanics, 3rd Edition (Hoboken, NJ, John Wiley and Sons, 2011). (5) Ronald K. Thornton and David R. Sokoloff, "Assessing student learning of Newton's laws: The Force and Motion Conceptual Evaluation and the Evaluation of Active Learning Laboratory and Lecture Curricula", Am. J. Phys.: 66, 338-352 (1998) (6) See http://www.colorado.edu/sei/departments/phys-advlab-eclass.htm

### AC06: 9:20-9:30 a.m. Exploring JITT with Traditional Classroom and Modern Technologies

*Contributed – Gen Long, St John's University, 8000 Utopia Pkwy., Jamaica, NY 11439-0001; longg@stjohns.edu*

*Mostafa Sadoqi, Huizhong Xu, St. John's University*

In this presentation, we report an ongoing exploring study of adopting Just In Time Teaching in a classroom with heavy traditional setting while adopting modern technologies to help students learn whenever they see fit. By requiring students to preview and review lectures content on their own, as well as providing lecture videos online so that they can access them whenever needed, we found that the average grades of the class are improved.

### AC07: 9:30-9:40 a.m. Investigating Students' Usage Pattern of Web-based Computer Coaches

*Contributed – Bijaya Aryal, University of Minnesota Rochester, 111 S. Broadway, Suite 300, Rochester, MN 55904; baryal@r.umn.edu*

This presentation describes introductory level physics students' usage patterns of web-based Computer Coaches for physics problem solving. Nineteen students volunteered to participate in this study. Each student interacted with the Coaches individually, followed by semi-structured clinical interviews. Three patterns of usage ('clickers', 'reflectors', and 'optimizers') were identified by analysis of the interview data. Data analysis also revealed that students' difficulties interacting with the Coaches negatively impacted student learning of physics problem solving. Results of this study indicate the importance of adjusting Coaches' interactions for optimal task time and rigor for maintaining student engagement in order to improve educational impact of the tool. This study found a qualitative relationship between students' usage pattern and their problem solving and educational performance in physics. Moreover, it demonstrates strong links between the time spent in different parts of a problem solving task and student motivation to use the Coach.

### AC08: 9:40-9:50 a.m. Let's Code Physics: A Playful Approach to Learning Computational Physics

*Contributed – W. Brian Lane, Jacksonville University, 2800 University Blvd., North Jacksonville, FL 32211; wlane@ju.edu*

Let's Code Physics is a YouTube channel that examines physics-related scenarios using computational modeling. Following the popular Let's Play format (in which a video gamer records their progress through a game while providing commentary, thereby offering both entertainment and insights to the viewer), these Let's Code videos record the development and implementation of a computational model (the code for which is made available so the viewer may "play along") while offering commentary on the planning and revision of the code and an analysis of the results. The goals of Let's Code Physics include spreading interest in computational physics, demonstrating successful coding practices, sharing ideas with viewers, and reducing the perception of dry formality of programming. Let's Code Physics has proven popular (with 640 subscribers in 70 countries at the start of its second season), particularly among Let's Play fans and physics students.

### AC09: 9:50-10 a.m. Model Making and Model Breaking with Direct Measurement Video

*Contributed – Peter H. Bohacek, Direct Measurement Video Project, 1897 Delaware Ave., Mendota Heights, MN 55118; peter.bohacek@isd197.org*

*Matt Vonk, University of Wisconsin, River Falls*

Curriculum based on direct measurement videos (DMVs) can be used to teach model making and model breaking skills. We define model making as the ability to determine a mathematical pattern in a data set measured from a physical phenomenon. This skill set includes experimental design, measurement, graphing data, curve fitting, and using mathematical relationships to make and test predictions. Model breaking is defined as the ability to determine whether a known mathematical model accurately describes a specific scenario. Our 160-student study shows evidence that students who use DMV-based curriculum to learn these skills show increased mastery compared to students who do not. We'll also provide updates on new videos and our upgraded web app.

## Session AD: Two Year Colleges

**Location:** CC – Room 301
**Sponsor:** AAPT
**Date:** Monday, July 18
**Time:** 8:30–9:20 a.m.

*Presider: Julia Olsen*

### AD01: 8:30-8:40 a.m. Successful STEM Student Pathways: A Two- and Four-year Partnership*

*Contributed – Charles J. DeLeone, California State University, San Marcos, Physics Dept., San Marcos, CA 92096-0001; cdeleone@csusm.edu*

*Debbie DeRoma, Edward Price, California State University, San Marcos*

*Daniel Sourbeer, Palomar College*

*Chandra Turpen, University of Maryland, College Park*

Many geographically related two- and four-year institutions share a large percentage of their students. However, most two- and four- year institutions have weak STEM-specific linkages between the institutions despite the benefits of such linkages to the students. We have been engaged in a multi-year effort to strengthen the partnership between STEM programs at two regional institutions, California State University, San Marcos, and Palomar College, with the goal of creating more coherent STEM pathways for students. This talk will focus on how the partnership has improved outcomes for students, including increases in the number of two-year students prepared in STEM domains, number of transfers, and the success of transfers within CSUSM STEM programs. An associated poster will provide more detail on the processes that brought about this change.

*Supported in part by NSF-DUE#1068477

### AD02: 8:40-8:50 a.m. Assessing a Course Text Book

*Contributed – Heidi Wainscott, United States Air Force Academy, 2354 Fairchild Drive, Suite 2A31, USAF Academy, CO 80840; heidi.wainscott@usafa.edu*

At the university where I teach we reevaluate our course text about every five years to make sure that it is meeting the needs of both the students and instructors. I will walk you through our most recent review of several standard introductory physics texts. The discussion will cover; our review criteria, the scope of the review, how we involved both students and faculty in the review, and our results. If you are considering a new course text, our recent work in this area may be of use to you.

### AD03: 8:50-9 a.m. New York Times Automotive Article Applications that Help Teach Physics

*Contributed – John P. Cise, Austin Community College, 1212 Rio*

Grande St. Austin, TX 78701; jpcise@aol.com

Since 2007 I have been using New York Times articles with physics applications to help teach physics. The New York Times has many sections (Sports, Automotive, Science, Space, Astronomy, etc.) with articles containing physics applications. Articles & related graphics are placed in WORD then edited to fit on one web page. More graphics are added. Also added are: Introduction, questions, hints, and answers. The one page WORD document is saved as a pdf file and uploaded to the authors N Y Times application site. About 800 physics applications can be found at: http://CisePhysics.homestead.com/files/NYTCisePhysics.pdf . The site specific to this paper on "NY Times Automotive Article Applications which Help Teach Physics" is: http://CisePhysics.homestead.com/files/NYTAuto.pdf. The author uses the N Y Times Applications for: Introduction to new concepts, quizzes, extra credit, and test questions. Students and author enjoy these current physics news applications.



### AD04: 9-9:10 a.m. Definition of Physics in Introductory Physics Classes

*Contributed – Genrikh Golin, Touro College, New York, 448 Neptune Ave. #15K, Brooklyn, NY 11224; Genrikhgolin@yahoo.com*

The following is a summary of the introductory lecture "What Is Physics?" This is how we generally start a physics course. This topic can be used also as the concluding lecture. Indeed, physics is the study of matter moving in space and time. Scientists still hold seven forms of matter movement, and physics as science (and a course) is splitting into seven branches. Physicists today study three worlds: macro-, micro-, and mega- worlds. All three kinds of objects move differently, are defined by different laws and theories, and are discovered at different times. In the presentation we will construct a table including forms of motion and the corresponding branches of physics. Traditionally, the first three branches of physics are called classical physics. Optics belongs both to classical physics and modern physics, the last three branches belong to modern physics.

### AD05: 9:10-9:20 a.m. An Easy Determination of an Approximate Value for Absolute Zero

*Contributed – A. James Mallmann, Milwaukee School of Engineering, 20250 W Jeffers Drive, New Berlin, WI 53146-2522; mallmann@msoe.edu*

A method to determine an approximately accurate value for absolute zero will be described. The needed data can be easily obtained using simple, inexpensive apparatus, and the value for absolute zero can be determined without doing any calculations or using any equations.

## Session AE: PER: Examining Content Understanding and Reasoning – B

**Location:** CC – Room 314
**Sponsor:** Committee on Research in Physics Education
**Date:** Monday, July 18
**Time:** 8:30–10 a.m.

*Presider: Deborah Hemingway*

### AE01: 8:30-8:40 a.m. Comparing Two Activities' Effectiveness Improving Reasoning with Multiple-Variable Graphed Information

*Contributed – Rebecca J. Rosenblatt, Illinois State University, 218 Willard Ave., Bloomington, IL 61701; rosenblatt.rebecca@gmail.com*

*James Peronne, Illinois State University*

Past findings show large differences in student ability to use, and reason with, certain graphed data. Namely, many students incorrectly assume there must be dependence between the axes of any graph whether or not the data suggests a relation and whether or not a controlled experiment was done. In addition, students have similar difficulties reasoning with multivariable data displayed on a graph in multiple trend-lines. A majority of the errors made are consistent with a failure to properly control variables and/or reasoning illogically about the data. We developed and pilot tested two different one-hour group work activities to improve student understanding. One activity was laboratory based and focused on control of variables and experimentation. The other was recitation based and focused on logical reasoning and data manipulation. Results show the relative effectiveness of the activities and suggest interesting facts about the importance of logical reasoning vs. control of variables when working with graphed data.

### AE02: 8:40-8:50 a.m. Construction and Interpretation of Linear Best-fit Graphs in Introductory Labs

*Contributed – Craig C. Wiegert, University of Georgia, Department of Physics and Astronomy, Athens, GA 30602-2451; wiegert@physast.uga.edu*

*Ryan S. Nixon, Brigham Young University*

*T.J. Godfrey, Nicholas T. Mayhew, University of Georgia*

Instructional labs are an important element of undergraduate introductory physics. Many lab activities require students to construct graphs of their data and interpret their results, connecting their lab experience to underlying physics concepts. We investigated students' construction and interpretation of linear best-fit graphs in the context of two lab activities. Students' graphs were evaluated for overall quality as well as for the quality of the best-fit line. We then interviewed students to determine the strategies used in graph construction and fitting, and to assess student understanding of the meaning of the graph. Our results indicate that undergraduate introductory physics students can successfully construct best-fit linear graphs while struggling to interpret graphs according to the physical concept under investigation. Furthermore we found, perhaps surprisingly, that the most challenging aspect of graph construction for students was establishing a correct and useful scale.

### AE03: 8:50-9 a.m. Developing Metacognitive Knowledge About Productive Reflection on Salient Distracting Features*

*Contributed – Thanh K. Le, University of Maine, 120 Bennett Hall, Orono, ME 04469; thanh.le@maine.edu*

*Jonathan T. Shemwell, MacKenzie R. Stetzer, University of Maine*

When students work on physics problems, certain problem features may cue specific lines of reasoning. In particular, salient distracting features (SDFs) are surface, situational, or contextual features of a problem that frequently cue incorrect lines of reasoning and inhibit the exploration of more productive reasoning approaches. A potential approach for addressing SDF-related reasoning difficulties is to target and enhance student metacognition. In the second semester of the calculus-based introductory physics sequence at the University of Maine, we developed and administered a flexible, web-based instructional intervention designed to help students construct metacognitive knowledge about productive reflection on the role of SDFs in influencing reasoning. In the intervention, students are asked to synthesize contrasting cases in which hypothetical students reflect upon physics problems containing SDFs. Preliminary data and emerging findings will be presented.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1245313 and DUE-0962805.

### AE04: 9-9:10 a.m. Sense-making with Inscriptions in Quantum Mechanics*

*Contributed – Erin Ronayne Sohr, University of Maryland, College Park, Rm 1322, Physics Building, College Park, MD 20742; erinsohr@gmail.com*

*Benjamin W. Dreyfus, Ayush Gupta, Adrew Elby, University of Maryland College Park*

In this presentation, we focus on students' sense-making with a graphical representation commonly used in quantum mechanics textbooks; that of overlaid potential energy and wavefunction plots in the context of quantum well(s) and barriers. Previous research has pointed to a conflation of the energy and wavefunction axes as leading to common student difficulties in understanding phenomena such as tunneling. The existence of this difficulty has influenced QMCS survey items and design choices in several PhET simulations. We add to this research by investigating how students use and interact with this graphical representation while sense-making. Through fine-timescale analysis of video data from clinical interviews with engineering majors in a modern physics course, we document that the inscription can play both communicative and generative roles in the student's reasoning. We report the different ways in which the inscription gets embedded in students' reasoning and potential instructional implications.

*This work is supported by NSF-DUE1323129.

### AE05: 9:10-9:20 a.m. Words vs. Graphs: Tracking Shifts in Students' Understanding of Forces

*Contributed – Trevor I. Smith, Rowan University, 201 Mullica Hill Rd., Glassboro, NJ 08028; smithtr@rowan.edu*

*Ian T. Griffin, Nicholas J. Wright, Rowan University*

Many studies have shown that students often struggle to interpret and generate graphs of various physical quantities. This can be seen in students' responses to the Force and Motion Conceptual Evaluation. When analyzing consistency on questions asking students to select graphs of force vs. time to accompany a described motion compared to questions asking them to choose verbal descriptions of forces, we have previously used consistency plots to show that students are more likely to improve on the graph questions than the natural language questions. This suggests that students may have developed a formal understanding of the relationship between force and motion but do not apply it when reasoning about situations related to their daily lives. We expand on these results by incorporating data from multiple colleges and universities and show how these results relate to other analyses of the data.

### AE06: 9:20-9:30 a.m. Teacher Knowledge of Student Difficulties: "Collectively, We're a Genius!"*

*Contributed – Michael Carl, Wittmann University of Maine, 5709 Bennett Hall, University of Maine, Orono, ME 04469-5709; mwittmann@maine.edu*

*Carolina Alvarado, Laura A. Millay, University of Maine*

In a teacher professional development meeting of the MainePSP, teachers were asked a question about potential energy and then to discuss why students might give a particular response to it. Collectively, they came up with a rich, nuanced description of student reasoning, touching on multiple ways of thinking about energy, and how these might affect student responses. Where PD organizers (... the talk authors) had predicted three or four, teachers came up with six explanations of a particular answer. These included ideas in the literature (related to time, effort, and work, for example) and ideas not in the literature (a wonderfully compelling reverse deficit model of energy). We find that bringing teachers together and sharing student data within a facilitated community lets teachers arrive at surprising insights about how their students think about energy.

*Funded in part by NSF MSP 0962805 and DRL 1222580.

### AE07: 9:30-9:40 a.m. Investigating the Impact of Different Prompts on Student Reasoning *

*Contributed – Cody Gette, North Dakota State University, 4214 9th Ave., S Fargo, ND 58103; cody.gette@ndsu.edu*

*Mila Kryjevskaia, North Dakota State University*

*MacKenzie Stetzer, University of Maine*

*Andrew Boudreaux, Western Washington University*

Prior research suggests that students who demonstrate conceptual knowledge on one task often fail to apply consistent thinking on closely related tasks. This is consistent with the dual-process theory of reasoning that suggests that some students tend to focus on surface features that often elicit intuitive ideas. As such, these students tend to provide answers based on their first reactions or gut feelings. We applied a paired-question methodology, in which screening and target questions required the application of the same concepts and skills. Three versions of screening-target sequences were designed in the context of friction. The sequences only differed in the level of abstractness that describe setups presented in the screening questions. The impact of these differences on student performance on the target question was examined. Results from introductory algebra-based physics class will be presented and discussed.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, 1431940, 1432052, and 1432765.

### AE08: 9:40-9:50 a.m. How Students Combine Knowledge Elements While Learning

*Contributed – Alan Richards, The College of New Jersey, 2000 Pennington Rd., Ewing, NJ 08628; aj.richards@tcnj.edu*

*Darrick C. Jones, Eugenia Etkina, Rutgers University*

We recorded pre-service physics teachers learning about the physics of solar cells. Using a knowledge-in-pieces theoretical framework, we analyze their interactions in order to make inferences about the elements of prior knowledge they call upon as they build understanding of how these devices function. Of special interest are the instances when a student makes a significant conceptual breakthrough. We find that students who combine different aspects of their prior knowledge in specific ways may be more likely to make breakthroughs. We will discuss what instructors can do to prime learners to combine knowledge in productive ways so they are better able to achieve these breakthroughs.

### AE09: 9:50-10 a.m. Improving Understanding of Gauss's Law by Replacing Examples with Reasoning

*Contributed – Marshall J. Styczinski, University of Washington, Dept. of Physics, Seattle, WA 98195-1560; mjstyczi@uw.edu*

*Peter Shaffer, Paula Heron, Aziz Khan, Ryan Hazelton, University of Washington*

Gauss's law is a fixture in introductory physics classes in part because the reasoning skills and fundamental physics knowledge required for its application represent important course goals. We have found that students struggle to apply Gauss's law to conceptual questions as well as typical end-of-chapter problems, even after coverage in lecture and the relevant sections of Tutorials in Introductory Physics(1). To address persistent difficulties we are modifying tutorial curriculum to reduce the number of examples and emphasize the development of a conceptual framework around flux and Gauss's law. The goal is to improve student performance on both conceptual questions and typical calculation questions. A summary of the student difficulties uncovered, details of modifications to the established curriculum, and preliminary results will be presented.

1, McDermott, Shaffer, and the UWPEG (2012). *Tutorials in Introductory Physics. Pearson Learning Solutions.*

* This material is based upon work supported by NSF Grant No. DUE-1022449.

## Session AF: Robert Noyce Scholars in Physics Teacher Preparation

**Location:** CC – Room 304/305
**Sponsor:** Committee on Teacher Preparation
**Date:** Monday, July 18
**Time:** 8:30–10 a.m.

*Presider: David Rosengrant*

*This session will focus on the role that the Robert Noyce Scholarship program can play in physics teacher preparation. We will highlight the work of various universities that successfully implemented this grant into their physics teacher preparation programs.*

### AF01: 8:30-9 a.m. Robert Noyce Scholarship Programs at Kennesaw State University

*Panel – David Rosengrant, Kennesaw State University, 370 Paulding Ave., Kennesaw, GA 30144; drosengr@kennesaw.edu*

*Samuel J. Polizzi, Michelle Head, Kennesaw State University*

*Greg Rushton, Stony Brook University*

Kennesaw State University has had a very successful history with Robert Noyce Scholarship Programs. Thus far we have had five total programs for the university, three of which deal specifically with chemistry and physics teachers. The first helped us create our Masters of Arts and Teaching Program. Our second deals with the recruitment and retention of chemistry and physics teachers. This program recruited career changers into the profession while at the same time we are working with area master teachers. These teachers have mastered their practice in the classroom and now we are working with them to become leaders in the profession. The third chemistry and physics specific program involves recruiting undergraduates into chemistry and physics teacher preparation. Furthermore, we specifically target our recruitment efforts towards women and minorities. This part of the talk will highlight our successes and challenges.

### AF02: 9-9:30 a.m. Noyce Scholarship: Expanding Horizons

*Panel – Debbie S. Andres, Rutgers University, Graduate School of Education, 10 Seminary Place, New Brunswick, NJ 08901; dandres126@gmail.com*

The Robert Noyce Scholarship opened a door for me that I did not think was possible as an engineering major. The Rutgers Physics Teacher Preparation program is unique in its early clinical experiences by giving its students creative liberty as TAs in an undergraduate physics course. Our methods courses allowed me to learn physics in a classroom that accepted 'crazy ideas'. My education was enriched by the experiences of my instructors, cohort members, and graduates of the program. As a Noyce Scholar, my learning was expanded through teaching opportunities including high school outreach and summer bridge programs for incoming engineering students from low-income backgrounds. The opportunity to attend National AAPT meetings diversified our community, as my cohort was able to attend, join committees, and be the voices for high school teachers. Being a Noyce Scholar enabled me to be in this program, but it did so much more than that.

### AF03: 9:30-10 a.m. Noyce Scholar and MTF Experiences in Teacher Research Teams

*Panel – Michelle N. Belleau, University of Colorado, 249 UCB, Boulder, CO 80309; shelly.belleau@gmail.com*

*Emily J. Quinty, University of Colorado*

At the University of Colorado Boulder, the Robert Noyce scholarship program involves pre-service (Noyce Fellows) and in-service teachers (including NSF Noyce Master Teaching Fellows) collaborating in Teacher Research Teams (TRTs). TRTs engage in professional development by inducing principles about effective teaching practice from their discipline-based education research. The Physics TRTs are implementing the Physics and Everyday Thinking High School (PET-HS) curriculum and studying student learning and behaviors in the PET-HS courses. In this session we will discuss pre- and in-service teacher growth as evidenced by survey data, self-reflections, and trends in research topics throughout their participation in the program. Additionally, we will discuss both high school student and teacher pre- and post-results on the PET conceptual assessment and the Colorado Learning Attitudes about Science Survey (CLASS).

## Session AG: CIRTL: A Network Model to Transform STEM Education and Prepare Future Faculty

**Location:** CC – Room 312
**Sponsor:** Committee on Graduate Education in Physics
**Date:** Monday, July 18
**Time:** 8:30–9:50 a.m.

*Presider: Manher Jariwala*

### AG01: 8:30-9 a.m. The Integration of Research, Teaching and Learning: Preparation of the Future STEM Faculty

*Invited – Robert D. Mathieu, University of Wisconsin - Madison, Department of Astronomy, Madison, WI 53706-1380; mathieu@astro.wisc.edu*

Graduate students at research universities shape the future of STEM undergraduate education in the United States. These future faculty flow into the STEM faculties of several thousand research universities, comprehensive universities, liberal arts colleges, and community and tribal colleges. The Center for the Integration of Research, Teaching, and Learning (CIRTL) uses graduate education as the leverage point to develop STEM faculty with the capability and commitment to implement and improve effective teaching and learning practices. CIRTL has developed, implemented, and evaluated successful strategies based on three core ideas — teaching-as-research, learning communities, and learning through diversity. A decade of research demonstrates that STEM future faculty in CIRTL learning communities understand, use, and advance high-impact teaching practices. Today the CIRTL Network includes 46 research universities. Ultimately, CIRTL seeks a national STEM faculty who enable all students to learn effectively and achieve STEM literacy, whose teaching enhances recruitment into STEM careers, and whose leadership ensures continued advancement of STEM education.

### AG02: 9-9:30 a.m. New Doorways to Physics Instruction: Blending A MOOC and Classroom Discussion to Train Graduate Students and Postdocs in Evidence-based Teaching

*Invited – Bennett Goldberg, Boston University, 8 Saint Mary's St., Photonics Center, Boston, MA 02215; goldberg@bu.edu*

*Henry (Rique) Campa, III, Michigan State University*

*Derek Bruff, Vanderbilt University*

*Robert Mathieu, Kitch Barnicle, University of Wisconsin-Madison*

A challenge facing physics education is how to encourage and support the adoption of evidence-based instructional practices that years of physics education research has shown to be effective. Like many STEM departments, our community struggles to overcome the barriers of faculty knowledge, motivation and time; institutional cultures and reward systems; and disciplinary traditions. Research has demonstrated successful transformation of department-level approaches to instruction through critical components of local learning communities, in-house expertise, and department administrative support. In this presentation, I will discuss how physics and other STEM departments can use a MOOC on evidence-based instruction together with in-person seminar discussions to create a learning community of graduate students and postdocs, and how such communities can affect departmental change in teaching and learning. Four university members of the 21-university network working to prepare future faculty to be both excellent researchers and excellent teachers collaborated on an NSF WIDER project to develop and deliver two massive open online courses (MOOCs) in evidence-based STEM instruction. A key innovation is a new blended mode of delivery where groups of participants engaged with the online content and then meet weekly in local learning communities to discuss, convey current experiences, and delve deeper into particular techniques of local interest. The MOOC team supported these so-called MOOC-Centered Learning Communities, or MCLCs, with detailed facilitator guides complete with synopses of online content, learning goals and suggested activities for in-person meetings, as well as virtual MCLC communities for sharing and feedback. In the initial run of the first MOOC, 40 MCLCs were created; in the second run this past fall, more than 80 MCLCs formed. Further, target audiences of STEM graduate students and postdocs completed at a 40-50% rate, indicating the value they place in building their knowledge in evidence-based instruction. We will present data on the impact of being in an MCLC on completion and learning outcomes, as well as data on departmental change in physics supported by MCLCs.

### AG03: 9:30-9:40 a.m. Teaching and Research Training: A Graduate Student Perspective

*Contributed – Alexander P. Becker, Boston University, 590 Commonwealth Ave., Boston, MA 02215; apbecker@bu.edu*

*Bennett Goldberg, Manher Jariwala, Boston University*

CIRTL seeks to improve the teaching and research training of graduate students. At Boston University, two major initiatives are the "Teaching Fellow Peer Mentoring" program (TFP.m.) and the "Teaching as Research" fellowship (TAR). I will offer a graduate student's perspective on these efforts to train future educators. Having been first mentee and then mentor within the TFP.m., I will present experiences, data, and activities that sustain and expand this student-run program. The TAR fellowship comprises a seminar and research project, for which graduate students and professors team up to investigate one aspect of undergraduate or graduate education. Getting graduate students involved is one goal, another one being the further improvement of teaching at BU. I will present challenges and opportunities, by example of my own TAR research project.

### AG04: 9:40-9:50 a.m. The CIRTL Network and Graduate Professional Development at Texas A&M University

*Contributed – Robert C. Webb, Texas A&M University, Department of Physics and Astronomy, College Station, TX 77843-4242; webb@physics.tamu.edu*

The CIRTL mission is to improve undergraduate education in the STEM disciplines through providing future faculty (a.k.a. grad students and postdoctorals) with various forms of professional development using the three CIRTL pillars: teaching as research (TAR); learning communities; and learning through diversity. Texas A&M has been a member of the CIRTL Network for nearly 10 years and during that time we have developed a number of programs aimed at addressing this mission. In this presentation we will give an overview of the primary TAMU CIRTL activities at Texas A&M and then spend a few minutes discussing how these activities have begun to impact physics education research in our department.

## Session AH: Outreach Demonstrations

**Location:** CC – Room 315
**Sponsor:** Committee on Apparatus
**Co-Sponsor:** Committee on Science Education for the Public
**Date:** Monday, July 18
**Time:** 8:30–10 a.m.

*Presider: David Maiullo*

### AH01: 8:30-9 a.m. LIGO SEC Connecting the Detection with Demos

*Invited – Kathy Holt, LIGO Science Education Center, P.O. Box 940, 19100 LIGO Lane, Livingston, LA 70754; kholt@ligo-la.caltech.edu*

The LIGO Lab in Livingston, LA, on Feb. 11, 2016, announced the detection of gravitational waves or ripples in space-time caused by the collision of two black holes. This is a new way of looking at the universe. LIGO Science Education Center seeks to connect the scientific discovery of gravitational waves to the public through simple science activities and demonstrations. Kathy Holt, Senior Science Educator at LIGO, will encourage the participation in activities and demos.

### AH02: 9-9:30 a.m. What I Do at the U of U (University of Utah)

*Invited – Adam J. Beehler, University of Utah, 115 S. 1400 E #201, Salt Lake City, UT 84112-0830; beehler@physics.utah.edu*

Doing outreach is not my main job and was not the purpose of me being hired at the University of Utah's Department of Physics & Astronomy in Salt Lake City, UT. However, I have a passion for outreach and thus try to provide it when and where I can. I intend to share with you how I am able to pull it off. I will discuss aspects of organization, collaboration, funding, assessment, advertisement, implementation, safety, security, support, adaptation, etc. Basically, since I am the department's Lecture Demonstration Specialist and manage many demonstrations for regular classroom instruction, I am able to present such demonstrations to a wide variety of audiences outside of the regularly scheduled classes. I generally am able to share science this way with about 6,000-10,000 people annually. Hopefully, this talk will help others in some way with their outreach efforts.

### AH03: 9:30-10 a.m. Considerations for a Successful and Long Running Outreach Program

*Invited – Dale Stille, University of Iowa, Rm 58, Van Allen Hall, Department of Physics and Astronomy, Iowa City, IA 52242; dale-stille@uiowa.edu*

Many different aspects must come together in the creation of a successful, sustainable outreach program. In many respects the demonstrations and hands-on activities are of secondary importance when weighed against the problems of funding, transportation, staffing, infrastructure, etc. I will focus on those problems and some of the solutions that we have found while coordinating our long running "Hawk-Eyes on Science" and our recently implemented "Hawkeyes in Space" outreach programs at the University of Iowa Department of Physics and Astronomy. In addition I will show examples of demonstrations that we have chosen for their topic versatility and the variety of settings or themes in which we have used them.

## Session AI: PER: Exploring Problem Solving Approaches and Skills

**Location:** CC – Room 311
**Sponsor:** AAPT
**Date:** Monday, July 18
**Time:** 8:30–9:40 a.m.

*Presider: Daryl Pedigo*

### AI01: 8:30-8:40 a.m. Can Analogical Reasoning Help Students Learn to Solve Synthesis Problems?

*Contributed – Daniel R. White, The Ohio State University, Department of Physics, 191 West Woodruff Ave., Columbus, OH 43210-1168; drwhite@mps.ohio-state.edu*

*Ryan Badeau, Andrew F. Heckler, The Ohio State University, Department of Physics*

*Bashirah Ibrahim, Lin Ding, The Ohio State University, Department of Teaching and Learning*

Improving students' skills in solving synthesis problems, which are problems requiring the application of multiple concepts such as energy conservation and kinematics, is typically a key instructional goal. We have previously found that students struggle with some synthesis problems more than their single-concept counterparts in part because of difficulty recognizing all the relevant concepts or that multiple concepts are needed. Analogical reasoning, which involves practice activities that guide students through comparisons of the deep structure of physics problems, is a promising technique for helping students recognize relevant concepts in novel problems. We report on a couple experiments testing simple implementations of analogical reasoning and show that these activities can be effective in improving student performance on synthesis problems. However, we also show evidence that these activities may not be as useful in cases where concept recognition is a less significant bottleneck.



### AI02: 8:40-8:50 a.m. Identifying Student Difficulties in Causal Reasoning

*Contributed – Lindsay Owens, University of Cincinnati, 3843 Mantell Ave., Cincinnati, OH 45236; owensly@mail.uc.edu*

*Lei Bao, The Ohio State University*

*Kathy Koenig, University of Cincinnati*

There has been an increasing push for the refinement of curricula in university level algebra-based and calculus-based physics classes to focus on scientific reasoning skills. There are nine recognized domains of scientific reasoning, and this study focused on the causal reasoning domain. Quantitative data were gathered from selected items given as part of the Inventory of Scientific Thinking and Reasoning (iSTAR) assessment at the beginning and end of two semesters. The focus of this analysis was to identify student difficulties in making causal judgements. Initial results from the data suggested that students entangle forward and reverse causality statements; they often selected a forward causal statement "X causes Y" and a reverse causal statement "Y causes X" simultaneously to explain some observed result.

### AI03: 8:50-9 a.m. Prompted Evaluation in Calculus-based Introductory Physics

*Contributed – MacKenzie Lenz, 310 Weniger Hall, Corvallis, OR 97331-8507; lenzm@oregonstate.edu*

*Elizabeth Gire*

Physics instructors generally expect students to think about the correctness and reflect on the meanings of their answers. This answer evaluation process may include a variety of considerations, including checking units, looking at limiting cases, and thinking about the reasonableness of numbers. In order to encourage answer evaluation, instructors explicitly prompt for it in class assignments. We examine students' responses to such a prompt on homework and exam problems in a large enrollment first term calculus-based physics course. We will discuss the distribution of strategies students used, student performance with these strategies, and the extent to which the development of answer evaluation skills was supported throughout the course.

### AI04: 9-9:10 a.m. Purpose of Representation Use in Modeling Instruction Physics

*Contributed – Daryl McPadden, Florida International University, 11200 SW 8th St., Miami, FL 33199; dmcpadden621@gmail.com*

*Vashti Sawtelle, Marcos D. Caballero, Michigan State University*

*Eric Brewe, Florida International University*

Representations (i.e. graphs, equations, pictures) are the foundational tools that students use to understand and solve physics problems. This study aims to understand the purpose with which students use particular representations. In the Modeling Instruction courses, representation use is a primary focus with explicit class time spent on introducing, practicing, coordinating, and applying multiple representations. Consequently, we conducted pre/post think-aloud, problem-solving interviews with groups of students in the Modeling Instruction – Electricity and Magnetism (MI-E&M) course. In each recorded interview, students were asked to solve three physics problems, which varied by context (mechanics and E&M), difficulty, and familiarity with the topic to show the breadth of how students use representations when problem solving. From video analysis and coding, we will present the common themes and purposes with which students use various representations.

### AI05: 9:10-9:20 a.m. The Impact of Students' Epistemological Framing and Beliefs on a Task Requiring Representational Consistency*

*Contributed – Alexandru Maries, University of Cincinnati, 3405 Telford St., Cincinnati, OH 45220; mariesau@ucmail.uc.edu*

*Chandralekha Singh, University of Pittsburgh*

The ability to flexibly transform between different representations (e.g., from mathematical to graphical representations) of the same concept is a hallmark of expertise. This ability is often lacking in many introductory students as evidenced by the lack of consistency in students' representations (i.e., students construct two representations for the same concept in the same situation that are not consistent with one another). In this study, we asked students to construct two representations for the electric field for a situation involving spherical symmetry (charged conducting sphere surrounded by charged conducting spherical shell). This type of problem has been found to result in many students constructing representations that are not consistent with one another. Here, we present findings from individual interviews with students which suggest that students' lack of consistency may partly be attributed to the type of knowledge that the graphical and mathematical contexts trigger. Using the epistemic games framework terminology, the two representations students are asked to construct (mathematical vs. graphical) may lead them to play two different epistemic games. We discuss how students' epistemological framing and beliefs may contribute to their lack of representational consistency.

*Work supported by the National Science Foundation

### AI06: 9:20-9:30 a.m. Using Spaced Recall to Encourage Expert Practice

*Contributed – Eugene T. Torigoe, Thiel College, 75 College Ave., Greenville, PA 16125; etorigoe@thiel.edu*

*Dominic Licata, Thiel College*

Introductory physics students were shown an example problem and asked to recall the solution from memory over a period of weeks, with feedback after each attempt. The structure of this activity was designed to reward expert practices that benefit the long-term retention of information. For example, reasoning with a diagram to form the proper equation, rather than just memorizing the equation. This talk will discuss the performance of a class of 15 students throughout an entire semester, as well as the analysis of four videotaped interviews.

### AI07: 9:30-9:40 a.m. Using the Cognitive Reflection Test to Investigate Student Reasoning Inconsistencies*

*Contributed – Nathaniel C. Grosz, Department of Physics, NDSU, Dept. 2755, P.O. Box 6050, Fargo, ND 58102; Nathaniel.C.Grosz@ndsu.edu*

*Mila Kryjevskaia, Cody Gette, Department of Physics, NDSU*

*Andrew Boudreaux, Western Washington University*

*MacKenzie Stetzer, University of Maine*

Students who demonstrate correct conceptual knowledge and formal reasoning approaches on one physics question often abandon these approaches in favor of more intuitive reasoning on an isomorphic question. The heuristic-analytic theory of reasoning suggests that the intuitive approaches used by these students stem from the heuristic process and are cued by salient, distracting features of the isomorphic problems. This apparent failure to engage the analytic process productively may stem from a lack of metacognition. We speculate that the students who continue to use formal reasoning on the isomorphic problems tend to be more reflective, analytical thinkers. In order to investigate this possibility, we have been using the Cognitive Reflection Test (CRT) in conjunction with a pair of isomorphic questions to examine the extent to which students' reflection abilities impact performance.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, 1431940, 1432052, and 1432765.

## Session AJ: Adaptation of Physics Activities to Three Major Components of NGSS

**Location:** CC – Room 317/318
**Sponsor:** Committee on Physics in High Schools
**Date:** Monday, July 18
**Time:** 8:30–9:50 a.m.

*Presider: Trina Cannon*

### AJ01: 8:30-9 a.m. Integrating NGSS Physics Concepts with Common Core Mathematics and English

*Invited – Jan Mader, Great Falls High School, 1900 2nd Ave. S, Great Falls, MT 59404; Jan_Mader@gfps.k12.mt.us*

*Karen Jo Matsler, UT Arlington*

With the push for literacy in all core areas, high school physics and middle school physical science instructors are encouraged to demonstrate the integration of NGSS performance expectations to other science disciplines, engineering and the Common Core State Standards in Mathematics and English Language Arts. Using the concept of energy, this session will focus on the development of a learning cycle and the integration of mathematics and literacy strategies.

### AJ02: 9-9:30 a.m. Adaptation of Physics Activities to the Three Main Components of NGSS

*Invited – Janie Head, Foster High School, 4400 FM 723, Richmond, TX 77469; mhead@lcisd.org*

Integrating physics and geology over decades is a transition into engineering and technology of today. Today geophysics employs techniques designed through partnerships in the sciences. Technology has expanded in this field. Practical applications of classroom lessons need to be encouraged.

### AJ03: 9:30-9:40 a.m. Designing and Testing Crash Barriers, an Engaging NGSS Activity

*Contributed – Daniel J. Burns, Los Gatos High School, 20 High School Court, Los Gatos, CA 95030; dburns@lgsuhsd.org*

*Bree Barnett-Dreyfuss, Amador Valley High School*

The design of highway crash barriers is rich in physics and the potential to engage students. Crash barriers are ubiquitous in urban, suburban, and rural areas. There are many different types in use. Designing them is an effective way to address NGSS standard HS-PS2-3 that asks students to apply scientific and engineering ideas to design a device that minimizes the force on an object during a collision. Crash barriers involve many physics topics like Newton's laws, impulse and momentum, energy, and kinematics. The lab requires only one set of equipment but no eggs! Students design and build crash barriers from inexpensive materials and test them using a cart, track, and accelerometer. They can use their test results to improve their design. We will show several variations of crash barrier test setups using a variety of vendor equipment. We will show student examples and test data.

### AJ04: 9:40-9:50 a.m. NGSSifying Exploratorium Snacks (Activities)

*Contributed – Marc 'Zeke' Kossover, Exploratorium, 17 Pier, Suite 100, San Francisco, CA 94111; zkossover@exploratorium.edu*

*Sara Heredia, Exploratorium*

An Exploratorium Snack is a hands-on science activity. They are tabletop exhibits or explorations of natural phenomena that teachers or students can make using common, inexpensive, readily available materials. Some of them can be found at www.exploratorium.edu/snacks. Snacks are ideal candidates for NGSS activities because they support teachers in bringing phenomena into the classroom to be explored by students. However, Snacks alone won't ensure that your students engage in the science practices successfully. See how we have retrofitted Snacks from decades ago to make them better. We are also investigating how we can help new teachers NGSSify our Snacks. We have a planning tool that you might find useful too.

## Session AK: 30 Demos in 60 Minutes

**Location:** CC – Room 313
**Sponsor:** Committee on Teacher Preparation
**Co-Sponsor:** Committee on Physics in Pre-High School Education
**Date:** Monday, July 18
**Time:** 8:30–9:30 a.m.

*Presider: Wendy Adams*

*Our panel of physics teachers will present at least 30 dynamic demonstrations that will engage students in the wonder of science. Presenters will share tips on the setup, materials, procedure, and underlying science concepts so the audience can integrate these demos into their own classrooms.*

## Session AL: Computer Modeling and Simulation in Sustainability Courses

**Location:** CC – Room 310
**Sponsor:** Committee on Physics in Undergraduate Education
**Date:** Monday, July 18
**Time:** 8:30–10 a.m.

*Presider: Juan Burciaga*

*Climate change, the environment, sustainability … all of these topics present challenges that can best be addressed using computer models and simulations. And increasingly, to have a good understanding of issues and arguments in these areas, voters are required to have a sophisticated appreciation and understanding of the power and limitations of models and computer simulations. How should we be using models and simulations in our courses in sustainability and the environment? What should be our goals for both majors and non-majors in these courses? What should we be including in our courses? What pedagogical challenges are there in teaching computer models and simulations?*

### AL01: 8:30-10 a.m. Deepening Understanding by Implementing (Simple) Systems Modeling

*Panel – Steve Lindaas, Minnesota State University, Moorhead, 1104 7th Ave. South, Moorhead, MN 56563; lindaas@mnstate.edu*

As physicists we often take a reductionist viewpoint and simplify our systems. This cause and effect approach supports the notion that the interaction between objects in the natural world is linear. A watch analogy is often used to describe this view. Understanding how the watch (whole system) works can be accomplished by taking the watch apart to understand the interaction of each gear and part. Unfortunately systems in the natural world exhibit feedback that produces non-linear and often unexpected outcomes. Having students model systems promotes deeper understanding. Students can ask "what if" questions to gain deeper insight and comprehension. Modeling has been implemented in two sustainability courses: "Energy and the Environment" and "Thinking in Systems: Introduction to Sustainability." These courses are designed for non-majors but are also part of the sustainability major. Modeling is done using spreadsheets to make it more accessible but there are still challenges… and opportunities.

**AL02: 8:30-10 a.m. Computer Modeling in the Environmental Physics Course**

*Panel – Tara Peppard, Department of Physics, Cleveland State University, 2121 Euclid Ave., SI-112, Cleveland, OH 44115; t.peppard@csuohio.edu*

*Miron Kaufman, Cleveland State University*

Since 1996 we have been offering at Cleveland State University a course entitled Environmental Physics. The goal of the course is to teach the physical laws underlying environmental and sustainability issues. The students have a variety of backgrounds: ranging from physics and engineering to urban studies, law and education. The students learn to work in interdisciplinary groups. The course is, by necessity, algebra-based. To compensate, we use computer modeling extensively. It enhances the understanding of phenomena through visualizations, and it teaches students useful skills such as data analysis. For example, the students are exposed to chaos theory by analyzing the period-doubling route to chaos prevalent in population models. The diffusion of pollutants in the atmosphere and radioactive decay are taught through Monte-Carlo simulations. The Brunt-Väisälä oscillations are modeled and the stability of the atmosphere is discussed. Simulations are also performed on models of consumption such as the Hubbert model, to illustrate aspects of sustainability.

## Session TOP01: Celestial Navigation in the Pacific: Polynesian Insights into Old Traditions

**Location:** Sheraton – Baker
**Sponsor:** Committee on Space Science and Astronomy
**Co-Sponsor:** Committee on History and Philosophy in Physics
**Date:** Monday, July 18
**Time:** 12–1:30 p.m.

*Presider: Stephanie Slater*

## Session TOP02: Finding Time To Do It: New Lessons in Time Management for Busy Faculty

**Location:** CC – Room 319
**Sponsor:** Committee on Physics in Undergraduate Education
**Date:** Monday, July 18
**Time:** 12–1:30 p.m.

*Presider: Tim Slater*

*Faculty are busy—busier than ever. No matter what your institutions' size, focus, or location, there is simply more to be done every day than can be. There are students to be taught, papers and reports to be written, and meeting and service commitments to attend to. All of this while you are supposed to be innovatively creative and lead a balanced reflective and supportive personal life. If you are going to get out of the whirlwind and be more productive at work while successfully maintaining a healthy home life, you need some tried and true time management strategies that actually work for busy professors. With the right mindset and a carefully tuned toolbox of time saving techniques, you can successfully manage your email, get more writing done, innovate in the classroom, be more responsive to students, be prepared and on time for meetings, and still have a healthy home life.*

## Session TOP03: The Role of the AAPT in preK-8 Physics Education: What Can We Do to Support and Learn from preK-8 Teachers?

**Location:** CC – Room 317/318
**Sponsor:** Committee on Physics in Pre-High School Education
**Date:** Monday, July 18
**Time:** 12–1:30 p.m.

*Presider: Rebecca Vieyra*

*Bring your questions and insights about how AAPT and its members can support physics and general science educators at the preK-8 level. All science and physics educators across the preK-higher education spectrum are welcome to attend to engage in dialogue about this important endeavor to support science literacy and interest in the early years through formal and informal means. Participants who have had experience engaging preK-8 children and/or their teachers in physics are encouraged to share their results. The AAPT's new K-12 Program Manager will preside at this discussion to hear the ideas put forth for consideration in AAPT's K-12 Programs.*

# Awards Session

AAPT PHYSICS EDUCATION

**Location:** Sheraton - Magnolia/Camellia
**Date:** Monday, July 18
**Time:** 10:30 a.m.–12 p.m.

*Presider: Mary Mogge*

Tom Erekson

## Paul W. Zitzewitz Excellence in K-12 Teaching Award: presented to Tom Erekson, Lone Peak High School, UT

### Physics is for everyone!

Physics is a class that every high school student should take. While enrollments have increased nationally over the past 15 years, nearly two-thirds of students still graduate without taking Physics. In 19 years at my present school, Physics enrollment has gone from 15% to over 70% of all graduates. I will share some strategies that have helped increase student interest and enrollment in high school Physics courses.

Andrew Gavrin

## Halliday and Resnick Undergraduate Physics Teaching Award: presented to Andy Gavrin, Indiana University - Purdue University Indianapolis

### Our Students are Learning!

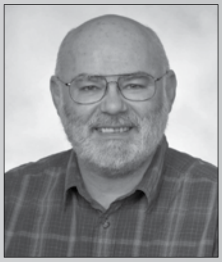
Teaching and learning physics is, I think, uniquely difficult. We ask our students to learn a lot, and we ask them to do it fast. We ask them to learn abstract concepts and methods, and to use multiple representations of their knowledge. We challenge their core understanding of the world around them, and we hold them to high standards of achievement. We also hold ourselves to high standards as teachers. We strive to be clear, correct, engaging, and innovative, and we work in a variety of institutions that may not always provide the support we need. As a result, we are sometimes disappointed with our students' efforts, unhappy with our institutions, and frustrated with our progress. But this is a matter of perspective. In this talk, I will touch, but not linger on the frustrations and failures. I will, instead, focus on the evidence that our students are learning. They are learning to work hard, they are learning to think analytically, and yes, they are learning physics. .

## Homer L. Dodge Citations for Distinguished Service to AAPT

**Kathleen Falconer**
Buffalo State University

**Stephen Kanim**
New Mexico State University

**Kevin Lee**
University of Nebraska-Lincoln



**Dan MacIsaac**
SUNY College at Buffalo

**Mel Sabella**
Chicago State University

## Session BA: Best Practices in Educational Technology

**Location:** CC – Room 306
**Sponsor:** Committee on Educational Technologies
**Date:** Monday, July 18
**Time:** 1:30–3:30 p.m.

*Presider: Nina Morley Daye*

### BA01: 1:30-2 p.m. Supporting Sense-Making in Computational Modeling

*Invited – Ruth Chabay, NC State University, 515 E. Coronado Road, Santa Fe, NM 87505; rwchabay@ncsu.edu*

*Shawn Weatherford, St. Leo University*

*Brandon Lunk, Texas State University, San Marcos*

Students at the introductory level can approach both physical and computational laboratory activities either as routine tasks to be completed or as opportunities to apply and explore physics concepts. We'll show examples of student interactions as they approach computational modeling tasks, and discuss ways of supporting and encouraging sense-making in these contexts.

### BA02: 2-2:30 p.m. Voice Recognition Breaks into Education

*Invited – William Dittrich, Portland Community College, 12000 SW 49th Ave., Portland, OR 97219; tdittric@pcc.edu*

In all of education today, and physics included, the fact that so little educational effort is expended toward students honing oral expression skills, and using those skills to enhance academic success, is highly problematic. While earning an online degree, it is even possible that the student could have never spoken a single word during their education. This is true in light of the fact that oral exercise has been shown to increase understanding of academic content, enhance concept retention, and improve grades (Nelson, 2011). There is extensive research attesting to oral communication being a prerequisite to student's academic, personal, and professional success. Numerous studies express the benefit for adding an oral expression compliment to curriculum, at all levels of education (Ford, 2009; Butler & Stevens, 1997). This problem is addressed with a new, patented, educational software technology called Instant Note Capture (INC) and the Virtual Oral Recitation/Examination (VORE) technologies. These new educational interventions will be described.

### BA03: 2:30-3 p.m. Two-way Communication with Students Via Videos

*Invited – Andy Rundquist, Hamline University, 1536 Hewitt Ave., MS B1807, Saint Paul, MN 55104-1284; arundquist@hamline.edu*

Teacher-produced screencasts and videos have long been a useful resource for students. When I realized how dense their information content can be, I wanted to explore how students could use them to submit their assessments. In this talk I'll describe how student-submitted screencasts are integral to my assessment approach and also discuss the related logistical issues. My feedback to my students is also a video and I'll describe the whole feedback cycle and why I find it to be very complimentary to my Standards-Based Assessment strategy. I'll also describe my switch to a back-flip teaching method that changes when I produce video resources from before class to after class.

### BA04: 3-3:30 p.m. The Power of Student Coding in Physics

*Invited – Joshua Gates, The Tatnall School, 1501 Barley Mill Rd., Wilmington, DE 19807; jgates@tatnall.org*

Technology affords teachers numerous methods to improve the efficiency, flexibility, and speed of the sorts of tasks that educators have been doing for decades. These efficiencies are readily recognized and widely available, but they do not change the teaching or learning experiences in a meaningful way. The potential to explore qualitatively different avenues in physics education through technology is therefore often untapped, as many classrooms operate in much the same way as they did before the influx of classroom gadgets. There is, however, the potential to meaningfully change what is done in these classrooms, by using student coding. The potential for transformative effect of coding in classrooms reaches from introductory to upper-level courses. Tools, example assignments and applications, and ideas for effective coding instruction in the physics classroom will be presented.

## Session BB: PER: Diverse Investigations – B

**Location:** CC – Room 307
**Sponsor:** AAPT
**Date:** Monday, July 18
**Time:** 1:30–3:30 p.m.

*Presider: Julia Olsen*

### BB01: 1:30-1:40 p.m. New Resources on PhysPort: Supporting Physics Teaching with Research-based Resources

*Contributed – Sarah B. McKagan, American Association of Physics Teachers, 124 28th Ave., Seattle, WA 98122; sam.mckagan@gmail.com*

*Adrian M. Madsen, American Association of Physics Teachers*

Physics education researchers have created research results, teaching methods, curricula, and assessments that can dramatically improve physics education. PhysPort (www.physport.org) is the go-to place for ordinary physics faculty to find resources for research-based teaching and assessment. First released in 2011 as the PER User's Guide, PhysPort has undergone re-branding, redesign, and expansion, including many new resources: overviews of over 50 research-based teaching methods and over 50 research-based assessment instruments, Expert Recommendations, the Virtual New Faculty Workshop, the Periscope collection of video-based TA training and faculty professional development materials, and the Assessment Data Explorer, an interactive tool for faculty to get instant analysis and visualization of their students' responses to research-based assessment instruments including the FCI, BEMA, and CLASS, and compare their results to national averages and students like theirs. The development of PhysPort includes research to determine faculty needs and usability testing to ensure that we meet those needs.

### BB02: 1:40-1:50 p.m. Pathways to a Physics Degree: A Statistical Story

*Contributed – John M. Aiken, Helmholtz Centre, Potsdam GFZ, German Research Centre for Geosciences, Helmholtzstrasse, Potsdam, Br 14473, Germany; johnm.aiken@gmail.com*

*Marcos D. Caballero, Michigan State University*

Michigan State University (MSU) has collected a wide body of data on students for over 10 years allowing for a robust, statistical picture to be painted of how students enter and exit the physics world. This data includes course grade, gender, ethnicity, student major choices, etc. and can help us paint a pathway of every student who has received a physics bachelor's degree at MSU. While this data set contains over 100,000 students who have taken math and physics courses at MSU only 2% of these students have declared a physics major and only 0.5% of students have gone on to graduate with a bachelors in physics. Students who declare physics and then move away from the major perform poorly in introductory courses and are demographically different from the typical physics graduate.

### BB03: 1:50-2 p.m. SPOTing Effective Teaching: An Engaging and Reflective Faculty Workshop Series*

*Contributed – Cassandra Paul, San José State University, One Wash-*

ington Square, San Jose, CA 95192-0001 United States cassandra.paul@sjsu.edu

*Katrina Roseler, Chaminade University of Honolulu*

*Cara H. Theisen, University of California, Davis*

Because so few physics faculty are formally trained in education and pedagogy, in-service faculty professional development workshops are important for improving teaching skills. While these workshops often address the importance of engaging students in active and reflective classroom activities, emergent research suggests that more can be done to engage faculty workshop attendees in active and reflective activities. In this presentation, we discuss analysis of data collected from implementation of the SPOTing Effective Teaching Workshop series, a professional development experience that integrates use of the Student Participation Observational Tool (SPOT) within a faculty community of practice. This experience incorporates interactive and reflective elements to guide faculty in a shared experience of analyzing their teaching and discussing alternative approaches. Results indicate that as a result of this experience, faculty articulate pedagogical discontentment and identify desired changes to their teaching practice that are more in line with active, student-centered approaches.

*Research Funded in part by NSF

### BB04: 2-2:10 p.m. STEM Workplace Communication and Implications for the Physics Curriculum

*Contributed – Anne E. Leak, Rochester Institute of Technology, 85 Lomb Memorial Drive, Rochester, NY 14623; aelsps@rit.edu*

*Kelly N. Martin, Benjamin M. Zwickl, Rochester Institute of Technology*

Though communication is essential for success in STEM careers, it is typically a minor focus within the undergraduate physics curriculum. With the emphasis of argumentation in K-12 NGSS and key role of collaboration and discussion in active learning environments, it is important to more fully understand how such practices prepare students to communicate effectively in STEM careers. We conducted 30 semi-structured interviews with new hires and their managers in academia and industry, using the field of optics as a disciplinary focus. We coded these interviews using emergent and grounded theory approaches to better understand how communication skills were developed and used in the workplace. Findings include a taxonomy of diverse communication skills ranging from written (e.g. documentation), visual (e.g. interpreting diagrams), and oral (e.g. asking questions) communication. In each case there were unexpected situations where communication was necessary and inseparable from technical knowledge used in the workplace.

### BB05: 2:10-2:20 p.m. The Access Network: Working Towards More Equitable and Inclusive STEM

*Contributed – Angela Little, Michigan State University, 4101 N. Broadway, Chicago, IL 60613; angie.little@gmail.com*

*Chandra Turpen, Gina Quan, University of Maryland, College Park*

*Kali Johnson, Alex L. Brimhall, Arizona State University*

The Access Network consists of six university-based programs co-working with graduate and undergraduate students from across the country towards a vision of a more diverse, equitable, inclusive, and accessible STEM community. To realize this vision, Access and its member programs empower students as co-leaders, giving them voice and ownership over local and national efforts. Access sites focus on fostering supportive learning communities, engaging students in authentic science practices, and attending to students' development as STEM professionals. Programmatically, sites offer a range of services from summer programs to academic year mentoring. In this talk, we will share preliminary evidence of our network's efforts: (1) building a community of student representatives committed to communicating across sites, celebrating local successes, and supporting each other through local struggles, (2) developing and implementing our first in-person gathering of student representatives from Access sites, and (3) fostering routines for sharing of ideas across sites.

### BB06: 2:20-2:30 p.m. The Effects of Grader Assessment Feedback on Student Self-Regulation

*Contributed – Annie Chase, San José State University, One Washington Sq., San Jose, CA 95192-0001; annie.chase@sjsu.edu*

*Cassandra Paul, San José State University*

Self-regulation is a self-initiated process through which students identify obstacles to their learning, find strategies that will allow them to overcome those obstacles, and finally exert the effort needed to succeed. Through collection of student responses to a web-based survey, we investigate what student self-regulation looks like across different undergraduate physics populations. Specifically, we examine how different styles of feedback on assessments correlate with students' self-regulation. We combine two models of self-regulation – (1) the Winne & Hadwin model which describes how external feedback influences student self-regulation and (2) Zimmerman's cyclical model of student self-regulation consisting of the phases forethought, self-control, and self-judgement – to create an a priori coding scheme. Informed by our theory of self-regulation, we also develop emergent, open codes from the data. We hypothesize that instructors can use particular feedback to influence subcomponents of student self-regulation, aiding students' knowledge construction.

### BB07: 2:30-2:40 p.m. Student Feedback as a Tool in Physics Course Development

*Contributed – Ilkka V. Hendolin, University of Helsinki, Department of Physics, Gustaf Hällströmin, katu 2, HELSINKI, FI 00014 Finland; ilkka.hendolin@helsinki.fi*

The effects of instructional reforms in university physics are typically evaluated through formative assessment, standardized concept inventories and/or attitude surveys. In addition, student feedback is collected by many departments, but reports of its use in course development are rare. At the University of Helsinki, Finland, student feedback has been regularly collected at fundamental physics courses since 2007. Over the years, feedback has proven to be an invaluable source of information for course development. It has revealed characteristics of physics courses and effects of instructional reforms hardly found by other means. Key factors for success are that all students have been motivated to give their considered opinions and feedback is solely used for the purposes of course development (and not e.g. for faculty promotions). In this talk, the feedback procedure will be presented along with examples of findings.

### BB08: 2:40-2:50 p.m. The Importance of Student Voice in Partnerships: Examples from the CSU Learning Assistant Program*

*Contributed – Mel S. Sabella, Chicago State University, Department of Chemistry and Physics, 9501 S. King Drive - SCI 309, Chicago, IL 60628; msabella@csu.edu*

*Felicia Davenport, Fidel Amezcua, Andrea Van Duzor, Chicago State University*

The CSU Learning Assistant (LA) program has grown from three students, in one discipline, to 19 students, in five disciplines. Central to this growth is the cultivation of teaching partnerships between LAs and faculty. In these partnerships, student ideas are valued and leveraged to improve the program, inform LA programs across the country, and publicize the program at the local and national level. In this talk we explore how recent interviews with LAs and the implementation of an LA Panel at CSU allows faculty and peers to get a glimpse of the LA Program that would not be possible without student voice. We also explore how the use of student voice to inform the program can create broad scale buy in for the LA Program and other types of instructional reform in the STEM classroom.

*Supported by the National Science Foundation (DUE #1356523 & DUE#1524829) and the Department of Education.

### BB09: 2:50-3 p.m. Using Conceptual Blending to Analyze Student Inquiry in Computer-based Environments

*Contributed – Bor Gregorcic, Uppsala University, Box 516 Uppsala, 75120 Sweden; bor.gregorcic@gmail.com*

*Jesper Haglund, Uppsala University*

Modern digital technologies allow students to engage in inquiry-based activities in topics that have traditionally been out of experimental reach, such as astronomy and particle physics. An expert-like understanding of a topic requires recognition and awareness of the different roles of formalisms, computer simulations, and physical experiments. Conceptual blending (also known as conceptual integration) is a framework for describing cognitive processes. We will illustrate how conceptual blending can be used to interpret how students make sense of the motion of stellar objects, as they explore them in an interactive whiteboard-based investigative group activity. Main findings include that students quickly accept the idea of being able to throw planets into orbit in the interactive computer environment. For consolidation of learning and for building an expert-like understanding, experiences from this playful activity and from everyday life have to be projected onto formal physics theory.

### BB10: 3-3:10 p.m. Situated Self-efficacy in Introductory Physics Students

*Contributed – Rachel Henderson, West Virginia University, 135 Willey St., Morgantown, WV 26506; rjhenderson127@gmail.com*

*Seth Devore, John Stewart, Cabot Zabriskie, West Virginia University*

*Lynnette Michaluk, West Virginia University Center for Excellence in STEM Education*

Students' perceptions of self-efficacy in the general university environment have been extensively studied and findings suggest that self-efficacy plays a role in student success. The role of perceived self-efficacy in Science, Technology, Engineering, and Mathematics (STEM) student success is investigated in the current research. A survey measuring students' feelings of self-efficacy within multiple environments, including science, mathematics and physics classes as well as within their major department and intended future career, was developed based on Pintrich et al. "Self-Efficacy for Learning Performance" subscale of the Motivated Learning Strategies Questionnaire. The survey was administered over the fall 2015 and spring 2016 semesters and demographic data was gathered for the introductory, calculus-based physics classes. An analysis of student perceived self-efficacy and its relation to student success will be discussed. The effect of gender and major on perceived self-efficacy and student success will also be explored.

### BB11: 3:10-3:20 p.m. Probing Indicators of Studio-mode Physics Student Success Through Instructor Interviews*

*Contributed – Jarrad W.T. Pond, University of Central Florida, 4000 Central Florida Blvd., Orlando, FL 32816; jarradpond@gmail.com*

*Westley D. James, Jacquelyn J. Chini, University of Central Florida*

As part of a project to explore successful strategies for using studio methods, such as SCALE-UP, we are investigating attitudes that students possess and actions they take that bolster or hinder success in their studio-mode physics courses. We interviewed SCALE-UP physics instructors at two large-enrollment research universities to explore their perspectives on the student-level variables that influence students' chances of excelling in their algebra-based studio-mode physics courses. We developed a coding scheme to characterize the beneficial and detrimental student qualities instructors observe and the actions instructors take to encourage beneficial student attitudes/behaviors and discourage detrimental ones. We present a snapshot of the coding scheme used and discuss common ideas about studio-mode physics student success identified by our participants.

*This work was funded by the National Science Foundation (Grant No. DUE-1347515).

### BB12: 3:20-3:30 p.m. The Evolution of Department-level Teaching Social Networks at One Institution

*Contributed – Alexis V. Knaub, Western Michigan University, 1903 W. Michigan Ave Kalamazoo, MI 49008; avknaub@gmail.com*

*Kathleen Quardokus, Fisher Oregon State University*

*Charles Henderson, Western Michigan University*

Social network analysis (SNA) provides a means of studying connections among entities. The information found through SNA has many uses, including identifying key leaders, demonstrating the current state of a system, or documenting change through collecting data at different time intervals. As part of a larger evaluation project related to institutional change, we have collected SNA department-level data related to teaching networks (teaching discussion and advice) in several departments at one institution. These data have been collected every two years for the past six years. This talk will discuss whether and how these networks have changed, striking trends, and ways these data have been used.

## Session BC: Art and Science of Teaching

**Location:** CC – Room 308
**Sponsor:** Committee on Physics in Undergraduate Education
**Date:** Monday, July 18
**Time:** 1:30–3 p.m.

*Presider: Andrew Gavrin*

### BC01: 1:30-2 p.m. How Can You Achieve the Ultimate Happiness While Teaching Physics?

*Invited – Eugenia Etkina, Rutgers University, 10 Seminary Place, New Brunswick, NJ 08901-1183; eugenia.etkina@gse.rutgers.edu*

Since teaching my first lesson in September of 1982 to a class of 38 teenagers, I noticed a very interesting phenomenon. Every lesson I ever taught (about 13,000 hours since my first) seemed very short. I never notice how time passes and only the bell or an accidental glance at a clock tell me that the lesson is over. Is this a result of poor planning or a sign of something else? About 15 years ago I found an answer. The answer was provided by a man with a very long name - Mihaly Csikszentmihalyi, a Croatian-born psychologist who uncovered the secret of ultimate happiness - the state in which one does not notice the passage of time. He called this state - FLOW. In my talk I will discuss what it is, how to achieve this state teaching physics and, most importantly, how to help our students achieve it.

### BC02: 2-2:30 p.m. Teaching Your Senator, Attorney, and Colleague

*Invited – R. Steven E. Turley, Brigham Young University, N345 ESC Provo, UT 84602-0002; turley@byu.edu*

As physics teachers, we rightfully expend considerable effort on teaching future physicists, physics teachers, and others in related STEM disciplines. To do so well, we hone our skills in correctly teaching core content of our discipline and its applications. In my institution (and mostly likely in yours) we also have a chance to teach future attorneys, politicians, business leaders, artists, athletes, and academic colleagues from other disciplines. Many will have little direct use for physics professionally, but still take courses in our discipline to broaden their understanding and sharpen their reasoning and problem-solving skills. I will discuss ideas I've developed in the art of successful teaching and learning in general education classes. These include making the subject appealing and relevant, giving students a memorable experience, developing transferable skills, and integrating the instruction with other disciplines. Examples will range from classes in large auditoriums to intimate seminars.

### BC03: 2:30-3 p.m. Integrating Physics and Music to Teach Waves

*Invited – Gordon Ramsey, Loyola University Chicago, 25311 S 88th Ave., Frankfort, IL 60423; gpr@anl.gov*

Sound and music are based on properties of waves. Conversely, wave phenomena provide motivating topics for learning physics and music. Students at all levels can participate in activities that help them understand how music and physics are related through the understanding of waves. The most recent "New Generation Science Standards" (NGSS) requires coverage of waves at all K-12 levels. Meanwhile, studies have shown that active student involvement is important in science education for helping the students understand physical concepts. There are numerous demonstrations, laboratory investigations and hands-on group activities that can be done to involve students in this understanding. This paper suggests ways to incorporate elements of acoustics and music to discuss waves at all levels, including beginning college. It is particularly useful for teachers to include such activities in their classes to enhance the learning of physics and music, and understand their relation.

## Session BD: PER Advances in Problem Solving

**Location:** CC – Room 313
**Sponsor:** Committee on Research in Physics Education
**Co-Sponsor:** Committee on Physics in Undergraduate Education
**Date:** Monday, July 18
**Time:** 1:30–3:30 p.m.

*Presider: Andrew Heckler*

### BD01: 1:30-2 p.m. Synthesis Problem Solving in Physics

*Invited – Bashirah Ibrahim, The Ohio State University, 231 Arps Hall, 1945 N. High St., School of Teaching and Learning, Columbus, OH 43210-1172; BASHIRAH2001@gmail.com*

*Lin Ding, The Ohio State University*

Problem solving is a crucial and integral element that needs to be highlighted both as a learning goal and an assessment tool in physics education. Our project deals with synthesis problem solving, i.e physics tasks consisting of two or more distinct concepts, typically from different chapters and separated in the teaching timeline. The core of synthesis problem solving is the integration of multiple concepts and mathematical formulations emerging from the application of relevant concepts. We report on the overarching, on-going studies of this project namely: (i) common difficulties faced by students when tackling synthesis problems; (ii) the effects of mathematical complexity on students' conceptual and mathematical performance with synthesis problems, and (iii) the effectiveness of two interventions, priming and analogical comparisons, in promoting students' synthesis problem solving. Instructional implications are discussed.

### BD02: 2-2:30 p.m. Perspectives on Problem Solving and Its Assessment*

*Invited – Leonardo Hsu, University of Minnesota, Department of Postsecondary Teaching and Learning, Minneapolis, MN 55455; lhsu@umn.edu*

Research on problem solving can be traced back more than half a century. During that time, researchers have had many different perspectives on issues including what constitutes a problem, what are the cognitive processes critical to problem solving, characteristics of expert versus novice problem solving, and how problem-solving expertise can be measured. In this talk, I describe the perspectives of the Minnesota PER group and how they have influenced our work on using computers to coach students to become better problem solvers, as well as how we assess whether students have indeed improved their problem-solving skills.

### BD03: 2:30-3 p.m. The Many Skills Used to Solve Complex Problems

*Invited – Wendy K. Adams, University of Northern Colorado, CB 133, Greeley, CO 80639; wendy.adams@unco.edu*

*Carl E. Wieman, Stanford University*

We have empirically identified over 40 distinct sub-skills that affect a person's ability to solve complex problems in many different contexts. The identification of so many sub-skills explains why it has been so difficult to teach or assess problem solving as a single skill. The existence of these sub-skills is supported by several studies comparing a wide range of individuals' strengths and weaknesses in these sub-skills, their "problem solving fingerprint," while solving different types of problems, including a mechanics problem, quantum mechanics problems, and a complex trip planning problem with no physics. We see clear differences in the problem solving fingerprint of physics and engineering majors compared to the elementary education majors who we tested. The implications of these findings for guiding the teaching and assessing of problem solving in physics instruction will be discussed.

### BD04: 3-3:30 p.m. Applying Ideas of Visual Cognition to Problem Solving in Physics*

*Invited – N. Sanjay Rebello, Purdue University, Dept. of Physics and Astronomy, 525 Northwestern Ave., West Lafayette, IN 47907-2040; rebellos@purdue.edu*

*Elise Agra, University of Chicago*

*Xian Wu, Lester C. Loschky, Kansas State University*

*Tianlong Zu, Purdue University*

Problem solving is a major emphasis area of physics education that has been studied extensively over the past several decades. Frequently, physics problems – and their solutions – have strong visuospatial components. However, most research on physics problem solving has not drawn from research in visual cognition. Over the past four years a collaboration of physics education researchers and visual cognitive psychologists has been exploring and exploiting the link between cognition and eye movements manipulated by cueing and feedback to facilitate physics problem solving. We combine theoretical perspectives on problem solving, such as representational change theory with theoretical perspectives on visual cognition, such as multimedia learning theory; as well as empirical research on visual cueing and feedback to develop and refine a conceptual model for physics problem solving with multimedia cueing. I will describe the collaborative work of our group and possible implications for online learning in physics and other STEM disciplines. *This research is supported in part by the U.S. National Science Foundation under grants 1348857 and 1138697. Opinions expressed are those of the authors and not necessarily those of the Foundation.

*This research is supported in part by the U.S. National Science Foundation under grants 1348857 and 1138697. Opinions expressed are those of the authors and not necessarily those of the Foundation.

## Session BE: Developing Experimental Skills at all Levels

**Location:** CC - Room 314
**Sponsor:** Committee on Laboratories
**Date:** Monday, July 18
**Time:** 1:30–3:10 p.m.

*Presider: Mary Ann Klassen*

### BE01: 1:30-1:40 p.m. Assessing Students' Laboratory Skills in Introductory and Intermediate Physics Courses

*Contributed – Duane L. Deardorff, The University of North Carolina at Chapel Hill, Campus Box 3255, Chapel Hill, NC 27599-3255; duane.deardorff@unc.edu*

For the past 15 years at UNC-Chapel Hill, we have been assessing students' laboratory skills in the introductory physics courses, and this past year we added a practicum to the intermediate physics lab course. The purpose of these exams is to evaluate how well our students are meeting our learning goals that include making accurate measurements with typical laboratory instruments, analyzing and interpreting empirical data, evaluating results, analyzing measurement uncertainties, and properly communicating findings. Trends in student performance and lessons learned will be shared in this talk. Sample lab exam questions and answers with explanations are provided for students to help them prepare for their exams; these can be found on our department website: www.physics.unc.edu/labs

### BE02: 1:40-1:50 p.m. Teaching Techniques for Experimental Success

*Contributed – David D. Allred, Brigham Young University, N265 ESC Provo, UT 84602-4636; dda@byu.edu*

*Nathan D. Powers, Dallin S. Durfee, Brigham Young University*

Physics laboratory instruction in some institutions focuses on teaching students how to perform classic or state-of-the-art experiments. In some cases, the experiments involve using complex and sometimes expensive equipment. While working with these tools exposes students to equipment that they may use at a future time, it can leave them feeling dependent on specific equipment to carry out experiments. I describe an advanced laboratory course that instead focuses on introducing students to some core components and techniques that are incorporated into more advanced equipment. Students use the equipment and techniques to design and carry out their own experiment. This approach helps students understand the concepts, limitations, and advantages behind more advanced tools while promoting confidence in their ability to create their own solutions. Examples of student experiments are also presented.

### BE03: 1:50-2 p.m. Enhancing Student-designed Experiments Using a Real-world Funding Scenario

*Contributed – Nathan D. Powers, Brigham Young University, BYU Department of Physics and Astronomy, N490 ESC Provo, UT 84602-0002; ndp5@byu.edu*

*David Allred, Dallin S. Durfee, Brigham Young University*

Acquiring funds and resources is a critical skill for all experimentalists and technical professionals but the benefits of this skill go beyond money. The act of proposal writing requires one to become aware of what is interesting, important, and achievable. Thus, the process of competing for funds improves both the experiment and experimentalist. While proposal writing is not typically associated with laboratory education, it is an effective tool for enhancing a student's ability to design and carry out experiments. I describe a real-world funding scenario that was incorporated into an advanced laboratory course to improve the quality of student-designed experiments. To do this, different sections of a class formed a review panel that decided which experiments should be "funded". "Funded" projects were then developed into full proposals that were reviewed for final approval. Students found the peer evaluation aspect both engaging and insightful.

### BE04: 2-2:10 p.m. Developing Student Attitudes About Experimental Science and Being a Scientist

*Contributed – Linda E. Strubbe, University of British Columbia, 6224 Agricultural Road, Vancouver, BC V6T 1Z1, Canada; linda@phas.ubc.ca*

*Doug Bonn, Joss Ives, University of British Columbia*

Learning in the affective domain is an important goal in many undergraduate laboratory courses: e.g., goals that students increase their appreciation of physics as an evidence-based way of understanding the world, and that they increase their self-identity as scientists. Unfortunately, studies have found that students' attitudes about science are difficult to improve. In our "structured quantitative inquiry" first-year physics lab course at UBC, we have introduced several course components specifically targeting students' beliefs about the nature of science and their self-identification as scientists. We use the Colorado Learning Attitudes about Science Survey for Experimental Physics (E-CLASS) to investigate students' differing incoming attitudes, and how these attitudes change through the course. We describe preliminary results for the ~600 students in our course this year, who include a variety of science majors at both honors and non-honors levels.

### BE05: 2:10-2:20 p.m. Exploratory Freedom for Student Learning in Laboratory Settings

*Contributed – Peter W. Odom,* Oral Roberts University, 38 East 44th St., Tulsa, OK 74105; podom@oru.edu*

This paper discusses two separate physics laboratory experiments where the students were permitted to use more time than traditionally scheduled for each lab as well as permitted to deviate from specific lab instructions if they desired. The result of this added freedom was unprecedented success in experimental measurement accuracy. One of the experiments was to measure the speed of light using the Foucault method, and the other was to measure the charge-to-mass ratio of the electron using J. J. Thompson's method. With their measurement of the speed of light, they eventually achieved an accuracy that only had 0.8% error relative to the accepted value. Comparable success was achieved with their measurements of the charge-to-mass ratio of the electron. After recounting the process by which the students improved their methods in these two experiments, this paper discusses the merit of letting students have more freedom when exploring experimental methods.

*I am an undergraduate student being funded by a PhysTEC supported site for this specific conference.

### BE06: 2:20-2:30 p.m. Scientific Reasoning Curriculum Effect on Students' Control of Variables Skills

*Contributed – Krista E. Wood, University of Cincinnati, 9555 Plainfield Rd., Cincinnati, OH 45236; Krista.Wood@uc.edu*

*Kathleen Koenig, University of Cincinnati*

*Lei Bao, The Ohio State University*

There is a need to explicitly target the development of scientific reasoning (SR) skills in physics lab and to research the effects of SR-targeted curriculum on students SR skills. Focusing on one SR skill, this study evaluated the development of students' abilities in control of variables (COV) during the first implementation of a SR-targeted lab curriculum at a TYC. Students' COV skills were evaluated using nine COV questions from the Inquiry for Scientific Thinking and Reasoning (iSTAR) assessment that targeted various complexity levels of COV skills. Findings indicated that students' skill development varied at the different COV skill levels. The curriculum appeared to have the greatest impact at the intermediate COV skill level and less impact at the low and high skill levels. These findings will be used to inform lab curriculum revisions, as well as to improve the implementation of the lab curriculum in future terms.

### BE07: 2:30-2:40 p.m. Troubleshooting in the Electronics Lab: A Study of Instructor Practices

*Contributed – Dimitri R. Dounas-Frazer, University of Colorado Boulder, Department of Physics, 390 UCB Boulder, CO 80309-0390; dimitri.dounasfrazer@colorado.edu*

Heather J. Lewandowski, University of Colorado Boulder

The ability to troubleshoot systems is a crucial aspect of experimental physics research and an important learning goal for undergraduate laboratory courses. Electronics courses are well suited to developing students' troubleshooting abilities because the need to troubleshoot arises naturally in most lab activities. To understand the role of troubleshooting in electronics courses, we interviewed 19 electronics instructors from 17 distinct institutions. Preliminary analysis of interview data suggests that: (1) developing the ability to troubleshoot is fundamentally tied to the purpose of electronics courses, (2) electronics courses are perceived to be one of the few places in the curriculum where students develop troubleshooting skills, and (3) instruction about troubleshooting occurs primarily during lab activities via apprenticeship-style interactions between the instructor and pairs of students. Few interviewees indicated that they implemented activities or assessments explicitly designed to teach or test troubleshooting ability. In this talk we describe our study in more detail.

### BE08: 2:40-2:50 p.m. Flipped Modular Skills-based Introductory Electronics Course: First-year Results

*Contributed – Eric Ayars, California State University, Chico, Campus Box 202, Chico, CA 95929-0202; eayars@csuchico.edu*

After enjoying good results with a flipped introductory physics course, I decided to flip our department's sophomore-level "Electronics for Scientists" course and associated lab. The course redesign got out of control, though, and the course ended up a collection of interdependent modules through which students could progress at their own pace, along multiple paths of their own choosing. As of the submission date for this abstract it is unclear whether this redesign is a good thing or not; but there are already some clear advantages to this approach as well as some expected (and unexpected) problems. I expect that the advantages will dominate, but either way this talk promises to be educational for anyone considering such a course change.

### BE09: 2:50-3 p.m. A Pedagogical Method for Advanced Laboratory Writing: Letters Home Project

*Contributed – Charles L. Ramey II, Texas Tech University, 2500 Broad St., Lubbock, TX 79409-4349; charles.ramey@ttu.edu*

The Modern Physics course at Texas Tech University (TTU) serves as a bridge to other upper-level courses. In the lab segment, students expand their conceptual understanding while learning experimental and observational skills which are fundamental for advanced labs and research experience. This presentation will focus on a research project we call Letters Home (LH). LH are an informal means of practicing scientific writing skills to various levels of audience while engaging the writer in gathering, critically analyzing, and reporting data. In fall 2015 we conducted 4 sets of LH with 28 students. Currently, we are analyzing the results from the previous semester and report our results. We also used a survey, the Colorado Learning about Science Survey for Experimental Physics (E-CLASS), to assess students' attitudes about physics, communication, and experimentation. We are continuing this research to increase our understanding of students learning and attitudes.

### BE10: 3-3:10 p.m. Normal Modes and Symmetry Breaking in Single Two-Dimensional Pendulum

*Contributed – Arvind Arvind, IISER Mohali Knowledge City, Sector 81 Mohali, Pb 140306 India; arvind@iisermohali.ac.in*

*Paramdeep Singh, IISER Mohali*

A two dimensional pendulum is expected to execute planner oscillations if the observation time is small compared to one day, so that the effect of the coriolis force can be neglected. What if the cylindrical symmetry of the suspension is broken? It turns out that such a pendulum with a controlled symmetry breaking can be turned into a pedagogical tool. We have developed an experimental setup to demonstrate normal modes and symmetry breaking in a two-dimensional pendulum. The broken cylindrical symmetry leads to non-degenerate normal modes of oscillation whose interplay gives rise to complex motion. This motion has several qualitative and quantitative features that help us use this experiment to teach three concepts: normal modes, symmetry breaking and appreciating the difficulties associated with building a Foucault's pendulum.

## Session BF: Teacher in Residence (TIR) Role in Mentoring

**Location:** CC – Room 310
**Sponsor:** Committee on Teacher Preparation
**Date:** Monday, July 18
**Time:** 1:30–3:10 p.m.

*Presider: Jon Anderson*

### BF01: 1:30-2 p.m. Expert Teacher Advice and What "We" Expect from Student Teachers

*Invited – Frank Lock, Georgia State University, c/o 4424 Sardis Rd., Gainesville, GA 30506; fasterlock@att.net*

One assignment the Teaching Candidates (student teachers) at Georgia State were required to complete was an interview with an expert teacher. Responses to such an interview will be presented and discussed, as well as the expectations of the pre-service teachers who are preparing for a career teaching high school physics.

### BF02: 2-2:10 p.m. Defining the Role of the TIR

*Contributed – Cherie Bornhorst, Mines/UNC STEM Teacher Preparation Program, 920 W 29th St., Loveland, CO 80538; cherie.bornhorst@thompsonschools.org*

One of the newest PhysTEC sites is operating on the School of Mines campus, a highly selective pubic applied sciences and engineering research university, but is a partnership with one of the state's premier teacher preparation institutions, the University of Northern Colorado. In efforts to clearly define the Teacher in Residence role within the Mines/UNC STEM Teacher Preparation Program we (the three first-year TIR's) formed a Teacher Advisory Group (TAG). We have met regularly with the teachers, administrators, state officials, and policymakers who make up our TAG, and gained information from them about what makes for strong university-school partnerships. We've also learned that mentoring needs extend beyond the teacher candidates to also include host teachers, administrators, and faculty in the schools and districts where our students are being placed.

### BF03: 2:10-2:20 p.m. Rowan University: New PhysTEC Teacher in Residence Perspectives

*Contributed – Patrick L. Chestnut, Rowan University, 201 Mullica Hill Road, Glassboro, NJ 08028-1700; chestnut@rowan.edu*

Rowan University was recently awarded a Comprehensive Site grant by the Physics Teacher Education Coalition (PhysTEC). The goal of Rowan's PhysTEC project is to increase the number of highly qualified physics teachers entering the workforce by creating a teacher-rich environment within the Department of Physics & Astronomy where teaching high school physics is a relevant and admirable career path for physics majors. The purpose of this discussion is to provide insight related to opportunities and challenges encountered in the creation of new physics teachers at Rowan University. We will present topics from the perspective of a new TIR including site-specific considerations in hiring, training, and placing learning assistants in physics classrooms, the impact of students working as learning assistants on teaching dispositions, the formation of regional professional learning communities, potential solutions to overcoming challenges in navigating teacher certification pathways, and lastly, long-term sustainability of PhysTEC programs.

### BF04: 2:20-2:30 p.m. Shared Responsibility: Multiple Teachers in Residence

*Contributed – Pamela Word,* Texas State University, 601 University Dr., San Antonio, TX 78666; Pamelakay0707@gmail.com*

Texas State University is a first year PhysTEC site that chose to bring

on three current classroom teachers to fulfill the responsibilities of the Teacher in Residence (TIR) role. This model of TIR implementation benefits both the site and the teachers. The teachers are from three different school districts, and provide unique perspectives, opportunities, and resources for mentoring current and prospective students. In addition to the diversity afforded to the program, the sharing of TIR responsibilities among the three teachers allows for a better balance between their classroom teaching and university mentoring. This presentation will elaborate on these benefits as well as address possible challenges that may be encountered when implementing this model.
*Sponsored by Jon Anderson

### BF05: 2:30-2:40 p.m. An Informal Mentoring Program Using Outreach and Volunteering

*Contributed – Jeffrey A. Rodriguez, University of Cincinnati, 8593 Coran Drive, Cincinnati, OH 45255; jeffrodriguez@foresthills.edu*

Informal mentoring and contact with physics majors can be accomplished through outreach and volunteering opportunities. A discussion of the type of activities developed in order to get physics majors a feeling for what its like to be a physics teacher. Participation in several Saturday physics programs for high school students, judging local science fairs, assisting with science Olympiad, and giving demonstrations through a traveling science show will be addressed.

### BF06: 2:40-2:50 p.m. Creating a New PhysTEC Program at WVU

*Contributed – Michael Tilley, West Virginia University, 135 Willey St., Morgantown, WV 26505; michael.tilley@mail.wvu.edu*

Even with accommodating faculty and staff, starting a PhysTEC program in a new location has its challenges; these challenges mount when the program leads are also new to the university. Being a Teacher in Residence (TIR) through such a change has been exciting. A well-designed, cooperative support structure and professors with PhysTEC experience ensured that this new program started successfully. I will discuss my role as TIR in recruiting new future teachers to the also recently launched WVUteach, a UTeach replication site. I will discuss strategies for providing accessible information about teaching for introductory students and helping more advanced students through a complicated licensure environment. I will also discuss the TIR's role in developing a culture of respect for the art of teaching and knowledge of active learning strategies in a traditional teaching assistant population.

### BF07: 2:50-3 p.m. Transience with Continuity: The TIR Paradox

*Contributed – Adam LaMee, University of Central Florida, 517 London Rd., Winter Park, FL 32792; adamlamee@gmail.com*

In mentoring future physics teachers, a Teacher-in-Residence often draws upon what has worked in the past, networks with the existing K-20 Physics education community, and connects with undergraduates more personally than a series of mass emails would allow. And the TIR position can also rotate in as little as one year. So how can a TIR build continuity knowing much of what they accomplish will have to be done by a stranger next August? Time is well-spent enhancing the university culture of valuing the teaching profession. Being a catalyst for local teachers to come together, either socially or for professional development, fosters a community of educators who anticipate being contacted each year to host students for field experience. As TIRs come and go, culture and community persist. And cloud storage. Meticulously organized cloud storage.

### BF08: 3-3:10 p.m. Power of the Emotional Component in Teaching and Learning

*Contributed – Michael J. Ponnambalam, M. Sundaranar University, 7-40 Sannathi St., Vadakkankulam, Tirunelvely Dt. Tamil Nadu, 627116; michael.ponnambalam@gmail.com*

The author is a Master Teacher, and Mentor for New Physics Staff, University of the West Indies, Jamaican Campus from 2006 to retirement at 2013. This paper presents details on the enormous power of the teachers' infectious enthusiasm and caring attitude in teaching and learning.

## Session BG: I Leadership and Other Skills in the Undergraduate Curriculum

**Location:** CC - Room 312
**Sponsor:** Committee on Women in Physics
**Date:** Monday, July 18
**Time:** 1:30–3:30 p.m.

*Presider: Juan Burciaga*

### BG01: 1:30-1:50 p.m. Strategies for Gender Equity in STEM

*Invited – Carol Isaac, Mercer University, 3001 Mercer University Dr., Atlanta, GA 30341; isaac_ca@mercer.edu*

Research concludes that institutional transformation is required to ensure equal opportunities for the participation and advancement of men and women. Such transformation requires changing the habitual attitudes and behaviors of faculty and students in higher education. Approaching implicit bias as a remediable habit, this presentation will present a theoretical basis and conceptual model to give the attendees tools to promote bias literacy among students as a step toward career advancement. This presentation will give an overview of how significant organizational cultural change occurred within an institution (Carnes et al., 2014). This presentation will address three topics: implicit bias as a habit, constructs underlying implicit bias, and strategies to reduce the influence of implicit bias. While this presentation will focus on gender equity, this information is applicable to other underrepresented groups as well. This practical framework gives strategies to mitigate destructive cognitive distortions created by educators as well as their students.

### BG02: 1:50-2:10 p.m. Students Leading for Change: Collaboration Outside the Classroom

*Invited – Edmund Bertschinger, MIT 77 Massahusetts Ave., Room 4-250, Cambridge, MA 02139; edbert@mit.edu*

Leadership skills are learned by practice, not by rote. As the past year has shown, some of the best examples on college campuses arise from student activism. #ConcernedStudent1950 has reminded us of the leadership inherent in Margaret Mead's words, "Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has." Teachable moments abound: from sit-ins to teach-ins to student/administration collaboration to effect change. In all cases, the key to success is the development of relationships. Students crave and benefit from relationships with faculty that value them as individuals. In my experience, the most effective relationships are honed outside the classroom, even on the street. I will describe how such relationships led to a collaborative rather than confrontational approach to diversity and inclusion at one university that empowers all students.

### BG03: 2:10-2:30 p.m. A Fleet of Ships – From Scholarship to Entrepreneurship to Leadership

*Invited – Robert W. Brown, Case Western Reserve University, 109 Rockefeller Bldg., Department of Physics, Cleveland, OH 44106-7079; rwb@case.edu*

*Edward M. Caner, Case Western Reserve University*

The set of goals in the classes we teach are usually described in terms of critical thinking and mastery of material – the higher learning of scholarship. We hope to encourage students to work well together to solve problems in school and to overcome the fear of giving, defending, and promoting one's ideas – the development of leadership and citizenship. In today's world we place a high premium on interdisciplinary education – the interrelationship of the many different areas of

STEAM (science, technology, engineering, art and mathematics). For almost two decades, Case Western Reserve University has offered PEP – Physics Entrepreneurship Program – with courses and internships and start-up possibilities available to young undergraduates as well as the master's student. We will discuss how undergraduates bolster their group work, interdisciplinary experiences, capability for innovation, self-directed thinking skills, and develop leadership in ESTEAM – Entrepreneurship STEAM.

### BG04: 2:30-2:50 p.m. Educating the Whole Student

*Invited – Roel Snieder, Colorado School of Mines, 1500 Illinois St., Golden, CO 80401-1887; rsnieder@mines.edu*

Educating undergraduate students is an awesome task. In doing so we ted to focus on teaching them the disciplinary skills and knowledge, this is the easy part of education. But what we are tasked to do as educators is to teach students in their formative years when it concerns growing into the professional of tomorrow. The young professionals will go out in the world, and have an impact for better or for worse, and because they likely will educate or supervise other young people, there is a huge multiplier effect of the way in which we educate students. So what are the ways in which we can help grow young professionals into balanced and well-rounded professionals? I will give an overview of existing educational initiatives at the Colorado School of Mines that assist in this growth.

### BG05: 3-3:30 p.m. Leadership Development in a Workshop Environment

*Poster – Juan R. Burciaga, Bowdoin College/Dept. of Physics & Astronomy, 8800 College Station, Brunswick, ME 04011-8448; jburciag@bowdoin.edu*

"Leadership Roles and Models in the Classroom, Academia and Beyond" is a workshop with a focus on the role of leadership in the professional development of STEM faculty, K-12 teachers, and science professionals. But what is the role of leadership in our careers? On what skills do we focus? What is the structure of the workshop? Are there any ways to structure leadership opportunities for our students? The poster will present a summary of the workshop and describe its goals, format, and content.

## Session BH: Integrating Computation into the Curriculum

**Location:** CC - Room 315
**Sponsor:** Committee on Physics in Undergraduate Education
**Co-Sponsor:** Committee on Educational Technologies
**Date:** Monday, July 18
**Time:** 1:30–3:30 p.m.

*Presider: Joe Kozminski*

### BH01: 1:30-2 p.m. Computational Physics Skills and Practices in the Undergraduate Physics Curriculum

*Invited – Ernest Behringer, Eastern Michigan University, Dept. Physics and Astronomy, Ypsilanti, MI 48197; ebehringe@emich.edu*

The AAPT issued a statement on Computational Physics in 2011 urging "every physics and astronomy department [to] provide its majors and potential majors with appropriate instruction in computational physics." The urge to include computational physics provided part of the motivation for the establishment of the AAPT Undergraduate Curriculum Task Force (UCTF) in January 2013. UCTF members have developed a set of recommendations for including computational physics skills and practices in the undergraduate physics curriculum, and these recommendations will be described here. Information about current implementations of computational physics instruction will also be presented.

### BH02: 2-2:30 p.m. Using PER to Investigate Student Use of Computational Modeling

*Invited – Marcos Caballero, Michigan State University, 567 Wilson Rd., Room 1310A, East Lansing, MI 48824-2320; caballero@pa.msu.edu*

Computation has revolutionized how modern science is done. Modern physicists use computational techniques to reduce mountains of data, to simulate impossible experiments, and to develop intuition about the behavior of complex systems. And yet, while computation is a crucial tool of practicing physicists, modern physics curricula do not reflect its importance and utility. In this talk, I will discuss the urgent need to construct such curricula and present recently completed work that demonstrates that curricula can be developed into existing course structures at a variety of levels (high school through upper-division courses). I will also discuss how Physics Education Research can be leveraged to investigate student proficiency with computation and to document how students draw from physics, mathematics, and computing knowledge to construct working computational models. This research will help develop effective teaching practices, research-based course activities, and valid assessment tools.

### BH03: 2:30-3 p.m. Computation as Part of a Balanced Physics Curriculum

*Invited – Marie Lopez, Del Puerto University of St. Thomas, 2115 Summit Ave., Saint Paul, MN 55105; mlpuerto@stthomas.edu*

The University of St. Thomas Physics Department has been working toward a balanced undergraduate physics curriculum by embedding computation, experiment, and communication skills throughout our program. In this talk we will detail how we have integrated computation by 1) providing an introduction to computational physics in our sophomore-level Applications of Modern Physics course and laboratory, 2) adding short computational projects in many of lecture-based courses, and 3) developing a Methods of Computational Physics course. We will outline the homework problems and laboratories that have been developed as part of the Applications of Modern Physics project, discuss our experience implementing them, and give interested faculty information on how to obtain these materials. This project has been funded in part by NSF grant DUE-1140034.

### BH04: 3-3:30 p.m. The Role of Computational Modeling in Engaging and Developing Successful Physics Students

*Invited – Aaron Titus, High Point University, One University Way, High Point, NC 27268; atitus@highpoint.edu*

Departmental learning objectives at High Point University include theory, experimental physics, and computational modeling. All three are important, and all three are woven into the four-year curriculum. Physics students learn VPython in the introductory calculus-based physics course using "Matter and Interactions" by Ruth Chabay and Bruce Sherwood. Simultaneously, students engage in a year-long introductory research project that often includes both experimental and computational components. At the second year and beyond, students use Jupyter Notebook (formerly IPython Notebook) for computational modeling, data analysis, and informal communication of their work. This approach prepares students to use computational modeling as a tool for research and problem solving, starting in their first year. Furthermore, it has an extraordinary impact on growing a thriving department. I will provide details of our approach, examples of student work, and evidence of its impact.

## Session BI: PER in Upper Divisions

**Location:** CC - Room 304/305
**Sponsor:** Committee on Research in Physics Education
**Date:** Monday, July 18
**Time:** 1:30–3:30 p.m.

*Presider: Mary Bridget Kustusch*

### BI01: 1:30-2 p.m. A Framework for Understanding the Patterns of Student Difficulties in Quantum Mechanics

*Invited – Chandralekha Singh, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu*

*Emily Marshman, University of Pittsburgh*

We describe a framework for understanding the patterns of student reasoning difficulties and how students develop expertise in quantum mechanics. The framework posits that the challenges many students face in developing expertise in quantum mechanics are analogous to the challenges introductory students face in developing expertise in classical mechanics. This framework incorporates the effects of diversity in students' prior preparation, goals and motivation for taking upper-level physics courses in general as well as the "paradigm shift" from classical mechanics to quantum mechanics. The framework is based on empirical investigations demonstrating that the patterns of reasoning, problem-solving, and self-monitoring difficulties in quantum mechanics bear a striking resemblance to those found in introductory classical mechanics. Examples from research in quantum mechanics and introductory mechanics will be discussed to illustrate how the patterns of difficulties are analogous as students learn to grasp the formalism in each knowledge domain during the development of expertise.

### BI02: 2-2:30 p.m. Student Ontologies in Teaching Quantum Mechanics and Researching Student Difficulties

*Invited – Charles Baily, University of St. Andrews, School of Physics & Astronomy, North Haugh St., Andrews, Fife, KY16 9SS Scotland, UK; crb6@st-andrews.ac.uk*

The primary focus of the majority of quantum mechanics education research to date has been on student difficulties with understanding and applying the mathematical formalism. Our research has shown that, regardless of the instructional approach, students do develop mental models of quantum processes, which influence (or are influenced by) their understanding of quantum theory. However, very little has been done to bridge the gap between these two lines of research; for example, the potential relationship between students' ontologies and their successes and difficulties with understanding quantum measurement has yet to be explored in depth. This talk will present evidence of the positive impact on student thinking of a modern physics curriculum that explicitly attends to students' classical and quantum ontologies. I will then summarize some of the efforts to draw connections between student ontologies and their understanding of quantum theory, and suggest potentially fruitful lines of research for the future.

### BI03: 2:30-3 p.m. Ontologies in Quantum Mechanics as a Research and Instructional Lens*

*Invited – Benjamin W. Dreyfus, University of Maryland, College Park, Department of Physics, College Park, MD 20742-2421; dreyfus@umd.edu*

*Erin Ronayne Sohr, Ayush Gupta, University of Maryland, College Park*

*Jessica Hoy, Noah D. Finkelstein, University of Colorado, Boulder*

Developing expertise in quantum mechanics involves not only learning new physics concepts and using new mathematical tools, but activating new ontologies: conceptions about what kind of entity something is. For example, the quantum mechanical electron shares some attributes with a classical particle and some with a classical wave, but also displays characteristics without clear classical analogs. One element of gaining a deeper understanding of quantum mechanics is increased metacognition about the productive ontologies to activate in a given situation. This talk synthesizes results from a collaborative project at Maryland and Colorado to present the implications for both research and instruction of an ontologies perspective to learning quantum mechanics. Encouraging students' ontological and metacognitive development has been a design goal for our curricular materials. Our research documents that students have the capacity for flexibility and reflectiveness around ontological conceptions, and this can benefit their understanding of quantum concepts.

*This work is supported by NSF-DUE 1323129 and 1322734.

### BI04: 3-3:30 p.m. Session Summary: The State of Quantum Mechanics PER

*Invited – Gina Passante, California State University, Fullerton, 800 N. State College Blvd., Fullerton, CA 92831-3547; gpassante@fullerton.edu*

I will act as a discussant for this invited session on PER in the upper division. In this role I will discuss how the research presented fits into the bigger picture of quantum mechanics PER, how the projects relate to each other, and propose some broader questions. I will leave plenty of time for the audience to ask additional questions of all presenters.

## Session BJ: Physicists with Disabilities

**Location:** CC - Room 311
**Sponsor:** Committee on Women in Physics
**Co-Sponsor:** Committee on Diversity in Physics
**Date:** Monday, July 18
**Time:** 1:30–3:10 p.m.

*Presider: Dwain Desbien*

### BJ01: 1:30-1:40 p.m. I Am a Disabled Physicist! But You Don't Look Handicapped!

*Contributed – Rebecca Lindell, Purdue University, 525 Northwestern Ave., West Lafayette, IN 47907; rlindell@purdue.edu*

I am one of many disabled physicists who does not look handicapped. Many of us remain hidden and do not share our disability with others for fear of being judged incapable of being a physicist. In this talk, I will introduce this special session on being disabled in physics, as well as hopefully raise the awareness of what it means to be a disabled physicist.

### BJ02: 1:40-2:10 p.m. My Joyous Struggle: Defying the Odds...and Still Climbing

*Invited – Angela M. Moore, Chicago State University, 7650 S. Saginaw Ave., 2nd Floor, Chicago, IL 60649; angela.moore27@gmail.com*

The focus of this talk is to detail my personal struggles with multiple chronic health conditions, while trying to obtain degrees in Engineering, Physics, and a certification in Secondary Education. I will cover how disability has affected my ability to pursue my original career, and caused me to search for a second. This has been a struggle that has lasted for more than two decades. The struggle has been intensified by caring for a disabled parent, and a special needs child, but is far from over. I will share my insights on how my path could have been a little easier. I hope to inspire and empower other women in physics to keep climbing and to defy the odds. Disability, gender, and race, will not limit me.

### BJ03: 2:10-2:40 p.m. You're Smart But . . . . Experiences as a Disabled Graduate Student

*Invited – Cristina I. Moody, 73 Pier Dr., Apt 102, Westmont, IL 60559; cristina_moody@yahoo.com*

I will present my perspective on being a woman with unseen disabilities, how this impacted the interactions, attitudes, and policies of my professors and department, and how this shaped my decisions to pursue and, ultimately, leave my PhD in physics.

Sponsored by Rebecca Lindell.

### BJ04: 2:40-3:10 p.m. "But You Don't Look Sick..." Tenure Track with a Disability

*Invited – Wendi N. Wampler, Central Oregon Community College, 2600 NW College Way, Bend, OR 97703; wwampler@cocc.edu*

In this talk, I will discuss my experiences dealing with my physical disability in graduate school, as an adjunct professor, and now as a tenure-track professor. My focus will be on the difficulties I faced finishing graduate school, my continuing difficulties achieving a work-health balance, as well as long-term wellness plans being considered by my institution.

## Session BK: Astronomy Papers

**Location:** CC - Room 301
**Sponsor:** AAPT
**Date:** Monday, July 18
**Time:** 1:30–2:20 p.m.

*Presider: Kathleen Falconer*

### BK01: 1:30-1:40 p.m. The Cosmic Perspective Timeline

*Contributed – Kristi D. Concannon, 133 North River St., Wilkes Barre, PA 18711; kristiconcannon@kings.edu*

The study of astronomy is vast both in space and time. To students, the 15-week tour of the universe is often little more than a series of facts and figures related to objects beyond reach or comprehension; there is little connection to their human story. To them, our understanding of the universe seems fixed, not fluid. While students may learn the story of the physical universe, they fail to appreciate how our understanding of our human place in the cosmos has changed over time. The cosmic perspective timeline is a short activity that encourages students to consider the timing of the key shifts in our understanding of the universe and to appreciate the changing nature of science.

### BK02: 1:40-1:50 p.m. Learning to See in Astronomy: Distinguishing Nebula in Telescopic Images

*Contributed – Luke D. Conlin, Stanford University, 1919 Cooley Ave., East Palo Alto, CA 94303; lconlin@stanford.edu*

A critical skill in astronomy, for professional astronomers and citizen scientists alike, is to distinguish astronomical objects in telescopic images. Little is known about the process of learning this skill, or how to effectively teach it. This study presents an experimental comparison of two approaches for training undergraduate students to distinguish and classify nebulae (planetary nebulae and supernova remnants). In one approach, students learned the visual characteristics of nebulae by comparing several exemplars to highlight similarities. In the other approach, students compared images that were paired as contrasting cases to highlight differences. Results from pre- and post-test measures show that both approaches helped students learn to distinguish nebulae, with contrasting cases showing descriptively (but not significantly) higher gains. Pre- and post-test measures of confidence suggest that part of the learning may be metacognitive: students learned to attune their confidence to their performance. Implications for teaching and research will be discussed.

### BK03: 1:50-2 p.m. Impact of Prior Astronomy Learning Experiences on TOAST Scores

*Contributed – Katie J. Berryhill, University of Wyoming, 1000 E University (Mail Code 3374), Laramie, WY 82071; timslaterwyo@gmail.com*

*Timothy F. Slater, University of Wyoming*

*Stephanie J. Slater, CAPER Center for Astronomy & Physics Education Research*

As Introductory Astronomy educators become more interested in experimentally testing innovative teaching strategies to enhance learning in ASTRO 101, scholars are placing increased attention toward better understanding factors impacting student gain scores on the widely used Test Of Astronomy STandards (TOAST). Usually used in a pre-test and post-test research design, one might naturally assume that the pre-course differences observed between high- and low-scoring college students might be due in large part to their pre-existing motivation, interest, and attitudes about astronomy. To explore this notion, 12 non-science majoring undergraduates taking ASTRO 101 at West coast community colleges were interviewed in the first few weeks of the course to better understand students pre-existing affect toward learning astronomy. Perhaps surprisingly, there was only weak correlation between students' motivation toward learning astronomy and their pre-test scores. Instead, the most fruitful predictor of pre-test scores was the quantity informal, self-directed astronomy learning experiences.

### BK04: 2-2:10 p.m. "How To Be Invisible?" As an Introduction to the Electromagnetic Spectrum

***abstract has moved to CA06***

*Contributed – Richard Gelderman, Western Kentucky University, Hardin Planetarium, 1906 College Heights Blvd., Bowling Green, KY 42101-1077; gelderman@wku.edu*

"I need your help. I must find a way to be completely invisible." This request is a perfect way to start any unit on optics and the nature of light, because the responses from the students in your class will invariably hit on every topic you hope to cover. Let then describe what it means to be opaque or transparent. Let them work out what it means to get light to bend from its tendency to travel in straight lines. Let them bring up detection at infrared, or other wavelengths in the electromagnetic spectrum.

### BK05: 2:10-2:20 p.m. Overview of U.S. Astronomy Education Research Dissertations in the iSTAR Database

*Contributed – Stephanie J. Slater, CAPER Center for Astronomy & Physics Education Research, 604 S 26th St., Laramie, WY 82070; stephanie@caperteam.com*

*Coty B. Tatge, Timothy F. Slater, University of Wyoming*

*Sharon P. Schleigh, East Carolina University*

*Paulo S. Bretones, Universidade Federal de São Carlos, Brazil*

Collecting and synthesizing the surprisingly vast amount of discipline-based astronomy education research is of great interest to astronomy education research scholars trying to understand the range and depth of prior studies. In support of those efforts, the CAPER Center for Astronomy & Physics Education Research has been developing the infrastructure needed to create and curate a comprehensive International Study of Astronomy Reasoning (iSTAR) Database, an online, searchable research tool, intended to catalog, characterize, and provide access to astronomy education research production, worldwide. As a first step to test iSTAR's functionality we surveyed the previously uncatalogued set of U.S.-based doctoral dissertations. This first-light target population was selected for its anticipated familiarity to the iSTAR team, and for its small expected sample size (50-75 objects). To our great surprise, our first-light observations revealed an excess of 300 astronomy education research dissertations, which were characterized across multiple variables.

## Session CA: Using Popular Media to Teach Astronomy

**Location:** CC - Room 306
**Sponsor:** Committee on Space Science and Astronomy
**Co-Sponsor:** Committee on Science Education for the Public
**Date:** Monday, July 18
**Time:** 4–5:50 p.m.

*Presider: Richard Gelderman*

### CA01: 4-4:30 p.m. How I Learned to Stop Worrying and Love Science in Movies

*Invited – Jacob Clark Blickenstaff, Pacific Science Center, 200 2nd Ave., North Seattle, WA 98109; jclarkblickenstaff@pacsci.org*

We should never underestimate the influence high school teachers have on their students. My high school physics teacher, Jerry Fujii, used to post newspaper articles that connected to some aspect of our class. I remember clearly that one had the headline "Superman Fails Physics," and now I realize that is where my interest in looking for real science in films and TV began. Since 2008 I have contributed a regular column to the National Science Teachers Association newsletter titled "Blick on Flicks." I will share a bit of the origin story for the column, describe a couple of the fun connections I have made, and attempt to stimulate some further thinking about using creative media in the science classroom.

### CA02: 4:30-5 p.m. Interdisciplinary Teaching: Science Fiction, Poetry, Drama, Music and More

*Invited – Andrew Fraknoi, Foothill College, 12345 El Monte Rd., Los Altos Hills, CA 94022; fraknoiandrew@fhda.edu*

For over three decades, I have enhanced my astronomy and "physics for poets" classes by including discussions of science fiction, music, drama, and poetry inspired by science in the course. I can make the properties of black holes come alive through a story where the protagonist swiftly must "dump" part of his spaceship into a black hole, so that his part remaind above the event horizon. Only later does he realize his girlfriend was on the part he dumped! Students enjoy pieces of music that relate to topics we study in astronomy, including some where science-data determine the notes or rhythm. I keep a website of science fiction with good physics and astronomy at: www.astrosociety.org/scifi and a list of astronomically inspired music at: http://dx.doi.org/10.3847/AER2012043 I'll have a handout on where to find a range of such interdisciplinary resources and fun examples that your students are likely to enjoy.

### CA03: 5-5:30 p.m. Just Real Enough – The Art of Physics at Pixar

*Invited – William A. Wise, Pixar Animation Studios, 1200 Park Ave., Emeryville, CA 94608; bwise@pixar.com*

At Pixar we use many physics-based tools to achieve the look of our films. From the light transport mechanisms used to model translucency in skin shading, to the bi-directional reflectance functions used in our lighting tools, to the fluid and finite element simulators we use to produce water or flesh and skin simulations — all use physics-based approaches drawn from many disciplines. But given that our task is to create art (and please directors and production designers) and not scientific visualization, there are a host of ways in which we cheat modify or otherwise bend physics to achieve our esthetic desires. This presentation investigates both the science and art of using physics to create the illusion of reality.

### CA04: 5:30-5:40 p.m. OK GO! (And Other Popular Culture Contexts to Learn Astronomy!)

*Contributed – Richard P. Hechter, University of Manitoba, Education Building, Room 234 Winnipeg, MB R3T2N2, Canada; richard.hechter@umanitoba.ca*

*Quinn J. Morris, University of Manitoba*

Come join us as we describe our use of popular culture media, including OK GO's "zero-g" music video for their song "Upside down and inside out", and other music, film, and television pieces as the contexts to teach and learn astronomical phenomena. This presentation will detail how we merged pragmatic strategies of this pedagogical approach with theoretical underpinnings of teaching and learning physics in our teacher education program, and how we shifted that focus in the secondary school to using the integration of popular culture media to encourage greater student investment in their learning.

### CA05: 5:40-5:50 p.m. Survivability of Potatoes and Soil Bacteria in a Mars Chamber

*Contributed – Jay Nadeau, Caltech, 1200 E. California Blvd., Pasadena, CA 91125-0001; jnadeau@caltech.edu*

*Manuel Bedrosssian, Chris Lindensmith, Caltech*

*Kris Zacny, Kathryn Luczek, Honeybee Robotics*

A key plot element of The Martian is death of potato plants grown by a stranded astronaut when the plants are subjected to Mars ambient temperature and pressure for ~1 day. It is a common misconception that water evaporates very rapidly on Mars. However, observations have demonstrated that the evaporation rate of water at low and moderate temperatures is relatively slow, allowing for a water cycle on the surface of the planet. Binding of water to soils also reduces evaporation. Based upon these studies and calculations of maximum evaporation rates, we hypothesized that potato plants and associated soil bacteria would be able to survive 24 h at 6 torr at either ambient temperature (~10 ºC, Martian summer) or -20 ºC. Tests were performed in a Mars chamber using a 2-gallon Russet potato. Results, including estimates of water loss and soil bacteria counts, are shown and discussed in a thermodynamic context.

## Session CB: PER: Modeling Student Engagement

**Location:** CC - Room 307
**Sponsor:** AAPT
**Date:** Monday, July 18
**Time:** 4–6 p.m.

*Presider: Colleen Megowan-Romanowicz*

### CB01: 4-4:10 p.m. Characterizing How Students Group Themselves for Group Exams

*Contributed – Joss Ives, University of British Columbia, 2329 West Mall, Vancouver, BC V6T 1Z4 joss@phas.ubc.ca*

When using ad hoc student groups for group exams, how do students group themselves? Are there clear preferences for grouping by sex, ability in the course, or years in university? In courses with multiple opportunities to form these ad hoc groups, do these preferences change as the course proceeds? This research is part of a larger study investigating the factors that contribute to group success, both in terms of the group's performance on that group exam as well as the performance of individuals on later assessments.

### CB02: 4:10-4:20 p.m. Group Formation on Physics Exams

*Contributed – Steven F. Wolf, East Carolina University, C-209, Howell Science Complex, Tenth St. Greenville, NC 27858-4353; wolfs15@ecu.edu*

*Cody Blakeney, Hunter G. Close, Texas State University*

As our classrooms become more active and collaborative, we need to consider ways that our assessments can take on the same active and collaborative spirit that our classes have. One way that has come into practice is through the use of group exams. We hypothesize that student groupings are embedded within exam response data giving us an assessment of our students' social profiles. This makes group exam response data an untapped resource that can tell us more about our students than their score on an exam. Using a duplicate exam format, we are developing a method for analyzing group formation for a particular exam using the framework of network analysis. This method will be compared to self-reported student grouping data for verification. Looking forward, we will consider questions such as, "Who do I need to work harder to include in the class?" and "Who might make a good LA?"

### CB03: 4:20-4:30 p.m. Performance and Active Engagement Through the Lens of Classroom Networks

*Contributed – Eric A. Williams, Florida International University, 11200 SW 8th St - CP 204, Miami, FL 33199; ewill085@fiu.edu*

*Justyna P. Zwolak, Eric Brewe, Remy Dou, Florida International University*

Theories developed by Tinto and Nora identify academic performance, learning gains, and student involvement in learning communities as important facets of student engagement that support student persistence. Collaborative learning environments, such as those employed in the Modeling Instruction (MI) introductory physics course, are considered especially important. Due to the inherently social nature of collaborative learning, we examine student social interactions in the classroom using Network Analysis methods to analyze a survey administered periodically in class. We then calculate centrality, a family of measures that quantify how connected or "central" a particular student is within the classroom social network. Building on previous work indicating relationships between classroom interactions and performance, we investigate this relationship further to better understand how student engagement manifests in the context of a large-scale MI course at Florida International University.

### CB04: 4:30-4:40 p.m. Assessing Difficult to Assess Learning Goals – Formative Feedback in P3

*Contributed – Paul W. Irving, Michigan State University and CREATE for STEM Institute (MSU), 1310A Biomedical and Physical Sciences Building, East Lansing, MI 48824-2320; paul.w.irving@gmail.com*

*Marcos Caballero, Michigan State University and CREATE for STEM Institute (MSU)*

P3 is a transformed introductory mechanics course at Michigan State University that focuses on the development of scientific practices. The design team, as part of the P3 course design made explicit attempts to assess learning goals that can often be perceived as being a part of the hidden curriculum or considered difficult to assess (for example: learning to work productively in a group). This assessment is in the form of formative feedback with students receiving a numbered grade and reflective commentary based around their interactions in the classroom for the week. In this presentation, case studies formed from student interviews conducted at the beginning and end of the semester are discussed to highlight how the formative feedback received, effected changes in student interactions in class. The presentation also highlights students' reflections on the feedback and how the effect it had on them changed over time.

### CB06: 4:50-5 p.m. "Stupidity in Science" – NOS Lesson or Balm for Inquiry Angst?*

*Contributed – Andy P. Johnson, Black Hills State University, CAMSE, 1200 University, Spearfish, SD 57799-9005; andy.johnson@bhsu.edu*

*Brant Hinrichs, Christos Deligkaris, Drury University*

Students in research-and-inquiry-based physics courses tend to feel uneasy with the lack of answers from the professor or textbook. Years of traditional schooling teach students to seek answers outside of their own reasoning. Also, students tend to bring to our classrooms unproductive views of science as being about "right answers" and they discount sense-making. Despite our efforts to encourage students to take risks and rely on their wits, many students feel unease about their ideas because they are not from authorities. Martin Schwartz addressed a similar concern among scientists in his essay "The importance of stupidity in scientific research". In this article Schwartz frames ignorance or stupidity as the essential driver of scientific research. We have investigated changes in student affect that result from reading this article as a homework assignment and find that, while students often misunderstand the point of the article, their feelings about the course improve considerably. *The Inquiry into Radioactivity Project has been supported by NSF DUE grant 0942699. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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### CB07: 5-5:10 p.m. Splits in Students' Attitudes Toward Classical and Quantum Physics*

*Contributed – Benjamin William Dreyfus, University of Maryland, College Park, Department of Physics, College Park, MD 20742-2421; dreyfus@umd.edu*

*Jessica Hoy, University of Colorado, Boulder*

*Erin R. Sohr, Ayush Gupta, Andrew Elby, University of Maryland*

Instruments that measure students' attitudes and epistemological beliefs about physics often assume implicitly that "physics" is monolithic. That is, while there are multiple dimensions to student attitudes, physics itself is treated as a single discipline. We administered a survey in modern physics courses for engineering students, with modified CLASS (Colorado Learning Attitudes about Science Survey) survey items in which "physics" was changed to "classical physics" and "quantum physics," and found significant splits between students' self-reported attitudes toward classical and quantum physics, both pre- and post-instruction. Specifically, students display greater evidence of real-world connections and problem-solving sophistication with classical than with quantum physics. We also found that, under some conditions, quantum physics instruction was associated with a pre-/post-shift in attitudes toward classical physics.

*This work is supported by NSF-DUE 1323129 and 1322734.

### CB08: 5:10-5:20 p.m. Research on Identity Trajectories in Undergraduate Research Experiences

*Contributed – Gina M. Quan, University of Maryland, 082 Regents Drive, College Park, MD 20782; gina.m.quan@gmail.com*

*Chandra Turpen, Andrew Elby, University of Maryland*

In this talk, we analyze shifts in students' identity trajectories as undergraduate physics majors participating in their first research experiences. Students in the study participated in an elective seminar in which they were paired with graduate student and faculty mentors on physics research projects and participated in a weekly discussions about research. Using video data from student interviews, classroom observations, research mentor interviews, and research observations, we study the development of students' identity trajectories. Relational dynamics between students and other members of the physics community contributed to the legitimization and delegitimization of students' physics identities. We highlight shifts in how students positioned themselves, and were positioned by others as more and less central members of the physics community. Finally, we draw out connections between student trajectories, and discuss implications for future research and programmatic design.

### CB09: 5:20-5:30 p.m. Traditional Physics vs. IPLS: Comparing Student Experiences

*Contributed – Haley Gerardi, Swarthmore College, 500 College Ave., Swarthmore, PA 19081; bgeller1@swarthmore.edu*

*Max Franklin, Benjamin Geller, Catherine Crouch, Swarthmore College*

*Chandra Turpen, University of Maryland, College Park*

At Swarthmore College, we recently introduced a first-semester Introductory Physics for the Life Sciences (IPLS) course that draws on authentic biological examples relating to kinematics, Newtonian mechanics, and thermodynamics. Because the course is offered only

every other year, we are uniquely situated to compare the experiences of those students who take the IPLS course to a similar set of students who take a traditional first-semester introductory physics course that covers the same topics but does not foreground biological connections. In this talk we draw on conceptual and attitudinal survey data, as well as a series of case-study interviews, to describe the conceptual, epistemological, and affective differences that we observe between the two student populations. We identify the features of the IPLS experience that were most salient to students, and suggest how particular course structures may have been especially important in supporting students' ability to do well in the IPLS environment.

### CB10: 5:30-5:40 p.m. Students' Problem Solving in an Upper Division Electromagnetic Field Course

*Contributed – Hai D. Nguyen, Kansas State University, 116 Cardwell Hall, Manhattan, KS 66506; donghai.per@gmail.com*

*Deepa Chari, Dean Zollman, Eleanor C. Sayre, Kansas State University*

As part of their upper-division electromagnetic fields course, students work in small groups to solve physics and mathematics problems during class. We categorize their epistemological framing along two orthogonal axes — physics to math and algorithmic to conceptual — to determine how shifts in students' framing interact with the instructor's framing and the problem at hand. Drawing from observational video data of classroom interactions, we characterize framing shifts over 50 episodes throughout two iterations of the course, seeking both diversity of student responses and diversity in problem type and duration. In this talk, we present our framework and some preliminary results.

### CB11: 5:40-5:50 p.m. Student Positioning in an Inquiry-based Physics Content and Methods Course

*Contributed – Enrique A. Suarez, University of Colorado, Boulder, School of Education, Boulder, CO 80309-0249; enrique.suarez@colorado.edu*

*Shelly M. Belleau, University of Colorado, Boulder*

This PER study focuses on university students in the physics content and pedagogy course, Energy and Interactions (formerly Physics and Everyday Thinking). By design, this course prepares future teachers and fulfills an undergraduate science requirement, thus enrolling students from a wide range of experiences and comfort with science content, from confident to struggling. The course is driven by students as they co-construct principles from lab-based evidence. This study asks how students describe and position themselves as learners in this environment, and how their positioning changes as they engage with different kinds of activities. We analyze students' weekly reflections and conceptual assessment scores. Preliminary results indicate that students are at first resistant to this student-driven model, but quickly start reporting feeling more confident in their abilities and reasoning, and begin valuing co-constructing knowledge with peers. We will present results and make inferences about how course components influence this shift in positioning.

### CB12: 5:50-6 p.m. Using Clickstream Analysis to Understand Student Peer Evaluation

*Contributed – Scott S. Douglas, Georgia Institute of Technology, 837 State St., Atlanta, GA 30332; scott.s.douglas@gatech.edu*

*John M. Aiken, Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences*

*Edwin F. Greco, Michael F. Schatz, Georgia Institute of Technology*

Peer grading of student work has been used extensively in large-enrollment courses, but this evaluative practice has not yet been deeply explored in the context of student work submitted as videos. Georgia Tech has run three semesters of an introductory mechanics course in which students were required to create lab reports as videos and post them online. We investigate student grading behaviors by comparing students' ratings of peer-produced lab reports with the students' online (clickstream) interactions with those lab reports during the grading process. We discuss particular features of the peer-grading process which may influence student ratings and engagement.

## Session CC: Physics and the Maker Movement

**Location:** CC - Room 310
**Sponsor:** Committee on Science Education for the Public
**Date:** Monday, July 18
**Time:** 4–6 p.m.

*Presider: Phillip Hammer*

### CC01: 4-4:30 p.m. Makerspaces and Beyond: Creating Unique Extensions through Physics

*Invited – Randall Tagg, University of Colorado, Denver, Physics, Campus Box 157, Denver, CO 80217-3364; randall.tagg@ucdenver.edu*

The rapid growth in popularity of Maker Spaces as community centers for design and innovation is a key opportunity to capture interest in physics as a subject of broad utility. An expanded version of a Maker Space called the "Innovation Hyperlab" shows how a wide range of topics in applied physics can be made accessible and useful to a larger community. This includes more advanced topics, such as photonics, electromagnetism, and microtechnology. Physics students serve important roles as participants, guides, and innovators in this highly creative environment. Students gain as much as they give by working with artists, engineers, small businesses, community members, teachers, youth, retirees, and many others. A space well equipped with physics instrumentation and methods becomes a powerful resource for innovation.

### CC02: 4:30-5 p.m. Physics Innovation and Entrepreneurship at a Liberal Arts University*

*Invited – Wouter Deconinck, College of William & Mary, P.O. Box 8795, Williamsburg, VA 23187; wdeconinck@wm.edu*

The Small Hall Makerspace in the Physics Department at the College of William & Mary, Virginia, provides students with access to equipment that is usually only found in research labs and machine shops, off-limits to all but a few. By encouraging an ecosystem of student clubs and the integration of makerspace activities in courses, the makerspace has expanded to provide students of both arts and sciences with a space where they can learn and innovate in interdisciplinary groups without the time pressures and rigid expectations of traditional teaching labs. In collaboration with the Entrepreneurship Center of the Business School, we are developing an entrepreneurship physics track that combines makerspace projects with development of funding proposals, business plans and management plans. At our relatively small institution without an engineering school we are using the makerspace to create experiences in innovation and entrepreneurship for our students.

*This work was supported in part by the National Science Foundation under Grant Nos. PHY-1359364, PHY-1405857.

### CC03: 5-5:30 p.m. Case Study: A Small Town Makerspace

*Invited – Jack Perrin Gorge, MakerSpace, P.O. Box 2273, White Salmon, WA 98672-2273; jacksonperrin@gmail.com*

The makerspace movement is a growing phenomenon that has the potential to engage diverse populations across the country in STEM subjects. The makerspace concept is simple: provide tools, expertise and a space to people and let them solve a design challenge in their own creative way. The manifestations of the movement are as varied as the populations they serve; there are makerspaces in libraries, schools, private tech firms, scouts and youth clubs, even refugee camps. Gorge MakerSpace serves kids with nowhere to go after school, families who want to learn together, homeschoolers, middle and high schoolers, summer campers and more. This presentation will highlight the format and content that has worked well at Gorge MakerSpace, including exciting new learning technologies like sewable electronics and open source platforms (e.g. Ardunio).

### CC04: 5:30-6 p.m. Art, Physics, Imagination

*Invited – Paul DeMarinis, Stanford, Dept. of Art & Art History, 355 Roth Way, Stanford, CA 94305; demarini@stanford.edu*

*Franco DeMarinis, Oakland Tech High School*

Artists have drawn on both the concepts and the lore of physics for inspiration and critical examination. Works by several contemporary artists who employ specific principles of physics such as fluid dynamics and will be presented and discussed along with ideas of how artists elaborate the treatment of these principles into artworks that engage the mind and the senses. An additional presentation will cover how artworks using physical principles can be employed in the classroom to demonstrate a variety of phenomena and serve as the basis for study of fundamental topics.

## Session CD: Professional Development Opportunities: Participant Perspective on What Works

**Location:** CC - Room 311
**Sponsor:** Committee on Women in Physics
**Co-Sponsor:** Committee on International Physics Education
**Date:** Monday, July 18
**Time:** 4–5:30 p.m.

*Presider: Patricia Sievert*

### CD01: 4-4:30 p.m. Professional Development Supporting Women in Physics at All Career Levels

*Panel – Beth Cunningham, American Association of Physics Teachers, 1 Physics Ellipse, College Park, MD 20740-3845; bcunningham@aapt.org*

*Anne Cox, Eckerd College*

*Sherry Yennello, Texas A&M University*

*Elaine Lalanne, UMBC*

A number of professional development opportunities exist for women in physics to network, mentor early career women, and receive advice from other women who are in similar situations. Some networks are small, such as mentoring groups, and some networks are larger, such as those built around the IUPAP International Conference on Women in Physics. We will describe activities that enhance experiences that women have through the U.S. Delegation to the IUPAP International Conference on Women in Physics. Specifically, we found that the process of selecting and engaging a group of women to prepare for an international conference focused on the experiences of women in physics across the world provided a unique platform for professional development. Deepened connection with the U.S. delegates provided to be one of the most beneficial outcomes. The networking between U.S. delegates continues long after the conference and has led to new projects supporting women in physics.

### CD02: 4:30-5 p.m. Mutual Mentoring and eAlliances*

*Panel – Cindy Blaha, Carleton College, One North College St., Northfield, MN 55057; cblaha@carleton.edu*

*Beth Cunningham, AAPT Executive Officer*

*Anne Cox, Eckerd College*

*Idalia Ramos, University of Puerto Rico at Humacao*

*Barbara Whitten, Colorado College*

There are many opportunities for professional development in physics, but you may wonder which will be worth your investment of time and energy. We will discuss the benefits of mutual mentoring for career development. One of us has been a member of a horizontal mentoring alliance of five senior women at liberal arts colleges. What began as part of an NSF-ADVANCE project from 2007-2010, and continues to the present, provides us all with important professional and personal support and fulfills mentoring needs we didn't even know we had. Horizontal or mentoring is very beneficial for under-represented and/or isolated groups within a profession. AAPT has recently received an NSF-ADVANCE grant designed to broaden these mutual mentoring networks to more women faculty within the physics and astronomy communities. The project will develop ten eAlliances of five participants each among women physics and astronomy faculty who are isolated in various ways. This project will reduce the isolation of participating members and provide support to enhance their career development.

*Supported by NSF Grant Number: HRD-1500529

### CD03: 5-5:30 p.m. Beyond the Valley of Stability

*Panel – Sherry Yennello, Texas A&M University, Cyclotron Inst., College Station, TX 77843-3366; yennello@comp.tamu.edu*

Often to advance one must move outside of their comfort zone; the place in which society has told them they are allowed to exist. In order to be successful in their journey individuals must have specific tools to help them not only to survive, but to thrive. Two such skills are communication and negotiation. Feedback on the professional development workshops provided by the Committee on the Status of Women in Physics of the APS has been overwhelmingly positive. Specific aspects of what makes these workshops so successful will be discussed.

## Session CE: Favorite *TPT* Articles

**Location:** CC - Room 308
**Sponsor:** Committee on the Interests of Senior Physicists
**Date:** Monday, July 18
**Time:** 4–6 p.m.

*Presider: Thomas O'kuma*



### CE01: 4-4:30 p.m. *TPT* Favorites – Overall Trends and Individual Impact

*Invited – Gary D. White, The George Washington University, Physics Department, 725 21st St. NW, Washington, DC 20052; gwhite@gwu.edu*

It's a little like picking favorites among children! Perhaps I have favorites, but is it really wise to admit it? So rather than trying to offer up a "Top Ten" or a "Best of *TPT*" list, I plan to highlight two kinds of favorites from *The Physics Teacher:* electronically popular and personally impactful. With the former, I hope to give some sense of which articles get downloaded the most, both by people within AAPT and outside the association. While *TPT* has thrived for decades without any of this kind of feedback, these are quick-changing times, and there are lessons lurking in these data, methinks. With the latter, I've selected a few papers whose clever ideas and thoughtful approaches have ended up in my own classroom, hopefully in a way that does justice to the authors' visions. Even with this very specific criterion for selection, the pool of papers from which these few are selected is a lot deeper than I imagined, a fact that speaks to the richness of content in *TPT*. Wise or not, I look forward to sharing these favorites with you.

### CE02: 4:30-5 p.m. Favorites from *The Physics Teacher*

*Invited – Thomas B. Greenslade, Jr., Kenyon College, Department of Physics, Gambier, OH 43022; greenslade@kenyon.edu*

Over the last 50 years, about 7000 articles have been published in *The Physics Teacher*. My favorite articles are those published in the latter years of the 20th century by Al Bartlett and Tom Rossing. We all thought that the series of articles that Al published on The Exponential Function would go on to – well – infinity! And we were all attuned to the series of articles that Tom wrote about Musical Acoustics; I often find myself referring to them. I was responsible for writing LVIII articles under the running title of "Nineteenth Century Textbook Illustrations" that ended up as two and three page articles with several illustrations. Then I wrote a series of articles on the general topic of oscillations and waves. Recently I have been writing a series of articles with John Daffron of Memphis in which we bring older apparatus back to life once more.

**CE03: 5-5:10 p.m. Coming Full Circle: *TPT* for All Phases of Teaching**

*Contributed – Diane M. Riendeau, Deerfield High School, 1959 Waukegan Rd., Deerfield, IL 60015; driendeau@dist113.org*

Throughout my professional career, *The Physics Teacher* served as a fantastic source for information, inspiration, dissemination, and affirmation. In this talk, I will highlight the articles that supported my growth as I worked through my teaching career, as a teacher, author, and column editor. I will highlight articles that helped me transform my teaching style, increased my content knowledge or encouraged me to keep pressing on. As column editor of "The New Teacher," I hope to "pay it forward" to new teachers. I will highlight some of my favorite articles from this era, as well.

**CE04: 5:10-5:20 p.m. LEDs Go to School**

*Contributed – Gorazd Planinsic, University of Ljubljana, Jadranska 19 Ljubljana, 1000 Slovenia; gorazd.planinsic@fmf.uni-lj.si*

*Eugenia Etkina, Rutgers University*

LEDs are becoming a ubiquitous feature of our life. Our students are surrounded by LEDs and yet there is almost no LED presence in a physics course. Although the detailed understanding of operation of these devices exceeds introductory physics curriculum, students can understand several fundamental physics ideas behind LEDs and these ideas might help them learn required traditional physics better. In the series of four papers we described how LEDs can be used in active learning units across the introductory physics curriculum so that students not only learn the physics underlying the LED operation but also to deepen their knowledge in other areas of physics and learn how to think like scientists. In this talk we will present examples of the experiments and related activities and share our experiences using LEDs with different student populations.

**CE05: 5:20-5:30 p.m. The Sand Pendulum**

*Contributed – Stephen Kanim, New Mexico State University, 600 West Union Ave., Las Cruces, NM 88005-3614; skanim@nmsu.edu*

One of the aspects of *The Physics Teacher* that I find most appealing is that so many of the articles offer ways to share our enthusiasm for physics with others. In this talk I use The Sand Pendulum written by Joe Rizzo and published in *TPT* in April 1987 as an example of how much impact a single such article can have. In 2004 I worked with an undergraduate student to build a hallway demonstration based on this paper. Our sand pendulum has been tracing out Lissajous figures in the hallway outside our lecture halls ever since. I will describe the modifications we made to the sand pendulum, and show some examples of the different patterns it makes.

**CE06: 5:30-5:40 p.m. Why "Wherefore a Science of Teaching?" Is My Favorite *TPT* Article**

*Contributed – Dwain M. Desbien, Estrella Mountain Community College, 10530 W Angels Lane, Peoria, AZ 85383; dwain.desbien@emcmail.maricopa.edu*

"Wherefore a science of teaching?" is my favorite *TPT* article for many reasons. First it was the article that got me interested in doing my PhD work in PER with its author David Hestenes. Second, even though published in 1979, many of the points in it are just as valid today as they were 36 years ago. I will share what speaks to me in this article and why I continue to recommend it to readers today.

**CE07: 5:40-5:50 p.m. Memorable Gems**

*Contributed – Christopher J. Chiaverina, New Trier High School (retired), 4111 Connecticut Trail, Crystal Lake, IL 60012; fizzforfun@aol.com*

When *The Physics Teacher* journal editor Karl Mamola, asked if I would like to edit a new column for the journal that would, in his words, "be devoted to very brief contributions that describe all sorts of creative physics teaching ideas such as, but not limited to, simple experiments and demonstrations," I jumped at the chance. I concurred with Karl's suggestion that the column be called "Little Gems," for the name reflects the fact that the activities were to be useful, engaging, and to the point. This coming fall will mark the beginning of the 11th year for "Little Gems." The number of creative experiments, demonstrations, and teaching tips that have been submitted since the column's inception has been gratifying. This talk will provide examples of what we consider to be "Little Gem" highlights.

**CE08: 5:50-6 p.m. Equations as Delightful Guides to Thinking**

*Contributed – Paul G. Hewitt, City College of San Francisco, 300 Beach Drive NE, 1103, St. Petersburg, FL 33701; pghewitt@aol.com*

Teaching the laws of physics ought to be central in any introductory physics course, whether for non-science or science students. Especially when students are taught to view the laws of physics as the laws of nature — nature's rules — many of which are in equation form. Equations are non-intimidating when presented as guides to thinking, rather than as formulas for solving algebraic problems. Focus on the meaning of symbols and how concepts relate to one another can result in a delightful learning experience. By postponing time-consuming computations to a second course (where they will be welcomed!) time allows coverage of a broad swath of classical and modern physics. Concepts first, computations later.

## Session CF: Introductory Labs/ Apparatus

**Location:** CC - Room 317/318
**Sponsor:** AAPT
**Date:** Monday, July 18
**Time:** 4–5:40 p.m.

*Presider: Eric Ayers*

**CF01: 4-4:10 p.m. Simple Hack of a CRT for Photoelectic Effect Demonstration**

*Contributed – John Avallone, Math for America and Stuyvesant High School, 345 Chambers St., New York, NY 10282; john.avallone@gmail.com*

This presentation will show how a cathode ray tube, laser pointers and an ammeter can be used to demonstrate, in "real life", the photoelectric effect. It is a simple, possibly accessible demonstration of a topic that, in high school classrooms, may otherwise only be heard about and "demonstrated" through PhET applet or the like. I have found it an exciting and attention grabbing "mystery" for my students to solve, that sets the stage for a deeper discussion of the topic.

**CF02: 4:10-4:20 p.m. Hacking the PASCO Power Brick for Direct Analog Measurements**

*Contributed – Roland C. Woodward, University of Wisconsin-Fond du Lac, 400 University Dr., Fond Du Lac, WI 54935; tpaa@thewoodwards.net*

The rapid and large-scale data acquisition made possible by microcomputer-based laboratory equipment has undeniably been a boon for physics teaching labs. However, I often found that my students must use the full system of computer, interface box, and sensor, in situations where a simple manual measurement would suffice. (The two most common measurements were temperature and magnetic field.) Rather than purchase new equipment, I modified the power supply "brick" for the PASCO interface box so that it could drive any PASCO analog sensor directly and feed the resulting signal to an ordinary voltmeter. In this talk, I give the details of the modification, describe my experience with it in my introductory physics labs, and argue that, in addition to reducing my dependence on my increasingly flaky computer interface boxes, this arrangement gives the students a more authentic lab experience.

## CF03: 4:20-4:30 p.m. Adapting AAPT Lab Recommendations to Meet Local Conditions: DATA Lab*

*Contributed – William M. Martinez, Michigan State University, Biomedical and Physical Sciences, East Lansing, MI 48824-2320; marti790@msu.edu*

*Kelsey M. Funkhouser, Abhilash Nair, Marcos D. Caballero, Michigan State University*

The AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum developed broad learning goals, in part to focus physics instruction on critical practices that are best engaged within a laboratory. However, adapting these goals to an institution's curriculum must involve molding these recommendations to local conditions. In this talk, strategies and practices that we employed at Michigan State University will be discussed, primarily focused on faculty interviews to set goals and develop buy-in. These discussions have led to locally implemented learning goals for Design, Analysis, Tools, and Apprenticeship (DATA) Lab, our recently transformed algebra-based lab for non-majors. Further, we will describe how our local goals relate to those set forth by the AAPT. *This work is funded by a Howard Hughes Medical Institute Science Education Grant

*This work is funded by a Howard Hughes Medical Institute Science Education Grant

## CF04: 4:30-4:40 p.m. Teaching Experimental and Data Analysis Skills in Online Labs

*Contributed – Firas Moosvi, University of British Columbia, 2329 West Mall, Vancouver, BC V6T 1Z4, Canada; Firas@moosvi.com*

*Stefan Reinsberg, Georg Rieger, University of British Columbia*

In this study, we evaluate the feasibility and pedagogy of transforming the lab component of an introductory physics course (N=800) such that it can be done entirely at home with common materials, a smartphone, and online support. Student performance in the online labs is compared to students doing similar labs face-to-face in a campus laboratory. The comparison is based on the end-of-term final projects that serve as the main assessment of learning for the lab component of the course. For the final projects, students first come up with a research question and then use the experimental and data analysis techniques learned over the term to attempt to answer the question. Fifteen TAs were used to assess the final projects using a rubric, and no significant performance difference was found between the face-to-face and the online lab format. The main features of the labs and the comparison analysis will be presented.

## CF05: 4:40-4:50 p.m. A Laser Apparatus for Measuring Angular Resolution of the Eye

*Contributed – Timothy L McCaskey, Columbia College Chicago, Dept. of Science and Mathematics, 600 S. Michigan Ave., Chicago, IL 60605-1996; tmccaskey@colum.edu*

*Luis Nasser, Nathan Linscheid, Columbia College Chicago*

We have built a device using laser light and fiber-optic cables to let students measure the angular resolution of the human eye. The cables transmit laser light to the front of a black box where the separation of sources can be carefully adjusted. Experimenters move the light sources closer together until a distant observer can no longer resolve them. By using different colors of laser light, one can investigate the effect of source wavelength on spatial resolution.

## CF06: 4:50-5 p.m. An Introductory Laboratory Reform Effort at the University of Illinois

*Contributed – Mats A. Selen, University of Illinois at Urbana-Champaign, 1110 W. Green St., Urbana, IL 61801; mats@illinois.edu*

*Katherine A. Ansell, William R. Evans, University of Illinois at Urbana-Champaign*

At the University of Illinois, we have piloted a new laboratory approach that has changed students lab experiences by introducing dorm room pre-lab experiments and focusing the classroom activities on experimental design and sense-making rather than physics concepts. This semester-long study involved students in our first-semester calculus-based mechanics course and used Interactive Online Laboratory (IOLab) devices with a curriculum inspired by the Investigative Science Learning Environment (ISLE). In this presentation, which is the first of three related talks in this session, we will describe the overall approach and discuss student experiences with the technology as well as the instructional approach.

## CF07: 5-5:10 p.m. A Situated Learning Approach to Introductory Laboratory Reform

*Contributed – Katherine Ansell, University of Illinois at Urbana-Champaign, 1110 W Green St., Urbana, IL 61801; crimmin1@illinois.edu*

*Mats Selen, University of Illinois at Urbana-Champaign*

At the University of Illinois, we have piloted a new laboratory approach that has changed the context of students' lab experiences by introducing dorm room prelab experiments and increasing the flexibility of the laboratory classroom setting. These changes were chosen in order to facilitate a shift from a "classroom" learning approach toward an "authentic" approach - that is, a learning approach that is consistent with coherent and purposeful activities – according to situated learning theory. The prelab experiments, which are held through an online delivery and response system, adds a new social context that both affects students' learning approach in the course and documents the effects of this approach. In this talk, we will discuss our observations of this learning approach and its implications for instruction.

## CF08: 5:10-5:20 p.m. Investigating Effects of Reformed Laboratories on Student Motivation and Attitude

*Contributed – William R. Evans, University of Illinois at Urbana-Champaign, 303 A1 Paddock Dr., W Savoy, IL 61874; wevans2@illinois.edu*

*Mats Selen, University of Illinois at Urbana-Champaign*

At the University of Illinois, we have piloted a new laboratory course that has changed the context of students' lab experiences by introducing dorm room pre-lab experiments and increasing the flexibility of the laboratory classroom setting in order to focus on critical thinking and sense-making. In this presentation we report on the effects of this new laboratory experience on students' motivation, attitude, and achievement goal orientation. We also look at the effects of the lab experience on other aspects of the course, including their ability to learn from analogous solutions. The information from the reformed lab sections is compared to that from parallel sections taught in a more traditional style.

## CF09: 5:20-5:30 p.m. Ionizing Radiation Experiments as a Mobile Lab

*Contributed – Jan D. Beks, Utrecht University, Eyckenstein, 46 Vleuten, 3452 JE, Netherlands; jan.beks@gmail.com*

*Ad Beune, Ad Mooldijk, Rob van Rijn, Utrecht University*

Initiated by the Dutch Ministry of Education, the Ioniserende Stralen Practicum at the Freudenthal Institute, Utrecht University, developed a mobile lab around 45 years ago. While currently equipped with three mobile labs, students from the 10th through 12th grades throughout the Netherlands familiarize themselves with radionuclides, the produced ionizing radiation and some of the processes involved. We describe the unique character of the experiments in their simple and easy to troubleshoot set-ups. The schools are offered closed lab instructions or open lab instructions, in which students design experiments using the limitations as given by the provided lab equipment. We will discuss (i) how the experiments support a physics curriculum, (ii) our unique approach of offering labs regarding ionizing radiation, and (iii) evidence of their positive impact on student concepts. In addition, we will share some early plans for implementing the use of smartphones and tablets to acquire and process data.

## CF10: 5:30-5:40 p.m. The Physics of Color Temperature in Photography

*Contributed – Steven Wetrich,* PhysicsVideos.com, AAPT Films, PO Box 11032Newport Beach, CA 92658; swetrich2@gmail.com*

*James Lincoln, SCAAPT*

When setting up lighting for photography or video, mixing color temperatures is an enormous problem. The origins of the problem are that the human eye adjusts to the color temperature of the environment, correcting for color temperature differences in order to recognize contrasting tones. In this talk, I begin with the Planck Black Body Theory and discuss how various light sources are represented, such as tungsten, fluorescent, and sunlight. Then I discuss how photography is an important application of this Modern Physics concept and how knowing more about it can engage students in these ideas.

*Sponsored by James Lincoln

## Session CG: PER: Diverse Investigations

**Location:** CC - Room 313
**Sponsor:** AAPT
**Date:** Monday, July 18
**Time:** 4–5:50 p.m.

*Presider: Jacquelyn Chini*

### CG01: 4-4:10 p.m. Assessing the Interactivity and Prescriptiveness of Professional Development Workshops

*Contributed – Alice R. Olmstead, University of Maryland, 66 Walnut Ave., Takoma Park, MD 20912; aolmstead@astro.umd.edu*

*Chandra A. Turpen, University of Maryland*

Professional development workshops are a primary mechanism used to help physics faculty improve their teaching, and draw in many instructors every year. Although workshops serve a critical role in changing instruction within our community, we rarely assess them through careful consideration of how they engage faculty. In order to encourage a shift towards more reflective, research-informed professional development, we have developed an observation tool, the Real-Time Professional Development Observation Tool (R-PDOT), to document the form and focus of faculty's engagement during workshops. During this talk, I will describe the development of the R-PDOT and introduce example R-PDOT data from sessions at the Physics and Astronomy New Faculty Workshop. We intend this tool to serve as a catalyst for workshop leaders' critical reflection and a stepping stone for future research on faculty professional development.

### CG02: 4:10-4:20 p.m. Career Preparation Models: Understanding the Interplay Between Education and Industry

*Contributed – Benjamin M. Zwickl, Rochester Institute of Technology, 84 Lomb Memorial Drive, Rochester, NY 14623-5603; ben.zwickl@rit.edu*

*Anne Leak, Kirk Winans, Kelly Martin, Rochester Institute of Technology*

The national need for a knowledgeable and diverse STEM workforce is a powerful motive for improving physics education and conducting physics education research. However, there is a need for coherent models for workforce training. Some STEM advocates believe training is the responsibility of higher education, while others see industry playing an integral and cooperative role. We studied career preparation using 30 semi-structured interviews with new hires and their managers in physics-related careers. We developed a data-driven model for where learning happens and how it transfers into the workplace, and found that essential learning occurs inside and outside of the classroom (e.g., hobbies, internships). We compared our model with others suggested in literature. Workforce development advocates would benefit from a holistic training model that encompasses higher education and industry. Further, physics departments would benefit from understanding the broad range of opportunities they can offer students for their future careers.

### CG03: 4:20-4:30 p.m. Curricular Knowledge as an Entry Point for Responsive Instruction*

*Contributed – Amy D. Robertson, Seattle Pacific University, 3307 Third Ave. W, Suite 307. Seattle, WA 98119-1997; robertsona2@spu.edu*

*Kara E. Gray Seattle Pacific University*

*Clarissa E. Lovegren, Kathryn L. Rininger, Scott T. Wenzinger*

Instruction that attends to and takes up the substance of what students are saying and doing – or "responsive instruction" – has the potential to transform learners' participation in the practices of science, support learner agency and voice, and promote equitable participation in the classroom, while preserving the conceptual gains our field has so long prized. In this talk, we show that the development of curricular knowledge – in this case, an understanding of the purposes of questions or sequences of questions in the "Tutorials in Introductory Physics" curriculum – can support the enactment of responsive teaching practices among novice teachers. We suggest possible implications for teacher education and future research.

*The material in this talk is based upon work supported by a Seattle Pacific University Faculty Research Grant and by National Science Foundation Grant Number 122732.

### CG04: 4:30-4:40 p.m. Linking Workshop Design to Faculty's Engagement in Professional Development

*Contributed – Chandra Anne Turpen, University of Maryland, College Park, 6701 Adelphi Rd., University Park, MD 20782; chandra.turpen@colorado.edu*

*Hannah Jardine, Alice R. Olmstead, University of Maryland*

Faculty often become motivated to try research-based instructional strategies (RBIS) after attending professional development workshops, but they are often underprepared to succeed in using RBIS [1]. In order to further explore the outcomes of faculty professional development, we analyze video-recordings of faculty's interactions during the Physics and Astronomy New Faculty Workshop. We select workshop episodes using our Real-time Professional Development Observation Tool, which allows us to identify instances where faculty members are voicing their ideas and collaborating with each other. We consider how workshop leaders' design decisions seem to influence faculty's engagement, e.g., how faculty take up workshop instructions, make sense of workshop activities, share and elaborate on their ideas, and justify their arguments. Lastly, we discuss the potential implications of these findings for faculty's future teaching practice.

[1] C. Henderson, M. Dancy, M. & M. Niewiadomska-Bugaj (2012). Phys. Rev. ST-PER, 8(2), 020104.

### CG05: 4:40-4:50 p.m. Improved Recruitment to Build a Better Faculty Online Learning Community

*Contributed – Adrienne L. Traxler, Wright State University, Department of Physics, 3640 Colonel Glenn Hwy., Dayton, OH 45435-0001; adrienne.traxler@wright.edu*

*Gillian Ryan, Kettering University*

*Andy Rundquist, Hamline University*

*Joel Corbo, Melissa Dancy, University of Colorado Boulder*

A Faculty Online Learning Community (FOLC) is a follow-up experience for participants in the Physics and Astronomy New Faculty Workshops. FOLC cohorts, composed of faculty members from around the country, meet biweekly by video for discussion with guest speakers and with each other about implementing active learning in their classrooms. Between meetings, members continue conversations, post materials, and ask for advice in a private social media group. FOLCs are intended to support faculty in meeting the challenges of classroom reform, which can be substantial even after attending the New Faculty Workshop. As a secondary benefit, FOLC cohorts have also proved to be a sounding board and discussion space for a broader range of issues facing junior faculty. Here we describe the ongoing development of the cohort formation process, with a particular focus on how recruitment and community-building efforts have evolved during the project.

## CG06: 4:50-5 p.m. Online Learning Communities to Support Scholarship of Teaching and Learning

*Contributed – Andy Rundquist, Hamline University, 1536 Hewitt Ave, MS B1807, Saint Paul, MN 55104-1284; arundquist@hamline.edu*

*Melissa Dancy, Joel Corbo, University of Colorado*

*Charles Henderson, Western Michigan University*

*Adrienne Traxler, Wright State University*

Faculty Online Learning Communities (FOLC) have recently been added to the New Faculty Workshops for Physics and Astronomy to help foster reflective teachers who are aware of and successfully adopt evidence-based pedagogical strategies. FOLC participants are encouraged to research their own teaching and the FOLC serves to support them and provide opportunities for communal research. This presentation will detail the first round of this research including an effort by several participants to have their students assess the work of their colleagues' students on the same lab taught at multiple institutions.

## CG07: 5-5:10 p.m. How Can Asynchronous Communication Support Virtual Faculty Learning Communities?

*Contributed – Joel C. Corbo, University of Colorado Boulder, 860 35th St., Boulder, CO 80303; joel.corbo@colorado.edu*

*Melissa H. Dancy; University of Colorado Boulder*

*Charles Henderson; Western Michigan University*

*Andy Rundquist; Hamline University*

The Physics and Astronomy New Faculty Workshop (NFW) does a good job of inspiring participants to try evidence-based teaching practices, but participants often face significant barriers to innovation that cause them to eventually revert to traditional instruction. Faculty Online Learning Communities (FOLCs) are year-long, virtual faculty communities designed to support participants after attending the in-person NFW. FOLCs provides participants with a community of peers and ongoing support to make it more likely that they will overcome barriers to improved teaching. In this presentation, we will analyze one FOLC communication channel: a private online message board. We will discuss how factors like the frequency and type of comments change over time as FOLC participants generate mutual trust and how these discussions support the learning that takes place during the synchronous FOLC meetings.

## CG08: 5:10-5:20 p.m. Helping Engineers to Become Effective Physics Teachers – Part A

*Contributed – Shulamit Kapon, Technion - Israel Institute of Technology, Faculty of Education in Science and Technology, Technion City, Haifa, 3200003 Israel; skapon@technion.ac.il*

*Avraham Merzel; Technion - Israel Institute of Technology*

How can we attract top university physics and engineering students to a career in teaching physics? How should we structure our teacher training programs to fit and best prepare talented people to become effective physics teachers and educational leaders? The Views program, launched at the Technion – Israel Institute of Technology, invites Technion graduates back to the Technion to earn an additional bachelor's degree in the Faculty of Education in Science and Technology. This talk discusses the physics education track within this program and focuses on the changes that are being made in the four physics PCK courses to provide a better fit for this unique population of students. The underlying principle guiding the design is to train these prospective physics teachers to become "learning engineers" instead of "transmitters of knowledge", and to shift their attention from "what I teach" to students' engagement and their learning.

## CG09: 5:20-5:30 p.m. Helping Engineers to Become Effective Physics Teachers – Part B

*Contributed – Avraham Merzel,* Technion - Israel Institute of Technology, Faculty of Education in Science and Technology, Technion City, Haifa, 3200003 Israel; amerzel@technion.ac.il*

*Shulamit Kapon; Technion - Israel Institute of Technology*

How can we attract top university physics and engineering students to a career in teaching physics? How should we structure our teacher training programs to fit and best prepare talented people to become effective physics teachers and educational leaders? We discuss the design, teaching, and learning in an innovative physics methods course that was structured as a workshop. This course is the first of four that focus on physics PCK in the Views program at the Technion – Israel Institute of Technology. The program invites Technion graduates back to the Technion to earn an additional bachelor's degree in science teaching. We present preliminary findings from a study that followed the students throughout the course, focus on the difficulties these pre-service teachers experienced with regard to the design and teaching of engaging lessons in physics, and discuss how we supported the students in this process.

*Sponsored by Shulamit Kapon

## CG10: 5:30-5:40 p.m. Supplemental Instruction Leader Development: A Longitudinal Study

*Contributed – Sissi L. Li ,California State University Fullerton, 800 N. State College Blvd., Fullerton, CA 92831-3547; sissili314@gmail.com*

*Gabriela Vasquez, Jennie Evangelista, Philip A. Janowicz, California State University Fullerton*

Supplemental Instruction (SI) is a program developed to target gateway courses with low passing rates. Students in these courses have the option to attend regular sessions outside of lecture where they are guided through problem solving and learning through group work. Each session is led by an SI leader, a student who has done well in the course and has applied for the position. Because student success is the primary goal of the program, much of the research focuses on student success. However, SI leaders also learn and grow significantly as a result of participating in the program. In this study, we have conducted longitudinal interviews with SI leaders in STEM disciplines to examine their experience in the program. We will present findings about the SI leaders' ideas about teaching and learning, their growth as content experts, and professionals in their fields.

## CG11: 5:40-5:50 p.m. National Survey: Computation Uses, Resources, and Attitudes in Undergraduate Physics*

*Contributed – Norman J. Chonacky, Dept. of Applied Physics, Yale University, 36 Lincoln St., New Haven, CT 06511; norman.chonacky@yale.edu*

*Marcos Caballero, Dept. of Physics and Astronomy, Michigan State University*

*Laura Merner, Statistical Research Center, American Institute of Physics*

*Robert Hilborn, Associate Executive Officer, American Association of Physics Teachers*

During past decades, computers have evolved from useful lab instruments to necessary problem solvers. Computation has become indispensable, interrelated to both theory and experiment, as a third methodology for solving scientific and engineering problems. By comparison, its effects on undergraduate education have been large in a few enclaves, spotty in others, and somewhere nearly nil. At least a decade of research on recent graduates with physics bachelor degrees has concluded this is a significant problem. Until now there has been no comprehensive assessment of departmental uses of computation, institutional environments for its integration into courses, personnel resources to effect such change, and local understanding of instructional methods helpful to its efficacy for learning physics. This survey is now completed. We report initial results in the context of computational curricular experiences, departmental resources and plans that the survey was designed to assess; complete details will follow at the 2017 winter meeting.

* Supported in part by the National Science Foundation DUE-1432363

## Session CH: The Physics of the NSF IUSE Program

**Location:** CC - Room 312
**Sponsor:** Committee on Physics in Undergraduate Education
**Date:** Monday, July 18
**Time:** 4–6 p.m.

*Presider: Kevin M. Lee*

### CH01: 4-4:30 p.m. Workshops and Learning Communities for Physics and Astronomy Faculty*

*Invited – Robert Hilborn, American Association of Physics Teachers, 1 Physics Ellipse, College Park, MD 20740-3845; rhilborn@aapt.org*

Since 1996, AAPT, AAS, and APS have been offering workshops for physics and astronomy new faculty members. These workshops introduce faculty to interactive engagement teaching methods and the evidence for their effectiveness, embedded in a framework of general professional development. Evidence indicates that the workshops are extremely successful in making the participants aware of interactive engagement methods and motivating them to implement these methods in their classes. However, studies of the participants indicate that about 1/3 of them stop using interactive engagement methods within a year or two. To address this issue, we have implemented faculty online learning communities (FOLCs). The FOLCs provide peer support and advice through webinars and coaching from more experienced faculty members. Evidence from the first FOLC cohort indicates that the FOLC does seem to provide the support needed to encourage faculty to continue implementation of interactive engagement teaching methods.

*This work is supported in part by NSF DUE IUSE Grants 1431638, 1431681, 1431779, and 1431454.

### CH02: 4:30-5 p.m. Assessing the Effect of Lab Courses on Students' Beliefs about Experimental Physics

*Invited – Heather Lewandowski, University of Colorado, CB 440, Boulder, CO 80309; lewandoh@colorado.edu*

There is a growing interest in improving student learning in undergraduate lab courses. A key component in the process of improving any educational experience is being able to measure to what extent students are meeting the learning objectives of the course. To support lab course transformation efforts across the U.S., our group developed, and now supports the administration of, the Colorado Learning Attitudes about Science Survey for Experimental Physics (E-CLASS). This assessment tool probes students' epistemologies about experimental physics, which is a learning goal included in the recently created AAPT Lab Guidelines document. I will discuss the initial outcomes of this NSF-funded project and my personal perspective about what aspects made the original proposal a strong candidate for funding.

### CH03: 5-5:30 p.m. Developing Scientific Reasoning: Targeted Physics Instruction for STEM Majors*

*Invited – Kathleen Koenig, University of Cincinnati, 2600 Clifton Ave., Cincinnati, OH 45221; kathy.koenig@uc.edu*

*Krista E. Wood, Carol Fabby, Lindsay Owens, University of Cincinnati*

*Lei Bao, The Ohio State University*

The economy and future workforce call for a shift of education goals from content drilling towards fostering higher end skills including reasoning, creativity, and open problem solving. Unfortunately, the typical introductory science course does not significantly impact students in these areas. Although scientific reasoning (SR) has become a widely targeted domain of high end skills in STEM learning, the knowledge base for the impact of SR-targeted curriculum along with assessment of SR is not widespread in the research community. This NSF-funded project seeks to address the gap in the literature by developing a lab curriculum designed to advance select SR skills, as well as provide evidence for how the course activities impact student development of SR, bringing advancement in this area. This presentation will discuss the portion of the grant work focused on developing and assessing the progression of student abilities in control of variables.

*Supported by NSF DUE 1431908

### CH04: 5:30-6 p.m. Multimedia Modules for Physics Instruction in a Flipped Classroom Course for Pre-health and Life Science Majors*

*Invited – Ralf Widenhorn, Portland State University, Department of Physics, Portland, OR 97201; ralfw@pdx.edu*

*Elliot Mylott, Justin C. Dunlap, Portland State University*

*Charles R. Thomas, Oregon Health and Science University*

*Warren Christensen, North Dakota State University*

We have developed modular multimedia educational material for undergraduate physics geared toward pre-health and life science majors. The flipped classroom course material emphasizes medical equipment and applied biomedical instrumentation utilized both clinically and for research. The multimedia learning modules include videos containing interviews with biomedical experts in conjunction with illustrations, images, and videos of the biomedical devices in clinical use. We are implementing formative and summative assessments to improve the learning material throughout the project. This includes evaluating learning gains for individual modules as well as assessing the impact on student attitudes. Here, we will present results and experiences after reaching the halfway point of the three year collaborative IUSE grant from Portland State University, North Dakota State University, and Oregon Health and Science University.

*This work is supported by the grant DUE-1431447 from the National Science Foundation.

## Session CI: Searching for Extraterrestrial Intelligence

**Location:** CC - Room 304/305
**Sponsor:** Committee on History and Philosophy in Physics
**Co-Sponsor:** Committee on Space Science and Astronomy
**Date:** Monday, July 18
**Time:** 4–5:30 p.m.

*Presider: Todd Timberlake*

### CI01: 4-4:30 p.m. Beyond the Singularity: The Search for Extraterrestrial Technologies and the Breakthrough Listen Initiative

*Invited – Andrew Siemion,* University of California at Berkeley, 501 Campbell Hall, Berkeley, CA 94720; siemion@berkeley.edu*

Astronomers have recently determined that the key environmental factors that are believed to have given rise to life on Earth are present in abundance throughout the Milky Way galaxy. Armed with the certainty that life could have developed elsewhere, scientists everywhere are racing to determine if indeed it did, and if so, whether some of that life went on to develop a technological capability similar to our own. In July 2015, Yuri Milner and Stephen Hawking announced Breakthrough Listen -- a 10-year 100-million-dollar search for extraterrestrial intelligence. This program will be the most sensitive, intensive and comprehensive search for intelligent life beyond the Earth in the history of humanity. I will discuss the scientific rationale behind the search for extraterrestrial intelligence and provide a review of the Breakthrough Listen project, including current observational status, early results and plans for the future.

*Sponsored by Todd Timberlake.

### CI02: 4:30-5 p.m. Radio SETI Observations at the SETI Institute*

*Invited – Gerald Harp, SETI Institute, 189 Bernardo, Ste. 200 Mountain View, CA 94043; gharp@seti.org*

For about eight years, the SETI Institute (SI) has been searching for extraterrestrial intelligence using our own interferometer telescope, the Allen Telescope Array (ATA). Technically, the approach taken by SI is different from other large radio SETI projects in a couple of ways: 1.The use of an array telescope allows us to look in more than one direction at a time. 2. We perform near-real-time follow-up of interesting candidate signals, and continue to follow them until they disappear or are proven to be human-generated. In this presentation, we will discuss some of these differences in approach, their advantages and disadvantages. Then we will review results from our SETI searches over decades of observing, and what conclusions we can draw from our search so far.

*The authors would like to acknowledge the generous support of Franklin Antonio for recent SETI searches at the Allen Telescope Array and this presentation. Sponsored by Todd Timberlake. For more information go to www.seti.org.

### CI03: 5-5:30 p.m. Messaging Extraterrestrial Intelligence: An Alternative Paradigmfor Making First Contact

*Invited – Douglas A. Vakoch,* METI International, 100 Pine St., Suite 1250, San Francisco, CA 94111-5235; dvakoch@meti.org*

Messaging Extraterrestrial Intelligence (METI) complements passive SETI observations by transmitting powerful, intentional signals to nearby stars, hoping to elicit a response. METI investigates the possibility that other civilizations may currently be listening and not transmitting, but they may be willing to reply if humankind takes the initiative to transmit. The nonprofit research and educational organization METI International encourages a long-term perspective by initiating ongoing transmission projects and developing novel approaches to sustaining passive SETI projects across generations (http://meti.org). For example, modest-sized optical SETI observatories can be operated by colleges and universities as educational and scientific facilities providing opportunities for students of astronomy, physics, engineering, and computer science. Faculty interested in collaborating as part of a nascent global optical SETI network should contact the speaker at (dvakoch@meti.org). Opportunities are also available for summer student internships at the Optical SETI Observatory at Boquete, Panama, in cooperation with METI International (http://optical-seti.org/).

*Sponsored by Todd Timberlake

## Session CJ: Comparing World-Class Physics Education Ideologies: A Closer Look at AP, Cambridge, and IB Programs (Panel)

**Location:** CC - Room 314
**Sponsor:** Committee on International Physics Education
**Co-Sponsor:** Committee on Physics in High Schools
**Date:** Monday, July 18
**Time:** 4–5:30 p.m.

*Presider: Tiberiu Dragoiu Luca*

### CJ01: 4-4:30 p.m. Advanced Placement Program

*Panel – Trinna Johnson, College Board, 3700 Crestwood Parkway, Duluth, GA 30096; tjohnson@collegeboard.org*

The College Board AP program is a rigorous academic program built on the commitment, passion, and hard work of students and educators from both secondary schools and higher education. Since 1955, the AP Program has enabled millions of students to take college-level courses and exams, and to earn college credit or placement while still in high school. The AP College Board program offers more than 30 courses. By taking an AP course and scoring successfully on the related AP Exam, you can save on college expenses: most colleges and universities nationwide offer college credit, advanced placement, or both for qualifying AP Exam scores. AP can transform what once seemed unattainable into something within reach. There are a million paths to a student's future. By giving students the opportunity to explore their interests, AP courses can help them find and pursue their unique direction.

### CJ02: 4:30-5 p.m. Cambridge International Examinations A and AS Levels

*Panel – David Styles, Cambridge International Examinations, The Barn, Minton Church, Stretton, SY6 6PS UK; d.r.styles@btinternet.com*

Cambridge International AS and A Levels are recognized worldwide. Typically A Level is a two-year course while AS is a one-year course. Students can specialize or study a wide range of subjects from a choice of 55 syllabuses. A Level students take either a staged assessment route with some assessment after one year or a linear route with all assessment at the end of the course. The syllabuses develop a deep understanding of subject material enabling students to apply knowledge and understanding to new and familiar situations. Students develop transferable skills such as independent thinking skills, presenting ordered, coherent arguments and communicating logically and clearly. Cambridge International AS and A levels are accepted at over 500 U.S. universities including all Ivy League universities as well as leading universities worldwide. Good grades in carefully chosen A Level subjects can result in up to one year of university course credit.

### CJ03: 5-5:30 p.m. Physics in the International Baccalaureate

*Panel – Graeme Anderson, International Baccalaureate, Churchillplein 6, The Hague, South Holland, 2517JW Netherlands; graeme.anderson@ibo.org*

The International Baccalaureate Diploma Programme is a two-year programme in which students study six subjects covering a range of subject areas, as well other core elements including Theory of Knowledge. The selection of subjects allows for a student to specialise in one area while maintaining a broad spectrum. All students completing the IB Diploma Programme are also required to complete a 4000-word individual research project on a topic of their choice. The IB aims to do more than other curricula by developing inquiring, knowledgeable and caring young people who are motivated to succeed. The study of physics, particularly at higher level, provides students with the required knowledge and skills for success at college or university in a wide range of different courses. Credit can be given for high grades in physics or based on the total number of points awarded in obtaining the Diploma.

## Session CK: Preparing and Supporting University Physics Educators (showcasing outcomes of PhysRev focused collection)

**Location:** CC - Room 301
**Sponsor:** Committee on Research in Physics Education
**Co-Sponsor:** Committee on Physics in Undergraduate Education
**Date:** Monday, July 18
**Time:** 4–6 p.m.

*Presider: Rachel Scherr*

### CK01: 4-4:30 p.m. Perceived Affordances and Constraints Regarding Instructors' Use of Peer Instruction

*Invited – Charles Henderson, Western Michigan University, WMU Physics, 1903 W. Michigan Ave., Kalamazoo, MI 49008-5252; charles.henderson@wmich.edu*

*Melissa H. Dancy, University of Colorado Boulder*

*Chandra Turpen, University of Maryland College Park*

Physics instructors generally report that they are aware of research-based instructional strategies and are interested in using them. However, sustained use is not widespread. Thus, an important unsolved problem is how to effectively spread and sustain the use of research-based instructional strategies. In this study, we conducted interviews with instructors regarding their experiences, knowledge, and use of Peer Instruction (PI). This talk focuses on how instructors come to know about PI, how they implement PI, and the reasons they give for taking up or not taking up aspects of PI. We found that 1) instructors commonly modify PI, 2) most instructors readily acknowledge the shortcomings of lecture, and 3) instructors are concerned that PI use will be taxing on their time, limit their coverage of content, and be a struggle to implement. Understanding these perspectives will help change agents more effectively partner with instructors in working towards effective instructional change.

### CK02: 4:30-5 p.m. Research-based Assessment Affordances and Constraints: Perceptions of Physics Faculty

*Invited – Adrian Madsen, American Association of Physics Teachers, 1100 Chokecherry Lane, Longmont, CO 80503; amadsen@aapt.org*

*Sarah B. McKagan, American Association of Physics Teachers*

*Mathew Sandy Martinuk, Alexander Bell, Cognition Technology*

*Eleanor C. Sayre, Kansas State University*

To help faculty use research-based materials in a more significant way, we learn about their perceived needs and suggest ways for the physics education research community to address them. We used phenomenographic interviews of physics faculty and department chairs to identify four families of issues that faculty have around research-based assessments (RBAs). First, many faculty are interested in using RBAs but need help with the practicalities of administering them. Second, at the same time, many faculty think that RBAs are limited and do not measure many of the things they care about, or are not applicable in their classes. Third, many faculty want to turn to communities of other faculty and experts to help them interpret their assessment results and suggest other ways to do assessment. Fourth, many faculty consider their courses in the broader contexts of accountability and their departments.

### CK03: 5-5:30 p.m. Characterizing Pedagogical Practices of Physics Students in Informal Learning Environments

*Invited – Kathleen Hinko, University of Colorado Boulder, 440 UCB Boulder, CO 80309; kathleen.hinko@colorado.edu*

*Peter Madigan, Eric Miller, Noah D. Finkelstein University of Colorado Boulder*

University educators (UEs) have a long history of teaching physics not only in formal classroom settings but also in informal outreach environments. The pedagogical practices of UEs in informal physics teaching have not been widely studied, and they may provide insight into formal practices and preparation. We investigate the interactions between UEs and children in an after-school physics program facilitated by university physics students from the University of Colorado Boulder. In this program, physics undergraduates, graduate students and post-doctoral researchers work with K-8 children on hands-on physics activities on a weekly basis over the course of a semester. We use an Activity Theoretic framework as a tool to examine situational aspects of individuals' behavior in the complex structure of the after-school program. Using this framework, we analyze video of UE-child interactions and identify three main pedagogical modalities that UEs display during activities: Instruction, C Based on this analysis, we discuss implications for promoting pedagogical strategies through purposeful curriculum development and university educator preparation.

### CK04: 5:30-6 p.m. Becoming Physics People: Developing Physics Identity Through the LA Experience*

*Invited – Eleanor W. Close, Texas State University, Dept. of Physics, 601 University Dr., San Marcos, TX 78666-4615; eclose@txstate.edu*

*Jessica Conn, Hunter G. Close, Texas State University*

In this study, we analyze the experience of students in the Physics Learning Assistant (LA) program at TXST in terms of the existing theoretical frameworks of community of practice and physics identity, and explore the implications suggested by these theories for LA program adoption and adaptation. The goal of our current project is to understand the details of the impacts of participation in the LA experience on participants' practice and self-concept, in order to identify critical elements of LA program structure that positively influence physics identity and physics career intentions for students. Our analysis suggests that participation in the LA program impacts LAs in ways that support both stronger "physics student" identity and stronger "physics instructor" identity, and that these identities are reconciled into a coherent integrated physics identity. Increased sense of community with peers, near-peers, and faculty seems to be an important component of this identity development and reconciliation.

*This work and the Texas State University Physics LA Program are supported in part by NSF grant DUE-1240036, the Halliburton Foundation, and the College of Science and Engineering at Texas State University.

## Session CL: Modern Physics Demonstrations and Labs

**Location:** CC - Room 315
**Sponsor:** Committee on Apparatus
**Date:** Monday, July 18
**Time:** 4–6 p.m.

*Presider: Roger Key*

### CL01: 4-4:30 p.m. Demonstrating the Photoelectric Effect in a Simple and Comprehensive Way by Using an Antique Photo Cell and LabVIEW Virtual instrumentation

*Invited – Urs Lauterburg,* University of Bern, Physics Institute, Sidlerstrasse 5 Bern, 3012 Switzerland; urs.lauterburg@space.unibe.ch*

An antique photoelectric cell is used in conjunction with modern LabVIEW type data acquisition technology to demonstrate the concept of the photoelectric effect in a lecture hall environment. The design and the layout of the experimental setup will be explained and discussed. The presenter will also walk through the steps of the demonstration and its physical content to illustrate the didactical aspects of the experiment.

*Sponsored by the PIRA group (Roger Key)

### CL02: 4:30-5 p.m. Chaotic Oscillation of a Magnetic Dipole

*Invited - Eric Ayars, California State University, Chico, Campus Box 202, Chico, CA 95929-0202; eayars@csuchico.edu*

*Brandon Thacker, Tucker Hartland, California State University, Chico*

We have built a chaotic oscillator consisting of a rotating magnetic dipole in an oscillating magnetic field. The apparatus allows complete computer control of oscillator parameters via SCPI commands and offers students a unique opportunity to investigate chaos in a simple-to-understand system. In this talk we will present typical student data that can be obtained with this apparatus, and uses of the apparatus in upper-division lab courses.

### CL03: 5-5:30 p.m. Thin Film Tunneling in an SIN Junction

*Invited – Dean Hudek, Brown University, 182 Hope St., #1843, Providence, RI 02912; dean_hudek@brown.edu*

Thin film tunneling has been a staple in our advanced labs for many years – which is only appropriate since Leon Cooper, the C in the BCS theory of superconductivity, is one of our faculty. Using photos and videos I will walk through the entire process of performing this lab, from understanding a 4 wire measurement, to creating the junctions in an evaporator, to transferring LHe and finally to collecting data. Along the way I will point out tips, tricks, potential pit falls and safety considerations involved in creating a similar apparatus for your lab and supporting it for students' use. This has long been one of my favorite advanced labs and I look forward to sharing it with you. Hope to see you at the talk!

### CL04: 5:30-5:40 p.m. Two-Photon Momentum Entanglement and Interference

*Contributed – Scott C. Johnson, Intel, 4635 NW 175th Place, Portland, OR 97229-2165; scott.c.johnson@intel.com*

Many undergrad labs now have the capability of doing experiments with entangled photons. Most of these use polarization-entangled photon pairs. With relatively small modifications, they can use momentum-entangled photons instead. The advantage of this is that the two-particle wave function, to an excellent approximation, can be calculated and graphed using the two-particle Schrodinger equation, allowing for a clearer and more intuitive visualization than for a polarization wave function. In this talk, I will show both experimental data and Schrodinger wave function calculations for two momentum-entanglement experiments. The first puts a pair of slits in one photon's path and find a correlated interference pattern between the two photons. The second starts with the same slits in photon 1's path, then puts a lens in the photon 2's path, and finds an image of the slits in photon 2's image plane, even though photon 2 never passed through the slits.

### CL05: 5:40-5:50 p.m. The Teaching Research of Two Dimensional Standing Waves on Metal Plates*

*Contributed – Yizhong Fang, Sun Yet-sen University, xingangxi Road, No.135, Guangzhou, GUA 510275; stsfyz@mail.sysu.edu.cn*

*Han Shen, Xintu Cui, Deju Liao, Raohui Feng, Sun Yet-sen University*

The analytical solution of Chladni figures on a thin metal plate is a difficult problem in theoretical acoustics. In our recent works, the two-dimensional standing waves on annular and circular plates (Chladni figures) are investigated both experimentally and theoretically at various kinds of boundary conditions. The experiments accord with the analytical solutions within large frequency scale. Furthermore, the radii of standing wave nodal circles in different frequencies and the elastic modulus of the plate are also obtained. In our program, such a contribution would be divided into three levels for undergraduate training. First, the two-dimensional standing waves of rectangular and circular plates explicated by freshmen experimentally and theoretically on high frequencies. Second, the similar work of annular plate is experienced by sophomores, who have learned the mathematical physics methods. Third, the problem with complex boundary such as fan or triangle will be studied by juniors or seniors.

*This project is supported by NSFC(J1103211).

### CL06: 5:50-6 p.m. An Easily Assembled Spectrograph for the Intermediate Lab

*Contributed – Timothy Todd Grove, IPFW, 2101 E. Coliseum Blvd., Fort Wayne, IN 46805; grovet@ipfw.edu*

We have been using low-cost spectrographs called shoebox spectrographs for a few years. In the process of our study, we decided to make a spectrograph using the same basic optical design (as the shoebox spectrograph) but with quality optical parts. This spectrograph was found to be easily aligned by students and enables intermediate and advanced students to study molecular spectral lines as well as the spectral line differences between hydrogen and deuterium.

## Session TOP04: Graduate Student Topical Discussion

**Location:** CC – Room 311
**Sponsor:** Committee on Graduate Education in Physics
**Co-Sponsor:** Committee on Research in Physics Education
**Date:** Monday, July 18
**Time:** 6–7:30 p.m.

*Presider: Claudia Fracchiolla*

## Session TOP05: Roundtable on Teaching Physics in High School

**Location:** CC – Room 304/305
**Sponsor:** Committee on Physics in High Schools
**Co-Sponsor:** Committee on Professional Concerns
**Date:** Monday, July 18
**Time:** 6–7:30 p.m.

*Presider: Charlene Rydgren*

*A focused discussion on implications of Educational Reforms such as NGSS, Race for the Top, APPR, VAM etc. on teaching High School Physics. Where are we now? Where do we want to be? How do we get there?*

## Session TOP06: Solo PER

**Location:** CC – Room 306
**Sponsor:** Committee on Research in Physics Education
**Co-Sponsor:** Committee on Professional Concerns
**Date:** Monday, July 18
**Time:** 6–7:30 p.m.

*Presider: Steven Maier*

*Are you the only professional active in PER within your department? Are there only one or two colleagues in close proximity you can talk "PER shop" with? The membership of Solo PER is larger than you may think, and more diverse than most suspect. Join us for this Topical Discussion to connect with other Solo PER professionals and learn what is being done to help our/your endeavors. As in the past, bring questions, ideas and professional concerns to share.*



# Awards Session

## Klopsteg Memorial Lecture Award: by Margaret Wertheim, *Institute for Figuring*

**Location:** Sheraton - Magnolia/Camellia
**Date:** Monday, July 18
**Time:** 7:30–8:30 p.m.

*Presider: Mary Mogge*

**Margaret Wertheim**
**Los Angeles, CA**

### Of Corals and the Cosmos: A Story of Hyperbolic Space

Throughout the natural world—in corals, cactuses, and lettuce leaves—we see swooping, curving, and crenelated forms. All these are biological manifestations of hyperbolic geometry, an alternative to the Euclidean geometry we learn about in school. While nature has been playing with permutations of hyperbolic space for hundreds of millions of years, humans spent centuries trying to prove that such forms were impossible. The discovery of hyperbolic geometry in the 19th century helped to usher in a revolution in our understanding of space, for such "non-Euclidean geometry" now underlies the general theory of relativity and thus our understanding of the universe. While physicists and astronomers are still trying to discover the geometry of the cosmos, on the Great Barrier Reef the corals making hyperbolic structures are being threatened by global warming and climate change. In this multifacted talk, bridging the domains of physics, math and culture, science writer and curator Margaret Wertheim will discuss the story of hyperbolic space and its resonances for how we see our world.

## PST1: Posters

**Location:** Sheraton - Gardenia
**Sponsor:** AAPT
**Date:** Monday, July 18
**Time:** 8:30–10 p.m.

*Poster presenters are asked to mount their posters by 8 a.m. The poster will remain available for viewing until 10 p.m.. Persons with odd-numbered posters will present their posters from 8:30 to 9:15 p.m.; those with even-numbered posters will present from 9:15 to 10 p.m..*

### Astronomy

#### PST1A01: 8:30-9:15 p.m. Exploring Temperature in Astronomy Demonstration Videos

*Poster – Kevin M. Lee, University of Nebraska, 244D Jorgensen Hall, Lincoln, NE 68505; klee6@unl.edu*

*Cliff Bettis, University of Nebraska*

AU is a series of short videos of physical demonstrations appropriate for use in introductory astronomy classes. Considerable effort is made to make the videos interactive through embedded peer instruction questions and accompanying worksheets. This poster will illustrate recently developed videos involving temperature and their interactive mechanisms. These materials are publicly available at http://astro.unl.edu and on YouTube on the UNL Astronomy Channel. They are funded through NSF grant #1245679.

#### PST1A02: 9:15-10 p.m. Incorporating Exoplanet Radial Velocity Detections to Teach Simple Harmonic Motion

*Poster – Jordan K. Steckloff, Purdue University - Department of Earth, Atmospheric, and Planetary Science, 550 Stadium Mall Drive, West Lafayette, IN 47907-2051; jstecklo@purdue.edu*

*Rebecca Lindell, Purdue University - Department of Physics and Astronomy*

All planets and stars orbit about their mutual center of mass (barycenter). Although, most planetary systems cannot be directly imaged using current technologies, the orbital motion of the host star induces a detectable doppler shift in its emitted light. Because the star's circular motion is generally unresolvable, its motion instead appears to be a mass undergoing simple harmonic motion along the line of the observer. Thus, this radial velocity method (RVM) of detecting exoplanets is an excellent method to be understood as a simple harmonic oscillator. However, whereas most harmonic oscillators are understood by detecting the change in their position, the RVM instead directly detects the velocity of the oscillator. We describe how the mass and orbital radius of the orbiting planet can be determined by measuring the harmonic velocity of the star, and understanding the forces that contribute to its acceleration. Suggestions for instruction will also be provided.

#### PST1A03: 8:30-9:15 p.m. Incorporating the Asteroid Light Curve Database into Introductory Mechanics

*Poster – Jordan K. Steckloff, Purdue University - Department of Earth, Atmospheric, and Planetary Science, 550 Stadium Mall Drive, West Lafayette, IN 47907; jstecklo@purdue.edu*

*Steven Dail, Harrison High School*

*Rebecca Lindell, Purdue University*

Elementary Mechanics is typically motivated with examples on the Earth that are familiar to students. However, such examples are subject to nonideal conditions (e.g. air drag, rolling friction, noninertial reference frames), and their use may unintentionally reinforce incorrect schema that students have on their underlying physical processes (e.g. moving objects naturally come to rest ithout a driving force). Asteroid motion is not subject to friction, representing an ideal situation for applying Newton's laws. Additionally, students are typically unfamiliar with asteroid mechanics and therefore possess fewer preconceived notions of how asteroids should behave. Here we present how we incorporated the Minor Planet Center's most recent published dataset of asteroid spin periods and radii (obtained from asteroid light curve studies) into an activity on gravitation and circular motion. We guide students through the scientific process: collecting data, identifying a trend and hypothesizing its cause, and making and testing a prediction.

#### PST1A05: 8:30-9:15 p.m. Preliminary Evaluation of a New Cosmology Curriculum

*Poster – Kimberly Coble, Chicago State University, 9501 South King Dr., Chicago, IL 60628-1598; kcoble@csu.edu*

*Dominique Martin, Patrycia Haye,s Chicago State University*

*Tom Targett Lynn R. Cominsky, Sonoma State University*

*Janelle Bailey, Temple University*

Informed by our research on student understanding of cosmology, The Big Ideas in Cosmology is an immersive set of web-based learning modules that integrates text, figures, and visualizations with short and long interactive tasks and real cosmological data. This enables the transformation of general education astronomy and cosmology classes from primarily lecture and book-based courses to a more engaging format that builds important STEM skills. During the spring 2014 semester, we field-tested a subset of chapters with the general education astronomy and cosmology classes at Sonoma State University in a flipped-classroom format. We administered pre- and post-content and attitude assessments in the two flipped classes as well as two lecture classes. When switching to an active mode of learning, students reported some dissatisfaction with "having to do more work" but made greater learning gains.

*Module development was supported by NASA ROSES E/PO Grant #NNX-l0AC89G, the Illinois Space Grant Consortium, the Fermi E/PO program, Sonoma State University's Space Science Education and Public Outreach Group, and Great River Technology/Kendall-Hunt Publishing.

#### PST1A06: 9:15-10 p.m. Teaching Inquiry in Nigeria: The West African International Summer School for Young Astronomers

*Poster – Linda E. Strubbe, University of British Columbia, 6224 Agricultural Road, Vancouver, BC V6T 1Z1 Canada; linda@phas.ubc.ca*

*Bonaventure Okere, Centre for Basic Space Science, University of Nigeria*

*Meiling Deng, University of British Columbia*

*Anabele Pardi, Max Planck Institut fuer Astrophysik*

*Jielai Zhang, University of Toronto*

The West African International Summer School for Young Astronomers (WAISSYA) is a week-long introduction to astronomy for science undergraduates and teachers from West Africa, held twice so far in Nigeria (2013 and 2015), and organized by astronomers from Canada, Nigeria, Germany, and Gabon. Goals of the school are to exchange ideas about teaching and learning science in West Africa and North America, and to increase interest in astronomy in West Africa. We design and lead activities to teach astronomy content, promote students' self-identity as scientists, and encourage students to think critically and figure out solutions themselves. Prior to the 2015 school year, we held a three-day workshop for WAISSYA instructors to learn about evidence-based teaching strategies. Here we describe the school's curriculum, share results from evaluations of the effectiveness of the program, and discuss longer-term plans for future schools and collaboration.

#### PST1A07: 8:30-9:15 p.m. (Don't) Hit My Planet! – Periapsis from Instantaneous Position and Velocity

*Poster – Philip R. Blanco, Grossmont College, 8800 Grossmont College Drive, El Cajon, CA 92020-1799; philip.blanco@gcccd.edu*

*Carl E. Mungan, United States Naval Academy*

Long-range radar detects an unidentified space object at an altitude of 6.53 Earth radii heading towards us at a radial velocity of 3.86 km/s, and traveling across the sky at 1.54 km/s (corrected for the Earth's rotation). What is its origin? Possibilities include a ballistic missile launched from another continent, an Earth-orbiting satellite, an asteroid or comet. Will it hit us, and if so, what velocity change is required to deflect it? This poster presents a physics-based method for students to determine the closest-approach (periapsis) distance of any unpowered space object, without having to calculate its detailed orbit. We apply this method to a few examples of the many possible astrodynamics problems that are accessible to introductory physics and astronomy students familiar with conservation laws.

## Teacher Training/Enhancement

### PST1B01: 8:30-9:15 p.m. Helping Prospective and Practicing Elementary Teachers Prepare for the NGSS

*Poster – Fred M. Goldberg, San Diego State University, CRMSE, 6475 Alvarado Road, Suite 206, San Diego, CA 92120; fgoldberg@mail.sdsu.edu*

The "Next Generation Physical Science and Everyday Thinking" curriculum[1,2] has been designed to help pre-service and in-service elementary teachers use practices of science and engineering and crosscutting concepts to develop and show understanding of NGSS core disciplinary ideas in physical science. The curriculum materials are modular and are available in two versions: one for studio style classrooms and one for lecture style classrooms. Optional teaching and learning activities help the teachers make connections between their own learning, the learning of elementary children and the NGSS. The online instructor resources provide detailed implementation information and captioned classroom video clips that provide substantive examples of how students learn science in the Next Gen PET environment.

(1) Next Gen PET has been supported in part by grants from the National Science Foundation and Chevron Corporation. It is adapted from parts of previous curricula: PET, PSET, LPS and LEP.

(2) Other co-authors of Next Gen PET are Stephen Robinson, Edward Price, Danielle Boyd Harlow, Julie Andrew, Michael McKean, Valerie Otero, Rebecca Stober and Cary Sneider.

### PST1B02: 9:15-10 p.m. 8.Mech.CCx: A Customized Open Online Course for Flipping the AP Physics C Classroom

*Poster – Zhongzhou Chen, Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 02139-4307; zchen22@mit.edu*

*Christopher Chudzicki, St. Paul's school*

*Sunbok Lee, David Pritchard, Massachusetts Institute of Technology*

The RELATE.MIT.edu group at MIT is offering our audited College Board AP C level physics MOOC, 8.MechCx Introductory Mechanics, as a free Custom Course on edX.org (CCX) for high school or college instructors. "Custom Course" (CCX) is a new feature of the edX platform that allows individual instructors to assign resources (problems, videos, texts) chosen from our MOOC to their own students according to their own schedule. This course features over 1000 high-quality problems at different levels of difficulty, over 370 pages of e-text written and edited by MIT faculty based on PER research, as well as interactive online simulations, labs based on Direct Measurement Videos created by Peter Bohacek and simple "build it yourself" laboratories. I will demonstrate the CCX course, show how to enroll your own students, assign resources, set due dates and view student progress.

### PST1B03: 8:30-9:15 p.m. Action Research and Design-based Research for Physics Teacher Preparation in Germany: A Case Study

*Poster – Joseph T. Heimburger, Buffalo State College, 1300 Elmwood Ave., Buffalo, NY 14222; jtheimburger@gmail.com*

*Jennifer Lorbach, Universität zu Köln*

*Dan MacIsaac, Buffalo State College*

*André Bresges, Universität zu Köln*

We describe preparations and initial pilot activity undertaken in collaboration with pre-service physics teacher, their instructors and mentors at the Universität zu Köln making use of Design Based Research and Action Research methods. A literature review was prepared to inform and guide our scholarly exchanges creating a Transatlantic Design Based Research / Action Research Network for physics teacher preparation in German and U.S. schools. AR projects have been used in the U.S. for teacher development, but not yet in Germany. We present data collected during a pilot study conducted on graduate student exchange visiting Cologne, Germany January – February 2015 and June 2015. The study follows one preservice teacher through the "Praxissemester", during which she developed classroom activities and assessed them in an AR/DBR format. We report her findings and discuss the appropriateness of using AR/DBR in the context of the German Praxissemester. This research was supported by the Noyce Foundation.

### PST1B04: 9:15-10 p.m. An Apprentice Teacher and Student's Perspective on Computer Problem-Solving Coaches

*Poster – Jeffrey M. Chaffin,* University of Minnesota, 520 2nd St. Apt 223, Minneapolis, MN 55414; chaf0026@umn.edu*

As both an upper-division undergraduate physics student as well as a Teaching Assistant for introductory physics courses, I have a unique perspective on the teaching and learning of problem-solving skills. Last summer, I worked with the Physics Education Research and Development group at the University of Minnesota to design and code several computer coaches using their C3PO software platform, which uses the Minnesota problem-solving framework. Designing the coaches both informed the way in which I taught introductory physics and transformed my own learning process in my more advanced coursework and I will share my experiences and lessons learned. Not only are the C3PO computer coaches an excellent tool for introductory students, but they also have secondary benefits for instructors who use it to design problems that fit into their curriculum.

*Sponsored by Professor Leonardo Hsu

### PST1B05: 8:30-9:15 p.m. ATE Workshop for Physics Faculty Project

*Poster – Thomas L. O'Kuma, Lee College, P. O. Box 818, Baytown, TX 77522-0818; tokuma@lee.edu*

*Dwain M. Desbien, Estrella Mountain Community College*

The ATE Workshop for Physics Faculty project is into its final year and has finished all of the scheduled workshops/conferences. In this poster, we will display information about the 15 workshops that were held since the first one, conducted in 2011.

## Labs/Apparatus

### PST1C01: 8:30-9:15 p.m. Dynamic Simulation of the Induced Polarization Effects by Mirrors

*Poster – Sarah J. Knudsen, California State University, Chico 420 W. Sacramento, Chico, CA 95926; sknudsen1@mail.csuchico.edu*

*Anna Petrova-Mayor, California State University Chico*

We designed a dynamic simulation to promote students' understanding of the induced polarization effects by mirrors for the practical case of a beam scanner. The state of polarization (SOP) of the reflected light strongly depends on the design of the mirrors (thickness, index of refraction, and order of the thin film layers) and their azimuthal orientation. Motivated by our research of an azimuth-over-elevation beam scanner for atmospheric polarization lidar we also incorporated a quarter waveplate to correct for the total induced polarization. The simulation is constructed by applying the Fresnel equations and Jones calculus and allows the user to adjust the parameters of the mirrors and the geometry of the included optical elements. This simulation is intended to be used for in-class demonstrations and for validating experimental results.

## PST1C02: 9:15-10 p.m. Electron Charge-to-Mass Ratio: Laser Focused on Perfection

*Poster – Peter W. Odom, Oral Roberts University, 7777 South Lewis Ave., Tulsa, OK 74171; podom@oru.edu*

*Joshua C. Williams, Lief Peterson, Elena Greggm, Oral Roberts University*

The charge-to-mass ratio of an electron was measured using J.J. Thomson's method. An electron gun generated and accelerated a beam of electrons inside a helium-filled vacuum bulb. The bulb was surrounded by a Helmholtz coil producing a magnetic field to force the electron beam into a circular path. By measuring the current through the Helmholtz coil, voltage across the electron gun and diameter of electron path, the charge-to-mas ratio of electrons was calculated. By using various methods to measure the diameter of the path (visual versus laser), values were found between 7% and 0.8% of the accepted value. A decrease in the standard deviation of measurements when using lasers was predicted and confirmed. Methods by which measurements were improved are discussed, chiefly among them being the implementation of aforementioned lasers. The unprecedented success resulted from being permitted more freedom and being allowed deviation from specific lab manual instructions.
I am an undergraduate student being funded by a PhysTEC supported sight for this specific conference.

## PST1C03: 8:30-9:15 p.m. Improving Students' Understanding of Lock-in Amplifiers

*Poster – Seth T. DeVore, 135 Willey St., Morgantown, WV 26506-0002; stdevore@mail.wvu.edu*

*Alexandre Gauthier, Jeremy Levy, Chandralekha Singh, University of Pittsburgh*

A lock-in amplifier is a versatile instrument frequently used in physics research. However, many students struggle with the basic operating principles of a lock-in amplifier which can lead to a variety of difficulties. To improve students' understanding, we have developed and evaluated a research-based tutorial which utilizes a computer simulation of a lock-in amplifier. The tutorial is based on a field-tested approach in which students realize their difficulties after predicting the outcome of simulated experiments involving a lock-in amplifier and check their predictions using the simulated lock-in amplifier. Then, the tutorial guides and helps students develop a coherent understanding of the basics of a lock-in amplifier. The tutorial development involved interviews with physics faculty members and graduate students and iteration of many versions of the tutorial with professors and graduate students. The student difficulties and the development and assessment of the research-based tutorial are discussed. Supported by the NSF.

## PST1C04: 9:15-10 p.m. Instrumented Trebuchet

*Poster – Joel C. Berlinghieri, The Citadel, Physics Department, Grimsley Hall, Charleston, SC 29409; berlinghieri@citadel.edu*

A trebuchet is a siege engine used in the Middle Ages to frustrate a castle's defenses. A trebuchet's design is focused on the efficient transfer of potential energy stored in a counter weight to kinetic energy in a projectile that is launched at a chosen angle. Projectile maximum range or maximum height might be a goal. For the past six years The Citadel with Google sponsorship has hosted a trebuchet event called "Storm The Citadel." Elementary, middle, high school, college, and corporate teams compete in various categories at accuracy, precision, and distance events. The Physics Department hosts workshops on the physics of the trebuchet with an explanation of each element of the various trebuchet designs and why they are needed. High school and corporate teams usually use phenomenological data to characterize their engine. That is adjust one variable repeatedly and shoot holding other variables constant. We have taken one design and instrumented the unit to measure angular position, velocity, and acceleration and linear position, velocity, and acceleration and forces at strategic points on the trebuchet. The data collected are used to develop insight into the connection between trebuchet settings and engine dynamics and projectile kinematics.

## PST1C05: 8:30-9:15 p.m. Introductory Physics Laboratory Writing Conferences

*Poster – Dwain M. Desbien, Estrella Mountain Community College, 10530 W Angels Lane, Peoria, AZ 85383; dwain.desbien@emcmail.maricopa.edu*

*Thomas L O'kuma, Lee College*

The Introductory Physics Laboratory Writing Conferences (IPLWC) is one of the two major components of the ATE Workshop for Physics Faculty project. Since 2011, nine IPLWCs conferences were conducted. The invited participants to the IPLWCs were experienced two-year college and high school physics faculty. Some of the IPLWCs were dedicated to types of laboratory activities, such as computational activities, conceptual activities, video activities, and others. Many of the developed activities were tested (and later modified) at the institutions of the IPLWC participants that developed them. In this poster, we will display information about the IPLWCs and some of the developed activities.

## PST1C06: 9:15-10 p.m. Ionizing Radiation Experiments as a Mobile Lab

*Poster – Jan D. Beks, Utrecht University, Eyckenstein 46, Vleuten, 3452 JE, Netherlands; jan.beks@gmail.com*

*Ad Beune, Ad Mooldijk, Rob van Rijn, Utrecht University*

Initiated by the Dutch Ministry of Education, the Ioniserende Stralen Practicum at the Freudenthal Institute, Utrecht University, developed a mobile lab around 45 years ago. While currently equipped with three mobile labs, students from the tenth through twelfth grades throughout the Netherlands familiarize themselves with radionuclides, the produced ionizing radiation and some of the processes involved. We describe the unique character of the experiments in their simple and easy to troubleshoot set-ups. The schools are offered closed lab instructions or open lab instructions, in which students design experiments using the limitations as given by the provided lab equipment. We will discuss (i) how the experiments support a Physics curriculum, (ii) our unique approach of offering labs regarding ionizing radiation, and (iii) evidence of their positive impact on student concepts. In addition, we will share some early plans for implementing the use of smartphones and tablets to acquire and process data.

## PST1C07: 8:30-9:15 p.m. Measuring and Visualizing Fields and Current Flow

*Poster – Scott Dudley, TASIS England, PSC 22, Box 154 FPO, AE 09421; scottcolton@msn.com*

*Sidney Mau, Francesco Insulla,Rachel Maerz, Anthony Ferraro, TASIS England*

Using a sheet of current we show how to measure and visualize the electric and magnetic fields around the sheet, and the flow of current in the sheet.

## PST1C08: 9:15-10 p.m. Mini-Lab Implementation to Enhance the Undergraduate Experience in Experimental Physics

*Poster – Colleen L. Countryman, North Carolina State University, 2401 Stinson Dr., Raleigh, NC 27695; colleen_countryman@ncsu.edu*

*Saroj Dangi, Laura Clarke, North Carolina State University*

After three introductory-level classes (with traditional labs) and before a project-based senior lab course, physics majors take seven physics lecture courses that have no lab component. Over the last few terms, we have worked towards addressing this issue in several of these courses by providing a single lab experience per course, innately connected to the classroom work. These mini-labs replace traditional homework assignments for one week in the term. They are developed and taught by a teaching assistant associated with a department-wide shared user research facility where the experiments are also housed, thus minimizing the effort needed by the instructor. Ultimately our goal is to have each student experience one or two mini-lab activities per term. From these experiences we intend to systematically strengthen student confidence in their experimental ability and demonstrate real world connections with the material in the classroom. We will present promising attitudinal results from the study.*

*Instructional materials were designed by Theodore Brzinski, Karen Daniels, Hans Hallen, Paul Huffman, Hong Wang, and Keith Weninger (North Carolina State University).

### PST1C09: 8:30-9:15 p.m. Normal Modes for Loaded String: Accounting for the String's Mass

*Poster – Alan J. DeWeerd, University of Redlands, 1200 E Colton Ave., Redlands, CA 92373-0999; alan_deweerd@redlands.edu*

The normal modes of a string loaded with evenly spaced masses are analogous to the modes of one-dimensional lattice vibrations, if the mass of the string is negligible. However, experiments show slight deviations from the idealized behavior because of the string's mass. Methods of accounting for the mass of the string are discussed. Theoretical predictions are compared with experimental data for the "monatomic" and "diatomic" strings.

### PST1C10: 9:15-10 p.m. Single Photon Investigations Using a Low-Cost Coincidence Counter

*Poster – Mark F. Masters, IPFW, 2101 Coliseum Blvd. E., Fort Wayne, IN 46805; masters@ipfw.edu*

*Kakathi Tummala, Alyssa Robison, Samantha Minick, IPFW*

*Tanner Heral*

Single photon investigations are very popular for a variety of experimental investigations in quantum mechanics. These investigations vary from Grainger's experiment to demonstrate that the photon is a particle, to Bell's inequality, to single photon interference. Unfortunately, these investigations are not low-cost, the chief expense being the single photon detectors, followed by a lot of optical components. One area in which there has been some cost savings has been the coincidence counting units. As our start to driving down the costs of these investigations, we present the development and testing of a low-cost coincidence counter (less than $40). This coincidence counter is based upon a Cypress PSoC 5 prototyping kit (CY8CKIT-059) and can have up to 10-24 bit counters, more than four input channels, have built in Digital to Analog for use in interferometry. The tests will include Bell's inequality, Grainger's experiment and single photon interference.

### PST1C11: 8:30-9:15 p.m. Speed of Light: Practice Makes Almost Perfect

*Poster – Peter W. Odom, 7777 South Lewis Ave., Tulsa, OK 74171; podom@oru.edu*

*Joshua C. Williams, Lief Peterson, Elena Gregg, Oral Roberts University*

In this experiment, the speed of light is measured using the Foucault method. A laser is focused through a beam splitter onto a rotating mirror that directs the beam onto a fixed mirror reflecting it back toward the rotating mirror and back through the beam splitter. By rotating the mirror at a known angular velocity first CW, then CCW, while measuring the displacement of the image produced by the reflected beam, the speed of light is measured at 3.02 x 108 m/s—a value only 0.7% larger than the accepted value of 2.998 x 108 m/s. Modifications of experimental setting show significant progress in the accuracy of the measurements. The initial attempt resulted in roughly 32% error; the second iteration narrowed accuracy to roughly 5% error; the last iteration yielded the above mentioned result. Factors contributing to the improvements in accuracy (i.e. freedom, creativity, and persistence) are discussed.

### PST1C12: 9:15-10 p.m. Student Research Projects with Arduino and the Xilinx Zedboard FPGA

*Poster – Michele McColgan, Siena College, 515 Loudon Road, School of Science, Loudonville, NY 12211; mmccolgan@siena.edu*

Examples of student research projects using the Arduino and Xilinx's Zedboard FPGA will be presented. Projects include a processing system to detect the difference between neutrons and gamma rays, a beacon system to transmit unique signals, a weather station to collect and display weather data in real time, and PID controller projects for different applications.

### PST1C13: 8:30-9:15 p.m. Teaching Fluid Dynamics Using a Transparent Circulatory System Model*

*Poster – Bradley Moser, University of New England, 11 Hills Beach Road, Biddeford, ME 04005; bmoser@une.edu*

*Kate Hruby, David Grimm, James Vesenka, University of New England*

Students have substantial difficulties applying physics concepts to anatomy and physiology (and vice versa). We have developed a mature kinesthetic learning circulatory system model, which requires students to apply multiple concepts (conservation of mass, the Hagen-Poiseuille principle, Reynolds Number and basic circuit theory) to understanding how the cardiovascular system functions. Kinesthetic learning allow students to manipulate different aspects of the simulated system. We have designed an inexpensive circulatory system model made from transparent plastic tubing, branched connectors, balloons, and pumps that enabled students to see the fluid travel at different speeds (visually) and pressures (through pressure sensors) simulating the cardiovascular system. The speeds and pressures are in reasonable agreement with theory. Noticeably absent from this discussion is the Bernoulli principle, often misapplied and can be demonstrated to play little role in the observed behavior of the pressure changes in our model system.

*Supported by NSF DUE grants 0737458 and 1044154.

### PST1C14: 9:15-10 p.m. Advanced Undergraduate Biophysics Lab on Fluid-Fluid Phase Separation

*Poster – Ryan McGorty, University of San Diego, 5998 Alcalá Park, San Diego, CA 92110; rmcgorty@sandiego.edu*

Compartmentalizing biomolecules is a necessary task for life to exist. Often cells use lipid membranes for such tasks. Cells are encapsulated within a membrane and within the cell exists the nuclear envelope, vesicles, and other lipid-membrane bound organelles. Intriguingly, a new way for cells to partition molecules has recently emerged. A few years ago, liquid-like bodies were observed within cells. These liquid-drops are the result of fluid-fluid phase separation within the cell. I will describe experiments done in an undergraduate biophysics lab course that explore fluid-fluid phase separation using colloidal and polymer solutions. Students use microscopy techniques including bright-field, differential interference contrast, laser-scanning confocal and light-sheet microscopy. Analysis of acquired images yield capillary times and lengths and students learn how those time and length scales relate to surface tension and other parameters. Students also construct a phase diagram to demark the concentrations of polymers or colloids required for phase separation.

### PST1C15: 8:30-9:15 p.m. An Easily Assembled Spectrograph for the Intermediate Lab

*Poster – Timothy Todd Grove, IPFW, 2101 E. Coliseum Blvd., Fort Wayne, IN 46805; grovet@ipfw.edu*

We have been using low-cost spectrographs called shoebox spectrographs for a few years. In the process of our study, we decided to make a spectrograph using the same basic optical design (as the shoebox spectrograph) but with quality optical parts. This spectrograph was found to be easily aligned by students and enables intermediate and advanced students to study molecular spectral lines as well as the spectral line differences between hydrogen and deuterium.

### PST1C17: 8:30-9:15 p.m. Best Practices for Intermediate Physics Laboratory Experiences Using E-CLASS

*Poster – Patricia E. Allen, Appalachian State University, Physics and Astronomy, Boone, NC 28607; allenpe@appstate.edu*

*John Cockman, Appalachian State University*

Undergraduate physics majors are often take an introductory lab sequence and a capstone lab experience, usually during their last year. Many in the PER (Physics Education Research) community have analyzed best practices to improve experiences at each end of a physics major's education. At institutions such as Appalachian State University, majors are required to take an intermediate lab course. However, little guidance is available to instructors on best practices for an intermediate lab experience to bridge intro and advanced lab courses. Efforts are under way at Appalachian State to determine best practices for such an intermediate lab course. E-CLASS (Colorado Learning Attitudes about Science Survey – Experimental) has been found to provide effective and informative feedback for both lab activities and pedagogical approaches. The authors present E-CLASS results for multiple sections of an intermediate lab course and how these results are used to identify best practices and areas for improvement. The impact of E-CLASS-inspired modifications will also be presented and discussed.

## Physics Education Research I

### PST1D01: 8:30-9:15 p.m. The Source of Student Engagement in IPLS

*Poster – Benjamin Geller, Swarthmore College, 500 College Ave., Swarthmore, PA 19081; bgeller1@swarthmore.edu*

*Chandra Turpen, University of Maryland, College Park*

*Catherine Crouch, Swarthmore College*

Effectively teaching an Introductory Physics for the Life Sciences (IPLS) course means engaging life science students in a subject matter for which they may not have considerable preexisting interest. While we have found that the inclusion of topical examples of relevance to life-science students can help to engage students whose initial interest in physics is less developed, we have found that the inclusion of biological content is just one of several dimensions supporting student engagement in IPLS. When describing what is salient to them about their IPLS experiences, students are just as quick to cite particular pedagogical structures and supports as they are to cite issues relating directly to content choices. In this poster we begin to unpack this complex interplay of content and pedagogy in fostering student engagement in the IPLS classroom. We also describe the role that explicit messaging around disciplinary coherence may play in students' experiences.

### PST1D02: 9:15-10 p.m. Toward a Conceptual Model for Problem Solving in Multimedia Learning*

*Poster – Xian Wu, Kansas State University, 116 Cardwell Hall, Manhattan, KS 66506; xian@phys.ksu.edu*

*Amy Rouinfar, Elise Agra, Lester C. Loschky, N. Sanjay Rebello, Brett DePaola, Purdue University*

Problem solving is one of the most important topics in physics education research. Due to the recent popularity of online courses and distance education in physics, studies have begun to focus on teaching problem solving in computer-based environments. Over the past four years, we have put our efforts toward developing a conceptual model that combines classic problem-solving theory with the cognitive theory of multimedia learning. Three eye-tracking studies have been guided by this conceptual model. The data of eye movements and problem-solving performance is consistent with our conceptual model and has also enhanced the model to further our understanding of students' problem-solving processes and its implications for multimedia instructional design.

*This research is supported in part by the U.S. National Science Foundation under Grants 1348857 and 1138697. Opinions expressed are those of the authors and not necessarily those of the Foundation.

### PST1D03: 8:30-9:15 p.m. Group Dynamics on Group Exams

*Poster – Steven F. Wolf, East Carolina University, C-209, Howell Science Complex, Tenth St., Greenville, NC 27858-4353; wolfs15@ecu.edu*

*William A. Burgess, Joi P. Walker, East Carolina University*

Student group behavior in both a classroom and group exam setting in the context of a calculus-based introductory physics class was observed in order to explore the patterns of behavior within each classroom environment. This observation focused on cognitive, epistemic, and social aspects of student interactions. The grain size considered is both the individual student level, and the group level. Of particular interest is the emergence of common roles that arise across groups, as well as any differential behaviors between the regular classroom settings and group exam settings.

### PST1D04: 9:15-10 p.m. Decreased Failure Rates Across all Ethnicities in UC Davis CLASP

*Poster – Mary K. Chessey,* Physics Department, University of California, Davis, One Shields Ave., Davis, CA 95616-5270; mkchessey@ucdavis.edu*

*David Webb, Wendell Potter, University of California, Davis*

We examine overall student success in the reformed large introductory physics course for undergraduate bioscience students at UC Davis and find significant reductions in failure rates for all ethnicities as compared to the traditional lecture format of the same course. Using statistical analysis of tens of thousands of student course grades across six years, we find that the UC Davis Collaborative Learning through Active Sense-making in Physics (CLASP) style interactive engagement course is associated with decreased failure rates, which are uniformly low across all ethnicities. In the traditional lecture format course, which the CLASP course replaced, failure rates vary widely between ethnicity groups. While the failure rates in the CLASP course are smaller for all ethnicities, other measures of student outcomes remained unchanged or improved[1].

*Sponsored by David Webb. (1) Reference DOI: 10.1119/1.4857435

### PST1D05: 8:30-9:15 p.m. Developing an Interactive Tutorial on a Quantum Eraser

*Poster – Emily M. Marshman, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu*

*Chandralekha Singh, University of Pittsburgh*

We developed a quantum interactive learning tutorial (QuILT) on a quantum eraser for students in upper-level quantum mechanics. The QuILT exposes students to contemporary topics in quantum mechanics and uses a guided approach to learning. It adapts existing visualization tools to help students build physical intuition about quantum phenomena and strives to help them develop the ability to apply quantum principles in physical situations. The quantum eraser apparatus in the gedanken (thought) experiments and simulations that students learn from in the QuILT uses a Mach-Zehnder Interferometer with single photons. We also discuss findings from a preliminary in-class evaluation. This work is sponsored by the National Science Foundation.

### PST1D06: 9:15-10 p.m. Developing and Evaluating a Quantum Interactive Learning Tutorial (QuILT) on the Double-slit Experiment

*Poster – Ryan T. Sayer, University of Pittsburgh, 6311 Morrowfield Ave., Pittsburgh, PA 15217; rts36@pitt.edu*

*Alexandru Maries, University of Cincinnati*

*Chandralekha Singh, University of Pittsburgh*

Learning quantum mechanics is challenging, even for upper-level undergraduate and graduate students. Interactive tutorials which build on students' prior knowledge can be useful tools to enhance student learning. We have been investigating student difficulties with the quantum mechanics pertaining to the double-slit experiment in various situations. Here we discuss the development and evaluation of a Quantum Interactive Learning Tutorial (QuILT) which makes use of an interactive simulation to improve student understanding. We summarize common difficulties and discuss the extent to which the QuILT is effective in addressing them in two types of courses.

## PST1D07: 8:30-9:15 p.m. Developing and Evaluating Quantum Mechanics Formalism and Postulates Survey

*Poster – Emily M. Marshman, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu*

*Chandralekha Singh, University of Pittsburgh*

Development of multiple-choice tests related to a particular physics topic is important for designing research-based learning tools to reduce the difficulties related to the topic. We explore the difficulties that the advanced undergraduate and graduate students have with quantum mechanics formalism and postulates. We developed a research-based multiple-choice survey that targets these issues to obtain information about the common difficulties and administered it to undergraduate and graduate students. We find that the advanced undergraduate and graduate students have many common difficulties with these topics. The survey can be administered to assess the effectiveness of various instructional strategies. This work is supported by the National Science Foundation.

## PST1D08: 9:15-10 p.m. The Effects of Grader Assessment Feedback on Student Motivation

*Poster – Kaala A. Cheney, San José State University, One Washington Sq., San Jose, CA 95192-0001; kaalacheney@aol.com*

*Annie Chase, Cassandra Paul San José State University*

Grader Assessment Feedback (GAF) -- defined as any written information a grader gives the student on a test, quiz, and/or any other form of assessment -- is a powerful tool that instructors can use to help students construct knowledge. Students from different GAF-driven introductory college-level physics courses at San Jose State University were invited to complete a web-based survey at the end of their semester. Through a hypothetical scenario survey question, we examine how students think an extrinsically motivated student should study for a grade and how an intrinsically motivated student should study for understanding. Previous research suggests that instructor use of non-traditional GAF methods correlate with student beliefs that studying for a good grade involves the same efforts as studying for understanding. We use qualitative methods to examine student responses to determine whether different types of GAF influence how students believe intrinsically motivated vs. extrinsically motivated students should study.

## PST1D09: 8:30-9:15 p.m. The Effects of SCALE-UP Intervention in Algebra-based Introductory Physics Classes

*Poster– Zeynep Topdemir, Georgia State University, One Park Place, 4th Floor Atlanta, GA 30303; ztopdemir1@gsu.edu*

*David N. Trusty, Ebru Oncul, Brian D. Thoms, Georgia State University*

We have implemented SCALE-UP in half of the algebra-based introductory physics classes at Georgia State University. In this study, we compare lab and lectures activities for Lecture/Laboratory format and SCALE-UP. Also, we have investigated the effects of these differences on success and withdrawal rates, student conceptual learning as measured by the Force Concept Inventory (FCI), and student attitudes as measured by Colorado Learning Attitudes about Science Survey (CLASS). Even though SCALE-UP algebra-based physics classes show no significant increase in FCI gains over traditional classes, SCALE-UP intervention shows a significant improvement in CLASS favorable scores for both Conceptual Understanding and Problem Solving categories.

## PST1D10: 9:15-10 p.m. The Power of Self Reflection in Student Groups

*Poster – Emily Schreiner,* Streamline to Mastery Program through CU Boulder, 6140 E 123rd Way, Brighton, CO 80602; sch018066@adams12.org*

*Shannon Wachowski, Streamline to Mastery Program through CU Boulder*

Several studies have been done with regard to group work in the high school setting. These studies often focus on group roles or methods of instruction in "good" group behaviors. In contrast, this study explores the impact of student self reflection on group behavior. Changes in group dynamics and academic performance were analyzed after students engaged in several self reflections on their skills in group work. Over 100 students participated in the study from physics and math courses. Data was collected from coding video observations, analyzing academic performance, and comparing pre- and post-surveys. The goal of this study was to collect data that supports the practice of engaging students in self reflection as an effective inquiry-based approach to improving group interactions and productivity. Analysis of the results and, experiences with implementing a group learning atmosphere will be shared.

*Sponsored by Valerie Otero

## PST1D11: 8:30-9:15 p.m. Time Evolution of Student Understanding of Quantum Mechanical Concepts

*Poster – Charles J. DeLeone, California State University, San Marcos, Physics Dept., San Marcos, CA 92096-0001; cdeleone@csusm.edu*

Upper-division physics students often struggle with quantum concepts during their first exposure to full-blown quantum mechanics. Research into student learning of quantum concepts with tools such as the Quantum Mechanics Concept Assessment have exposed challenges associated with student learning of concepts such as superposition and time evolution of states. But does student learning of these concepts persist and/or improve with further exposure to quantum concepts in a second semester course? This poster updates results from a multi-year study of a two-semester upper-division quantum course that uses a spins-first approach. Results concerning the robustness of student understanding of quantum concepts across representations along with issues particular to the spins-first approach will be presented.

## PST1D12: 9:15-10 p.m. Tracking Shifts in Students' Understanding: Force, Acceleration, and Graphs

*Poster – Trevor I. Smith, Rowan University, 201 Mullica Hill Rd,. Glassboro, NJ 08028; smithtr@rowan.edu*

*Nicholas J. Wright, Ian T. Griffin, Rowan University*

Many studies have shown that students often struggle to interpret and generate graphs of various physical quantities. This can be seen in students' responses to the Force and Motion Conceptual Evaluation when class performance differs on questions asking students to select graphs of force vs. time for a described motion compared to questions asking them to choose verbal descriptions of forces. We have previously shown that students are more likely to improve on the graph questions than the natural language questions. We expand on these results by incorporating data from multiple colleges and by including correlations between students' choices of graphs of force vs. time and acceleration vs. time for identical motions. We relate these results to other analyses of the data and provide evidence that using consistency plots to represent individual students' transitions from pretest to posttest provides rich information that is unavailable in other representations.

## PST1D13: 8:30-9:15 p.m. Traditional Physics vs. IPLS: Comparing Student Experiences

*Poster – Max Franklin, Swarthmore College, 500 College Ave., Swarthmore, PA 19081; bgeller1@swarthmore.edu*

*Haley Gerardi, Benjamin Geller, Catherine Crouch, Swarthmore College*

*Chandra Turpen, University of Maryland, College Park*

At Swarthmore College, we recently introduced a first-semester Introductory Physics for the Life Sciences (IPLS) course that draws on authentic biological examples relating to kinematics, Newtonian mechanics, and thermodynamics. Because the course is offered only every other year, we are uniquely situated to compare the experiences of those students who take the IPLS course to a similar set of students who take a traditional first-semester introductory physics course that covers the same topics but does not foreground biological connections. In this poster we draw on conceptual and attitudinal survey data, as well as a series of case-study interviews, to describe the conceptual, epistemological, and affective differences that we observe between the two student populations. We identify the features of the IPLS experience that were most salient to students, and suggest how particular course structures may have been especially important in supporting students' ability to do well in the IPLS environment.

### PST1D15: 8:30-9:15 p.m. Using Google Tools to Follow Student Learning of Scientific Abilities

*Poster – Danielle Bugge, Rugers University, 8 Perrine Path, West Windsor, NJ 08550; danielle.bugge@gse.rutgers.edu*

*Eugenia Etkina, Rutgers University*

High school physics students, initially unfamiliar with an inquiry-based environment, engaged in ISLE labs that focus on the development of student scientific abilities. We examine student lab reports in order to better understand the process students go through when they write these reports. Using the revision history feature on Google Documents provides additional insights into the development of these abilities, answering questions about factors such as time, ability type, and student grouping that influence student development of these abilities. Furthermore, this feature allows us to look at collaboration among students outside the classroom.

### PST1D16: 9:15-10 p.m. Using Isomorphic Problems to Probe Student Understanding of Speed

*Poster – Sheh Lit Chang, University of Washington/Department of Physics, 3910 15th Ave. NE, Seattle, WA 98195-0001; shehlit@gmail.com*

*Peter S Shaffer, University of Washington/Department of Physics*

We report results from a preliminary investigation into student ability to solve a basic multi-step problem involving both accelerated and uniform motions. Isomorphic questions were asked in a variety of contexts, at different times during instruction in introductory physics classes. One of the questions was also given to a range of student populations. The findings reveal a general failure of students to interpret and apply the concepts of average and instantaneous speed that persist at similar levels from high school to university.

### PST1D17: 8:30-9:15 p.m. Using Phenomenography to Better Understand Student Development with Computational Physics

*Poster – Michael J. Obsniuk, Michigan State University, Biomedical Physics Sciences, East Lansing, MI 48824-2320; obsniukm@msu.edu*

*Paul W. Irving, Macros D. Caballero, Michigan State University*

In Projects and Practices in Physics— a highly interactive and technologically modern introductory physics classroom with a strong pedagogical foundation — students are exposed to fundamental physics phenomena with the aid of computation. Within the context of this classroom, we have conducted a phenomenographic investigation of a small cohort of students. This cohort was exposed in-class to a "suite" of three scaffolded computational physics problems focusing on the fundamental physics phenomenon of force and motion. Over the three week duration of this "suite," we invited the cohort to repeated semi-structured interviews, one for each problem, in order to observe their development in approach to computational problems. From an analysis of the students' perceived variation in the computational features discerned to be critical, we have observed several qualitatively different categories of student development with modeling motion computationally.

### PST1D18: 9:15-10 p.m. Using Within-Cluster Regression Analysis to Understand Student Differences

*Poster – John C. Stewart, West Virginia University, 235 White Hall, Morgantown, WV 26506; jcstewart1@mail.wvu.edu*

*Rachel Stoiko, West Virginia University*

This poster presents an analysis of the effect of pre-preparation and effort on the performance in a physics class using data collected over 21 semesters (N=1747). Cluster analysis was used to identify distinct subgroups of students with different levels of incoming preparation for the class and distinctly different out-of-class study behaviors. Regression analysis within each cluster was then used to understand the factors affecting learning for these subgroups. Within the clusters, the degree to which different examination study behaviors, patterns of submitting assignments, and time invested in homework affected overall test performance was investigated and strong differences identified. These differences serve to partially explain the lack of correlation between beneficial behaviors and class outcomes.

### PST1D19: 8:30-9:15 p.m. Utilizing Student Expertise in Informing Programmatic Changes in STEM*

*Poster – Felicia Davenport, Chicago State University, Department of Chemistry and Physics, 9501 S. King Drive, SCI 309, Chicago, IL 60628; frdavenport81@gmail.com*

*Nicolette Sanders, Mel Sabella, Kristy Mardis, Chicago State University*

The CSU Learning Assistant (LA) Program and the CSU S-STEM Program rely on student expertise and leadership to be successful. LAs are undergraduate students who partner with faculty to improve courses. This involves LAs working with faculty to brainstorm about ways to reach students in their classes, assist in the classroom to support active engagement, co-develop activities to support learning, and identify specific student resources and needs. These partnerships place LAs in roles of significant responsibility. S-STEM scholars are also engaged in leadership efforts at both the local and national level. They form committees to engage in outreach, social media, and professional event planning. At the national level, they are involved, as members of the NSF-funded Access Network. Access is a collaboration of equity-focused programs across institutions that empower students through mutual support. In this poster we explore the synergy between these programs and how they rely on student expertise to create programmatic change.

*Supported by the National Science Foundation (DUE #1356523 & DUE#1524829) and the Department of Education.

### PST1D20: 9:15-10 p.m. Wave Functions & Measurements in Quantum Mechanics: Student Ideas in Chemistry and Physics

*Poster Gina Passante California State University, Fullerton 800 N. State College Blvd. Fullerton, CA 92831-3547 gpassante@fullerton.edu*

Quantum mechanics (QM) is not only an important theory in physics, but also in chemistry, electrical engineering, and computer science. Although quantum mechanics taught primarily in physics departments, it is also taught in other fields, and very little research has been done on students understanding across these disciplines. In this work we focus on the similarities and differences found in student responses to questions asked in both physics and chemistry courses that cover QM. In particular, we investigate student understanding of wave functions and how they relate to the probability of measurement outcomes in QM.

### PST1D21: 8:30-9:15 p.m. A Cross-sectional Study of Students' Use of Mathematics in the Upper-Division

*Poster – Anna M. Turnbull, Michigan State University, 575 N Hagadorn, East Lansing, MI 48823; turnbu41@msu.edu*

*Leanne Doughty, University of Colorado Denver*

*Marcos D. Caballero, Michigan State University*

Upper-division physics courses introduce quantitative models that require students to use sophisticated mathematical tools to develop an understanding of them. We have investigated students' in-the-moment math reasoning during physics problem solving, through observations in dyad interviews. By conducting interviews over a range of students' physics experience, we enabled a cross-sectional analysis of how students employ mathematical tools, particularly decomposing vectors and using multivariable integration. In investigating students' reasoning underlying their use of those mathematical tools we have catalogued student difficulties and identified productive approaches for pedagogical purposes. We observed multiple patterns in students' problem solving approaches. For example, when students were dissatisfied with their derived expression, they frequently decided to start again with a new approach without having examined the work that led them to their initial expression. In addition, the depth of reflection appears to be linked to students' ability to readily interpret their derived expressions in the context of the problem.

### PST1D22: 9:15-10 p.m. A Nonverbal Intelligence Test as a Predictor of FCI Gain

*Poster – Matthew R. Semak, University of Northern Colorado, Campus Box 127, Greeley, CO 80639; matthew.semak@unco.edu*

*Richard D. Dietz, Cynthia Galovich, University of Northern Colorado*

We have administered a commercial, nonverbal, intelligence test (the GAMA – General Ability Measure for Adults) to students in two introductory physics classes to determine if this test can be used in successfully predicting normalized gains on the Force Concept Inventory (FCI). The GAMA is made up of four subtests as it poses four types of problems to be solved: matching, analogies, sequences, and construction. For this population, we examine how the performance on each part correlates to their normalized FCI gain. Our analysis is gender specific and includes the students' overall performance on the GAMA as a predictor as well.

### PST1D23: 8:30-9:15 p.m. A Radiation Conceptual Evaluation*

*Poster – Andy P. Johnson, Black Hills State University, 1200 University, Spearfish, SD 57799-9005; andy.johnson@bhsu.edu*

*Anna Hafele, Black Hills State University*

A radiation conceptual evaluation has been created to identify student thinking in the most problematic areas of ionizing radiation. The most common set of ideas about radiation is the "substance-like view" which places radiation in the wrong ontological category, leads to problematic ideas about contamination, and interferes with the scientific view of ionizing radiation as processes at the subatomic scale. The Rad CE identifies facets of this view along with other problematic beliefs such as "radiation is waves." This poster details the diagnostic capabilities of the current draft of the Rad CE, and the typical ideas that it identifies. The Rad CE is part of the Inquiry into Radioactivity project which enables radiation literacy among nonscience college and high school students. More information at http://www.camse.org/radiation.

*The Inquiry into Radioactivity Project has been supported by NSF DUE grant 0942699. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

### PST1D24: 9:15-10 p.m. A Taxonomy of Conceptions about Buoyancy

*Poster – DJ Wagner, Grove City College, 100 Campus Drive, Grove City, PA 16127; djwagner@gcc.edu*

*Shannon Armstrong, Randon Hoselton, Ashley L Miller, Grove City College*

Numerous studies, dating back at least as far as Piaget, have used buoyancy to probe students' understanding of density. A few studies have instead probed students' understanding of buoyancy in terms of pressure, buoyant force and Archimedes' Principle. In this poster, we present an overview of the latest version of our buoyancy conception taxonomy. Included conceptions were collected both from prior studies involving subjects having a variety of ages, and from our own interviews and assessments given to college students.

### PST1D25: 8:30-9:15 p.m. Adapting AAPT Lab Recommendations to Meet Local Conditions: DATA Lab*

*Poster – William M. Martinez, Michigan State University, Biomedical and Physical Sciences, East Lansing, MI 48824-2320; marti790@msu.edu*

*Kelsey M. Funkhouser, Abhilash Nair, Marcos D. Caballero, Michigan State University*

The AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum developed broad learning goals, in part to focus physics laboratory instruction on critical practices that are best engaged within a laboratory. However, adapting these goals to an institution's curriculum must involve molding these recommendations to local conditions. This poster will present the alignment of AAPT recommendations with locally implemented learning goals set forth at Michigan State University as we developed Design, Analysis, Tools, and Apprenticeship (DATA) Lab, an algebra-based lab for non-majors. Strategies and practices we employed, such as faculty interviews, in order to incorporate faculty input as well as develop buy-in will also be presented.

*This work is funded by a Howard Hughes Medical Institute Science Education Grant

### PST1D26: 9:15-10 p.m. An Analysis of the Misconception about Shape Dependence of Buoyancy

*Poster – Sachiko Tosa, Niigata University, Ikarashi-2-cho, 8050-banchi,?Nishi-ku Niigata, 950-2181 Japan; stosa@ed.niigata-u.ac.jp*

The concept about buoyancy often exhibits difficulties for students to understand. In this study, student misconception about the shape dependence of buoyancy was explored through a survey and interviews. The study was conducted in two science workshops and a college class (N=166). The survey was used before and after the treatment to examine if the participants understand 1) the existence of buoyant force in water, and 2) independence of buoyant force on the shape of the object if it is submerged under water. The results show that more than 90% of the participants understand the existence of buoyant force in water after the treatment. However, the results indicated that about 50% of the participating children and 20% of adults hold the misconception about the shape-dependence of buoyancy even after the treatment. The persistence of the misconception and its connection to real-life experience is further discussed based on the interview results.

### PST1D28: 9:15-10 p.m. Analogous Patterns of Student Reasoning Difficulties in Introductory Physics and Upper-Level Quantum Mechanics

*Poster – Emily M. Marshman, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu*

*Chandralekha Singh, University of Pittsburgh*

Very little is known about how the nature of expertise in introductory and advanced courses compares in knowledge-rich domains such as physics. We develop a framework to compare the similarities and differences between learning and patterns of student difficulties in introductory physics and quantum mechanics. Based upon our framework, we argue that the qualitative patterns of student reasoning difficulties in introductory physics bear a striking resemblance to those found for upper-level quantum mechanics. The framework can guide the design of teaching and learning tools. This work is supported by the National Science Foundation.

### PST1D29: 8:30-9:15 p.m. Assessing Difficult to Assess Learning Goals – Formative Feedback in P3

*Poster – Paul W. Irving, Michigan State University and CREATE for STEM Institute (MSU), 1310A Biomedical and Physical Sciences Building, East Lansing, MI 48824-2320; paul.w.irving@gmail.com*

*Danny Caballero, Michigan State University and CREATE for STEM Institute (MSU)*

P3 is a transformed introductory mechanics course at Michigan State University that focuses on the development of scientific practices. The design team, as part of the P3 course design made explicit attempts to assess learning goals that can often be perceived as being a part of the hidden curriculum or considered difficult to assess (for example: learning to work productively in a group). This assessment is in the form of formative feedback with students receiving a numbered grade and reflective commentary based around their interactions in the classroom for the week. In this presentation, case studies formed from student interviews conducted at the beginning and end of the semester are discussed to highlight how the formative feedback received, effected changes in student interactions in class. The presentation also highlights students' reflections on the feedback and how the effect it had on them changed over time.

### PST1D30: 9:15-10 p.m. Assessing Gender Differences in Students' Understanding of Magnetism

*Poster – Chandralekha Singh, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu*

*Jing Li, University of Pittsburgh*

We investigate gender differences in students' difficulties with concepts related to magnetism using a multiple-choice test whose reliability and validity have been substantiated earlier. We also conduct individual interviews with a subset of students to get a better understanding of the rationale behind their responses. We find that females performed significantly worse than males when the test was given both as a pre-test and post-test in traditionally taught calculus-based introductory physics courses. In the algebra-based courses, the performance of females was significantly worse in the post-test but there was no statistical difference in the pre-test performance of males and females. These trends persisted regardless of the instructors. We discuss possible reasons for these differences. Supported by NSF.

### PST1D31: 8:30-9:15 p.m. Attitudes, Approaches to Physics Problem Solving: Turkish and American Students

*Poster – Andrew J. Mason, University of Central Arkansas, 201 Donaghey Ave., Conway, AR 72035-0001 ,ajmason@uca.edu*

*Nuri Balta Canik, Ba?ar? University*

*Chandralekha Singh, University of Pittsburgh*

The Attitudes and Approaches to Problem Solving Survey (AAPS) was developed in order to assess attitudes, as well as preferred approaches, towards physics problem solving. Establishment of validity and reliability was based on data from university-level students in introductory-level and graduate-level physics courses in the United States. However, the survey's validity and reliability needs to be investigated for educational systems in other nations, e.g. the Turkish secondary and university students. We present data taken from physics students in three different types of Turkish high schools, as well as a section of university students in Turkey. Validity and reliability measurements are presented that indicate the survey is useful for both the American and Turkish school systems, and results showcase differences in grade level, school type, and gender. Principal component analysis with matrix rotation indicates groupings of the survey's 33 items into potential item clusters.

### PST1D32: 9:15-10 p.m. Challenges Engaging Students via Interactive e-learning Tutorials for Introductory Physics

*Poster – Seth T. DeVore, 135 Willey St., Morgantown, WV 26506-0002; stdevore@mail.wvu.edu*

*Emily Marshman, Chandralekha Singh, University of Pittsburgh*

As self-paced adaptive e-learning tools become increasingly available, a critical issue educators encounter is implementing strategies for ensuring that all students engage with them as intended. Here, we discuss the effectiveness of adaptive e-learning tutorials as self-study tools in large enrollment brick and mortar introductory physics courses. These interactive tutorials were developed via research in physics education and were found to be effective for a diverse group of introductory physics student volunteers in one-on-one implementation. Our findings suggest that many students in need of out of class remediation via self-study tools may have difficulty motivating themselves and may lack self-regulation and time-management skills to engage effectively with the adaptive e-learning tools especially designed to help them learn at their own pace. We conclude by proposing a theoretical framework to help students with diverse prior preparations engage effectively with self-study tools. Supported by the NSF.

### PST1D33: 8:30-9:15 p.m. Characterizing How Students Group Themselves for Group Exams

*Poster – Joss Ives, University of British Columbia, 2329 West Mall, Vancouver, BC V6T 1Z4; joss@phas.ubc.ca*

When using ad hoc student groups for group exams, how do students group themselves? Are there clear preferences for grouping by sex, ability in the course or years in university? In courses with multiple opportunities to form these ad hoc groups, do these preferences change as the course proceeds? This research is part of a larger study investigating the factors that contribute to group success, both in terms of the group's performance on that group exam as well as the performance of individuals on later assessments.

### PST1D34: 9:15-10 p.m. Cognitive Wrappers: Learning How to Learn Physics

*Poster – Patricia Soto, Creighton University, 2500 California Plaza ,Omaha, NE 68178-0001; PatriciaSoto@creighton.edu*

*Gintaras Duda, Creighton University*

Cognitive exam wrappers are tools that focus on using metacognition and reflection skills to motivate students to analyze the factors that contribute to their performance on exams and plan strategies that will strengthen their study habits to improve their exam performance. Cognitive wrappers, utilized here in an introductory physics for the life sciences (IPLS) course, ask students to reflect on the following: 1) the amount of time they invested in preparing for an exam, 2) the root causes of errors made on the exam, 3) study habits that students feel positively impacted their preparation, and 4) strategies that students are willing to implement to improve their performance. Students also have the opportunity to provide suggestions to the instructor that they think will help improve their learning. In this work we report on the study habits that students employ to prepare for a physics exam, self-reported root-causes of mistakes on exams, and strategies that students are willing to try to improve their performance. In addition, we will report on the insight the instructor has gained to build a deeper understanding of the student population in this IPLS course.

### PST1D35: 8:30-9:15 p.m. Comparing Teaching Effectiveness Across Years Using Background-Attenuated Learning Gains

*Poster – Brent W. Barker, Roosevelt University, 425 S Wabash Ave., Rm WB816C, Chicago, IL 60605; bbarker@roosevelt.edu*

*Brittney Austin, Kayla Fouch, Roosevelt University*

Comparing learning gains between different offerings of the same course is helpful for studying effectiveness of instruction. In small classes, fluctuations in student background can introduce confounding variables and make direct comparison difficult. In the present work, we correlate student backgrounds with learning gains on conceptual inventories in introductory physics and show a method for accounting for differences in student backgrounds. We compare two consecutive years of classes and demonstrate the affect of accounting for these differences in backgrounds.

### PST1D36: 9:15-10 p.m. Comparing Two Activities' Effectiveness Improving Reasoning with Multiple-Variable Graphed Information

*Poster – Rebecca J. Rosenblatt, Illinois State University, 218 Willard Ave., Bloomington, IL 61701; rosenblatt.rebecca@gmail.com*

*James Peronne Illinois State University*

Past findings show large differences in student ability to use, and reason with, certain graphed data. Namely, many students incorrectly assume there must be dependence between the axes of any graph whether-or-not the data suggests a relation and whether-or-not a controlled experiment was done. In addition, students have similar difficulties reasoning with multivariable data displayed on a graph in multiple trend-lines. A majority of the errors made are consistent with a failure to properly control variables and/or reasoning illogically about the data. We developed and pilot tested two different one-hour group work activities to improve student understanding. One activity was laboratory based and focused on control of variables and experimentation. The other was recitation based and focused on logical reasoning and data manipulation. Results show the relative effectiveness of the activities and suggest interesting facts about the importance of logical reasoning vs. control of variables when working with graphed data.

### PST1D37: 8:30-9:15 p.m. Concept Inventories and the Next Generation of Assessment

*Poster – James T. Laverty, Michigan State University, 620 Farm Lane, Erickson Hall, Room 115, East Lansing, MI 48824-1046; laverty1@msu.edu*

*Marcos D. Caballero, Michigan State University*

In 2012, the National Research Council released A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. This report synthesized the literature on how students learn science into three dimensions that should be blended together in instruction, curriculum, and assessment. This "three-dimensional learning" is the basis for the Next Generation Science Standards and researchers have recently made calls to bring it to higher education as well. We have developed the Three-Dimensional Learning Assessment Protocol (3D-LAP), which can characterize assessments in introductory science courses as aligning (or not) with scientific practices, crosscutting concepts, and core ideas. In this poster, I apply the 3D-LAP to some commonly used concept inventories in physics to characterize their alignment with the three dimensions from the Framework. I will explore the potential utility of these concept inventories in the era of the Next Generation Science Standards.

### PST1D38: 9:15-10 p.m. Conceptual Blending: An Analytical Framework for Immersive Computer-Supported Learning

*Poster – Bor Gregorcic, Uppsala University, Box 516, Uppsala, 75120, Sweden; bor.gregorcic@gmail.com*

*Jesper Haglund, Uppsala University*

Modern technology allows students to engage in hands-on exploration of previously experimentally inaccessible topics. One example is using an interactive whiteboard and the Algodoo software to allow students to throw planets into orbits around a star. While students quickly accept the idea of them being able to throw planets into orbit, building an expert-like understanding of the topic of orbital motion requires a coordination of different perspectives on what is going on in such an activity. Conceptual blending is an analytical framework used to interpret cognitive processes as they take place at the meeting point of different mental input spaces. These can include physics formalisms, and everyday experiences of interacting with the real or the computer world. The poster will present a blending analysis of a student-centered activity in astronomy that engages students in playful inquiry.

### PST1D39: 8:30-9:15 p.m. Content Knowledge for the Teaching of Energy: Assessing Classroom Artifacts

*Poster – Robert C. Zisk, Rutgers University, 10 Seminary Pl., New Brunswick, NJ 08901-1281; robert.zisk@gse.rutgers.edu*

*Eugenia Etkina, Drew Gitomer, Rutgers University*

Assignments and assessments that a teacher makes for his or her students can provide insight into the intellectual demand and expectations of a classroom, as well as the content addressed during instruction. As part of a study to develop assessments of teachers' Content Knowledge for the Teaching of Energy, we developed a protocol to assess the intellectual demand of the assignments and assessments that a teacher uses during instruction. In this poster, we will describe our coding scheme, provide examples of artifacts collected from teachers during their unit on energy and discuss how the example artifacts are coded using our protocol. We will then show how the intellectual demand of artifacts as measured by our protocol is related to other measures of practice, such as classroom observation measures, a teacher's content knowledge for teaching and student outcomes.

### PST1D40: 9:15-10 p.m. Context Dependent Mindset: Building New Frameworks and Measurement Methodologies

*Poster – Angela Little, Michigan State University, 220 Trowbridge Rd., East Lansing, MI 48824; angie.little@gmail.com*

*Vashti Sawtelle, Bridget Humphrey, Michigan State University*

Mindset is a long-standing area of the psychology literature that focuses on students' beliefs about whether intelligence can grow and improve. Much of the mindset research involves Likert scale survey items such as, "Your intelligence is something about you that you can't change very much." People are often characterized as having either a growth or fixed mindset, however, Dweck recently noted the importance of "portraying people as mixtures," in various contexts (Dweck, 2015). Yet, methodologically, it is not possible to examine these "mixtures" with current broad survey tools. We draw from lessons learned from the science beliefs literature that similarly shifted to studying the context-dependent nature of beliefs through, "naturalistic case studies, including open-format interviews" (Hammer & Elby, 2002). In this presentation we examine preliminary interview data as a way of moving forward in studying issues of mindset.

### PST1D41: 8:30-9:15 p.m. Continued Use of Research-based Instructional Strategies After Paired Teaching

*Poster – Jared Stang, University of British Columbia, 334 - 6224 Agricultural Road, Vancouver, BC V6T 1Z1 Canada; jared@phas.ubc.ca*

*Linda Strubbe, University of British Columbia*

Paired (or co-)teaching is an arrangement in which two faculty are collaboratively responsible for all aspects of teaching a course. By pairing an instructor experienced in research-based instructional strategies (RBIS) with an instructor with little or no experience in RBIS, paired teaching can be used to promote the adoption of RBIS. We report on several examples of instructors who were the relative novices in such pairs. Using data from in-class observations, the Teaching Practices Inventory, and interviews with the instructors, we characterize the extent to which they have continued using RBIS in the courses they have taught after pair-teaching. Preliminary results indicate both a continued use of RBIS when teaching in the same course that they pair-taught in and some transfer of RBIS to new contexts.

### PST1D42: 9:15-10 p.m. Student Difficulties with Quantum States While Translating State Vectors in Dirac Notation to Wave Functions in Position and Momentum Representations

*Poster – Emily M. Marshman, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu*

*Chandralekha Singh, University of Pittsburgh*

Dirac notation is often used in upper-level quantum mechanics courses, but students struggle with this representation. To investigate the difficulties that advanced students (i.e., upper-level undergraduate and graduate students) have while translating state vectors in Dirac notation to wave functions in position and momentum representations, we administered free-response and multiple-choice questions and conducted individual interviews with students. We find that students display common difficulties with these topics. This work is funded by the National Science Foundation.

### PST1D43: 8:30-9:15 p.m. Student Discourse About Equity in an Introductory College Physics Course

*Poster – Abigail R. Daane, Seattle Pacific University, 3307 3rd Ave., West Seattle, WA 98115-3755; abigail.daane@gmail.com*

In a typical introductory college calculus-based physics course, the makeup of the classroom looks much like the physics community, including few women and even fewer underrepresented minorities. This lack of representation is well known, but is rarely an explicit topic of conversation in physics courses. In an introductory physics course at Seattle Pacific University, I facilitated several activities aimed at raising student awareness about the disparity between the demographics of the physics community and the demographics of the general population. Students had the opportunity to discuss and reflect about what it means to do physics, who does it, and why particular groups of people are not equitably represented in the field. In this presentation, I share preliminary findings about the impact of and response to these activities.

## PST1D44: 9:15-10 p.m. Student Ideas About Coordinate Systems in the Upper Division

*Poster – Brian D. Farlow, North Dakota State University, NDSU Dept. 2755, P.O. Box 6050, Fargo, ND 58108 ;brian.farlow@ndsu.edu*

*Mike Loverude, California State University Fullerton*

*Marlene Vega, California State University*

*Warren Christensen, North Dakota State University*

As part of a broader study on student thinking about mathematics in the undergraduate physics curriculum, we report on students' ideas about coordinate systems in the upper division. Early evidence suggests that upper-division physics students struggle to answer conceptual and pictorial questions requiring the use of Cartesian and non-Cartesian coordinate systems. Specifically, students have difficulty identifying the motion of objects using plane polar coordinates. Not recognizing that both radial displacement and polar angle change with respect to time for motion along non-circular paths is a specific example of this difficulty. We report findings from one-on-one interviews that used a think-aloud protocol designed to shed light on student thinking within this domain.

## PST1D45: 8:30-9:15 p.m. Student Use of Symbolic Forms When Constructing Differential Vector Elements*

*Poster – Benjamin P. Schermerhorn, University of Maine, Department of Physics and Astronomy, Orono, ME 04469; benjamin.schermerhorn@maine.edu*

*John R. Thompson, University of Maine*

As part of an effort to examine students' understanding of the structure of non-Cartesian coordinate systems and the differential elements associated with these systems when using vector calculus in electricity and magnetism (E&M), students in junior E&M were interviewed in pairs. In one task, students constructed differential length and volume elements for an unconventional spherical coordinate system. Here we describe one aspect of this study, which involves identifying the symbolic forms (Sherin, 2001) students invoked when building or checking these vector expressions. For example, the parts-of-a-whole form was particularly useful to students, allowing them to carve out the specific component structure of the needed vector differential length. Students also used the dependence form to account for dimensionality during construction of each component. Further analysis addresses the role of these symbolic forms in student performance on the task.

*This work was supported in part by NSF Grant PHY-1405726.

## PST1D46: 9:15-10 P.m. Surveying Introductory Physics Students' Attitudes and Approaches to Problem Solving

*Poster – Andrew J. Mason, University of Central Arkansas, 201 S. Donaghey Ave., Conway, AR 72035-0001; ajmason@uca.edu*

*Chandralekha Singh, University of Pittsburgh*

Students' attitudes and approaches to problem solving in a science domain can greatly impact their actual problem solving practices and also influence their motivation to learn and ultimately the development of expertise. We developed and validated an Attitudes and Approaches to Problem Solving (AAPS) survey [1] and administered it to students in the introductory physics courses in a typical research university in the United States. Here, we discuss the development and validation of the survey and analysis of the responses to the survey questions of students in introductory physics courses. The introductory physics students' responses to the survey questions were also compared with those of physics faculty members and graduate students. We find that introductory students are in general less expert-like than the physics faculty members and graduate students. Moreover, on some AAPS survey questions, the responses of students and faculty have unexpected trends and should be interpreted carefully.

[1] Source: A. Mason and C. Singh, "Surveying graduate students' attitudes and approaches to problem solving," Physical Review: Physics Education Research 6(2), 020124 (2010).

## PST1D47: 8:30-9:15 P.m. Surveying Student Understanding of Thermodynamic Processes and First and Second Laws: Development and Validation of a Survey

*Poster – Chandralekha Singh, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu*

*Ben Brown, University of Pittsburgh*

Research-based conceptual multiple-choice surveys are useful tools for evaluating student understanding of various topics and carefully developed and validated surveys can play an important role in evaluating the effectiveness of a curriculum and instruction. When compared to free response questions, multiple choice questions are free of grader bias and multiple-choice tests can be graded with great efficiency. Well-developed prior surveys focusing on different topics reveal that traditional instructional approaches are not effective in helping a majority of students develop a good understanding of various physics concepts and students in physics courses have many common conceptual difficulties about different topics. Here, we discuss the development and validation of a survey of Thermodynamic Processes and the First and Second Laws (STPFaSL). The validity and reliability of this survey along with the student difficulties with these topics among various groups from introductory students to physics graduate students will be discussed. We thank the National Science Foundation for support.

## PST1D48: 9:15-10 p.m. Teaching Diffusion Using a Beach Ball*

*Poster – Bradley Moser, University of New England, 11 Hills Beach Road, Biddeford, ME 04005; bmoser@une.edu*

*David Grimm, James Vesenka, University of New England*

Students have substantial difficulties applying physics concepts to anatomy and physiology (and vice versa). We have developed a kinesthetic diffusion model requiring students to apply multiple concepts (velocity, impulse, pressure, viscosity and statistical mechanics) to understanding diffusion. Students play the role of both participants and observers to the Brownian motion of a blood cell modeled by a beach ball. The activity additionally requires a pair of tennis balls/student, meter sticks for recording positions, a rope boundary (10-m diameter) and a flat surface such as a gym floor. The mean position versus collision event (time interval) from several trials is analyzed in lab to generate a macroscopic diffusion constant. Lab discussion connects the macroscopic diffusion to demystify microscopic behaviors such as aroma diffusion from popping corn, dye diffusion in a petri dish, or Brownian motion of silica beads observed with an optical microscope.

*NSF DUE grants 0737458 and 1044154

## PST1D49: 8:30-10 p.m. The Effect of Themed Learning Community on Physics Students' Performance

*Poster – Wataru Hashimoto, Northern Illinois University, 1175 Lincoln Dr. N, 503E1 DeKalb, IL 60115; whashimoto@niu.edu*

The current study will focus on the impact of a calculus and physics Themed Learning Community (TLC) in order to compare to non-TLC sections on the Force Concept Inventory (FCI), which tests student's conceptual understanding of physics. TLCs offer classes with the same major, smaller size, and in conjunction with two or three related classes. For example, students in TLC calculus and TLC physics will have the same classmates, and intention of TLC is to create the connection between students. As a result, the normalized FCI gain showed that TLC students performed significantly better than Non-TLC students. Therefore, we will further investigate the reason why the TLC students performed better than non-TLC students, by categorizing the FCI, using the FCI to study students' misconceptions, and combining the new data that we collected in fall 2015 to increase statistical significance.

### PST1D50: 9:15-10 p.m. Student Attitudes, Network Positions, and Conceptual Gains in Introductory Physics

*Poster – Adrienne L. Traxler, Wright State University, Department of Physics, 3640 Colonel Glenn Hwy., Dayton, OH 45435-0001; adrienne.traxler@wright.edu*

*Raym Alzahrani, Wright State University*

Student attitudes toward physics typically worsen over the first semester of introductory calculus-based physics, as measured by instruments like the Colorado Learning Attitudes about Science Survey (CLASS). Larger courses are particularly linked with these negative shifts, with positive shifts mostly measured in smaller courses using active learning. However, students in a large course may have very different experiences depending on whether they are socially isolated or work in collaborative groups. Social network analysis provides tools to distinguish between isolated and well-connected students within the same course and examine this possible latent variable in attitudinal shifts. Here, we compare CLASS shifts with students' initial and final network positions for several sections of introductory calculus-based physics. Where available, CLASS scores and shifts will also be compared to students' conceptual gains to form a more complete picture of their physics experience over the semester.

### PST1D51: 8:30-9:15 p.m. Using the Cognitive Reflection Test to Investigate Student Reasoning Inconsistencies*

*Poster – Nathaniel Grosz, Department of Physics, NDSU, NDSU Dept. 2755, P.O. Box 6050, Fargo, ND 58102; Nathaniel.C.Grosz@ndsu.edu*

*Mila Kryjevskaia Department of Physics, Cody Gette, Department of Physics, NDSU*

*Andrew Boudreaux, Western Washington University*

*MacKenzie Stetzer, University of Maine*

Students who demonstrate correct conceptual knowledge and formal reasoning approaches on one physics question often abandon these approaches in favor of more intuitive reasoning on an isomorphic question. The heuristic-analytic theory of reasoning suggests that the intuitive approaches used by these students stem from the heuristic process and are cued by salient, distracting features of the isomorphic problems. This apparent failure to engage the analytic process productively may stem from a lack of metacognition. We speculate that the students who continue to use formal reasoning on the isomorphic problems tend to be more reflective, analytical thinkers. In order to investigate this possibility, we have been using the Cognitive Reflection Test (CRT) in conjunction with a pair of isomorphic questions to examine the extent to which students' reflection abilities impact performance.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, 1431940, 1432052, and 1432765.

## Other Posters

### PST1E01: 8:30-9:15 p.m. Development of an English-Vietnamese Bilingual Online Course on Geometrical Optics

*Poster – Hai D. Nguyen, Kansas State University, 116 Cardwell Hall, Manhattan, KS 66506; donghai.per@gmail.com*

*Le-Hang Nguyen, Ho Chi Minh City, University of Pedagogy, Vietnam*

As Vietnam is accelerating its integration to the world in all aspects, there comes an urgent need that our young generation must be able to communicate in English not only in everyday conversation but also in sciences. However, the resources for learning science (including physics) in English are very rare in Vietnam. Hence, we decided to build an online course where students could learn physics in both English and Vietnamese. Our course followed the CLIL (Content Language Integrated Learning) approach which was developed in Europe in 1990s and has been applied to several disciplines in many countries. Our course is free and open for everyone at http://lophoc.thuvienvatly.com/course/view.php?id=92. In this presentation, we introduce the pedagogy and components of our online course as an example for teachers who desire to develop similar courses in other languages.

### PST1E02: 9:15-10 p.m. Improving Representation in Physical Sciences Using a Departmental Action Team

*Poster – Katherine D. Rainey, University of Colorado at Boulder, 4998 Moorhead Ave., Apt 210, Boulder, CO 80305-5567; katherine.rainey@colorado.edu*

*Ethan T. Neil, Meredith D. Betterton, Daniel L. Reinholz, Joel C. Corbo, University of Colorado at Boulder*

Women and minority students are largely underrepresented in the physical sciences. Here we describe a faculty-, student-, and staff-led group, called a Departmental Action Team (DAT), created to study the recruitment and retention of women and underrepresented minority (URM) students in one physical sciences department. As a result of the DAT's work, the department has created a new committee on Representation, Recruitment, and Retention (R-cubed) to improve outreach and support for underrepresented students. We describe how the grassroots efforts of the DAT created a departmental context that was able to leverage campus-level diversity efforts to support meaningful, department-wide discussions and an action plan for improving diversity and equity in the major. As such, we present a case study and model for departmental change in other physical science departments.

### PST1E03: 8:30-9:15 p.m. Inclusive STEM: A Discussion Group About Equity in STEM Fields

*Poster – Monica K. Cook, Georgia State University, 25 Park Place, Suite 600, Atlanta, GA 30302-3999; monica@physics.gsu.edu*

Inclusive STEM is a student organization at Georgia State University whose mission is to provide support to underrepresented minorities in Science, Technology, Engineering, and Mathematics (STEM) fields by giving a framework for discussion about equity issues in those fields. The group aims to educate STEM students and professionals about diversity, equity, and inclusion as these issues relate to being a culturally competent future scientist, technology professional, engineer, or mathematician.

### PST1E04: 9:15-10 p.m. Infinite Circuits Are Easy. How About Long Ones?

*Poster – Mikhail Kagan, Penn State Abington, 1600 Woodland Rd., Abington, PA 19001-3918; mak411@psu.edu*

*Xinzhe Wang, Penn State*

A ladder circuit is composed of resistors with alternating connections in series and parallel. An infinite ladder circuit made of identical resistors is known to have a "golden ratio" equivalent resistance. Things get much more interesting when the circuit is not infinite and when resistors are not all identical. We show how to derive a general explicit expression for the equivalent resistance as a function of the number of repeating blocks, R(n). This expression provides an insight on some adjacent topics, such as Fibonacci numbers, continued fractions and a druncard's random walk in a street with a gutter. We also remark on a possible method of solving the non-linear recurrent relation between R(n) and R(n+1). This result can be easily incorporated in a hands-on lab activity.

### PST1E05: 8:30-9:15 p.m. Integration of Computation into Undergraduate Physics Courses: Opportunities for Physics Faculty

*Poster – Kelly Roos, Bradley University, 1501 West Bradley Ave., Peoria, IL 61625; rooster@bradley.edu*

*Marcos D. Caballero, Michigan State University*

Monday afternoon

Norman Chonacky, Yale University

Larry P. Engelhardt, Francis Marion University

Marie Lopez del Puerto, University of St. Thomas

Robert C. Hilborn, AAPT

While computation has entered the undergraduate physics curriculum in the form of isolated courses on computational and numerical methods, and in a few institutions as a comprehensive program of study, computational instruction in an integrated mode is ostensibly scarce. The Partnership for Integration of Computation into Undergraduate Physics (PICUP) is a national-scale physics community dedicated to aiding and supporting physics faculty in integrating computation into their physics courses, and is also committed to positively impacting the undergraduate physics curriculum by fostering the ubiquitous use of computation as an important third way of doing physics, in addition to analytical theory and experimentation. This poster describes the PICUP community-based framework for integrating computation into the undergraduate physics curriculum, and also advertises an exciting opportunity for faculty who would like to try integrating computation into their physics courses.

### PST1E06: 9:15-10 p.m. Investigating Student Reasoning of Everyday Interdisciplinary Phenomena – Initial Phases

*Poster – K. K. Mashood,* Michigan State University, Physics Education Research Lab, Department of Physics and Astronomy, East Lansing, MI 48824; mashoodk@msu.edu*

*Vashti Sawtelle, Charles W. Anderson, Emily E. Scott, Rebecca L. Matz, Michigan State University*

*Sonia M. Underwood, Florida International University*

Nurturing interdisciplinary thinking is one of the major goals of a coherent undergraduate education. In this poster we describe the initial stages of a project investigating how students reason about some everyday interdisciplinary phenomena. Specifically, we are studying student explanations to questions such as "What happens to an egg when it boils?" or "How does a person sneezing make another person sick?" Semi-structured interviews were conducted with a group of biology majors enrolled in an introductory physics class (N=12). We are analyzing these interviews to uncover the extent to which students invoke various disciplinary tools, make connections within and across disciplines, and the nature of reasoning in their explanations. We also aim to identify major patterns in student reasoning, along with the challenges and affordances inherent in them. Our long-term goal includes development of a tool to assess interdisciplinary reasoning.

*Sponsored by Vashti Sawtelle, Michigan State University

### PST1E07: 8:30-9:15 p.m. Issues of a Community College in NY State: 64-Credit Cap, Transfer Paths, and Request to Wave Modern Physics

*Poster – Glenda Denicolo, Suffolk County Community College, 533 College Road, Selden, NY 11784; glenda.denicolo@gmail.com*

Suffolk County Community College (SCCC) is part of the State University of New York (SUNY) system. In September 2013, SUNY adopted the Seamless Transfer Requirements, in which two-year college programs had to reduce the total number of credits to 64 by May 2014, and at the same time in doing so, abide to the list of core courses in the Transfer Path designed for each discipline. During this period, SUNY was urged to revisit the list of "paths", and to have a more inclusive dialog with faculty representation from 2 and 4-year institutions. I participated in statewide conversations for Physics, for about six months, through discussion posts. A written summary of Transfer Path recommendations (list of core courses per program) was submitted by each advisory board in the discussion groups, and became effective as of 2015. In this process, our Associate Degree in Liberal Arts and Sciences: Physics Option at SCCC was reduced from a maximum of 72 credits to 64, and several local education requirements, and some General Education requirement courses had to be removed from the program in order to meet the Transfer Path for Physics. I will present our current two-year program, and our ongoing request to SUNY to waive Modern Physics from our program due to low-enrollment (Modern Physics is only required to physics majors), lack of equipment and physical space for this course in particular. Our calculus-based physics courses at SCCC are mostly service courses (mostly majors in engineering), with < 5 physics majors per year, and most of our students transfer to local 4-year institutions after their third semester taking physics at SCCC.

### PST1E08: 9:15-10 p.m. Magnets and Dominoes: A Simple Mechanics Analogy for Chemical Bonding

*Poster – Dan MacIsaac, SUNY Buffalo State College, Physics, 1300 Elmwood Ave., Buffalo, NY 14222; danmacisaac@mac.com*

*John Zamojski, SUNY Buffalo State Physics*

We present a common interdisciplinary misconception underlying chemical bonding energetics and review the associated literature. We present and describe a self-invented simple series of mechanical work activities making use of common ceramic CB60 magnets and everyday dominoes that we believe provides an insightful kinesthetic analogy leading to appropriately sophisticated insights into chemical bonding for introductory college students who have taken work and energy in introductory physics. Suggestions for how to use the activity in the class are included.

### PST1E09: 8:30-9:15 p.m. Resonance in Long LC-Ladder Circuits

*Poster – Elizabeth K. Seber, Penn State - Abington, 69 Anderson Road, Spring City, PA 19475; eks5194@psu.edu*

*Melanie Geiger, Mikhail Kagan, Penn State - Abington*

We investigated long but finite "ladder" circuits composed of alternating identical inductors and capacitors connected in series and parallel and derived an expression for the equivalent impedance of such circuits. The impedance formula's remarkable simplicity allowed for the direct procurement of all resonance and anti-resonance frequencies. We tested our analytical results by constructing circuits ranging from one to one hundred elements using the standard circuit simulation software (Multisim©), resulting in an equivalent impedance and voltage reading that agreed with our theoretical calculations. Additionally, we resolved the paradoxical phenomenon that for driving frequencies below some critical value, the impedance of a infinite purely reactive infinite circuit acquired a non-zero active part. Our formula revealed no paradox, and we investigated the behavior of the equivalent impedance as the circuit size increased. We did so for various representative values of driving frequency and again found our theoretical predictions in agreement with the modeled circuits.

### PST1E10: 9:15-10 p.m. Sense of Belonging in STEM: Intersections of Race and Gender

*Poster – Katherine D. Rainey, University of Colorado at Boulder, 4998 Moorhead Ave., Apt 210, Boulder, CO 80305-5567; katherine.rainey@colorado.edu*

*Melissa Dancy, University of Colorado at Boulder*

*Elizabeth Stearns, Roslyn A. Mickelson, Stephanie Moller, University of North Carolina at Charlotte*

Sense of academic and social belonging have been shown to affect retention and performance of students in STEM. Though many studies have looked at differences among gender or race in this respect, few studies discuss the intersections of the two. To investigate factors contributing to students' choices to major in STEM, interviews were conducted with over 300 college seniors who majored in STEM, left a STEM major, or avoided majoring in STEM. Interviews were analyzed and coded based on social connection and study habits. In this presentation, we discuss factors regarding women's sense of belonging in STEM, specifically focusing on racial aspects.

## PST1E11: 8:30–9:15 p.m. The "Embedded Expert" Model of Educational Transformation: The SEI and TRESTLE*

*Poster – Stephanie Chasteen, University of Colorado Boulder, 247 Regal St., Louisville, CO 80027; chasteen@colorado.edu*

In order to achieve broader educational change in STEM discipline, research suggests that we need to engage faculty within a discipline, with opportunities to reflect on their teaching over long periods of time. One strategy that achieves this is the "embedded expert" model, where educational experts are partnered with faculty within a department to support course transformation. This model has been successfully used in the Science Education Initiative (http://colorado.edu/sei) at two institutions, using postdoctoral fellows as embedded experts. This model is being adapted and studied at seven institutions, using various embedded experts, in a new NSF-funded project (TRESTLE; http://www.colorado.edu/csl/trestle) in order to test how this intervention can be implemented in different institutional contexts to propagate widespread STEM education reform. This poster will show how the embedded expert model works, and outline the plans for the TRESTLE grant as the next-step to build on the work of the SEI.

*This material is based upon work supported by the National Science Foundation under Grant No. 1525331

## PST1E12: 9:15-10 p.m. The Oklahoma PhysTEC Collaborative*

*Poster – Steven J. Maier, Northwestern Oklahoma State University, 709 Oklahoma Blvd., Alva, OK 73717-2799; sjmaier@nwosu.edu*

*Jenny Sattler, Northwestern Oklahoma State University*

The OK PhysTEC Collaborative consists of the four PhysTEC member institutions of Oklahoma. The goal of the project is to increase the number of physics education candidates statewide over a three-year span. To do this, high school and undergraduate students are being recruited into physics and science education programs. In addition, support for travel to physics education conferences is offered to high school teachers, undergraduate physics students, and in-service physics teachers. Participating institutions include Northwestern Oklahoma State University (lead institution), East Central University, Oklahoma State University, and Southwestern Oklahoma State University. In this poster, recruitment efforts to date will be reported, along with summaries of enrollments, program changes motivated by the project, and challenges that remain.

*The OK PhysTEC project is supported by a PhysTEC Recruitment Grant.

## PST1E13: 8:30-9:15 p.m. A Continuing List of Climate Myths VI

*Poster – Gordon J. Aubrecht, Ohio State University, Marion Campus, 193 N. Washington St., Delaware, OH 43015-1609; aubrecht.1@osu.edu*

This continues my series of posters on climate myths. A related talk is being presented.

## PST1E14: 9:15-10 p.m. Building STEM Student Pathways: A Two- and Four-year Partnership*

*Poster – Charles J. DeLeone, California State University, San Marcos, Physics Dept., San Marcos, CA 92096-0001; cdeleone@csusm.edu*

*Debbie DeRoma, Edward Price, California State University, San Marcos*

*Daniel Sourbeer, Palomar College*

*Chandra Turpen, University of Maryland, College Park*

Many geographically close two- and four-year institutions share a large percentage of their students, and STEM-specific linkages between the institutions can benefit students. So, how can local two- and four-year institutions forge strong, lasting relationships between their STEM programs? An associated talk will describe evidence of student success, which we hope will inspire others to pursue such partnerships. This poster describes the process by which we built such a partnership between two regional institutions, -- California State University, San Marcos, and Palomar College. Key steps included: building personal relationships among faculty and administrators across campuses, creating coherent academic support services, and establishing formal pathways for students. In describing this process, we identify critical elements such as mutual respect, shared goals, aligned institutional missions, and the catalyst of external funding. We hope our account of building such a partnership provides guidance to others who take up this important charge.

*Supported in part by NSF-DUE #1068477.

Monday afternoon

# Tuesday, July 19 Highlights

**AAPT Fun Run/Walk**
6–8 a.m.
Offsite

**Two-Year College Breakfast**
7–8:30 a.m.
CC - 103

**Exhibit Hall (open 10 a.m.–4 p.m.): $100 Amex Gift Card** (8:20 a.m.); **Kindle Fire HD Drawings** (3:50 p.m.)
Exhibit Hall D

**Millikan Medal Award to Stephen M. Pompea**
10:30 a.m.–12 p.m.
Sheraton - Magnolia/Camellia

**High School Teacher Lounge**
1:30–3:30 p.m., 4–6 p.m.
Sheraton - Falor

**LGBT Meetup**
12–1:30 p.m.
Sheraton - Bataglieri

**Committees, 12–1:15 p.m.**

| | |
|---|---|
| Apparatus | CC - 310 |
| Graduate Educ. in Physics | CC - 311 |
| International Physics Educ. | CC - 312 |
| Professional Concerns | Sheraton - Compagno |
| Space Science & Astronomy | Sheraton - Bondi |

**Free Commercial Workshops**

| | |
|---|---|
| WebAssign, 12–1 p.m. | CC - 316 |
| Perimeter Institute, 12–1 p.m., 2–3 p.m. | CC - 309 |
| Vernier, 12–2 p.m. | CC - 302/303 |

**PLENARY: Neil Gershenfeld, Center for Bits and Atoms**
4–5 p.m.
Sheraton - Magnolia/Camellia

**AAPT Summer Meeting Picnic**
6:30–8 p.m.
PASCO (transportation provided to and from CC)

**Demo Show**
8–9 p.m.
PASCO

## Session DA: Interactive Lecture Demonstrations: What's New? ILDs Using Clickers and Video Analysis

**Location:** CC - Room 315
**Sponsor:** Committee on Research in Physics Education
**Co-Sponsor:** Committee on Educational Technologies
**Date:** Tuesday, July 19
**Time:** 8:30-9:40 a.m.

*Presider: Priscilla Laws*

### DA01: 8:30-9 a.m. Interactive Lecture Demonstrations: Active Learning in Lecture Including Clickers and Video Analysis

*Invited – Ronald Thornton, Tufts University, 12 Temple St., Medford, MA 02155; ronald.thornton@tufts.edu*

*David Sokoloff, University of Oregon*

The results of physics education research and the availability of computer-based tools have led to the development of the Activity Based Physics Suite. [1] Most of the Suite materials are designed for hands-on learning, for example student-oriented laboratory curricula such as RealTime Physics. One reason for the success of these materials is that they encourage students to take an active part in their learning. This interactive session will demonstrate, through active audience participationŠ Suite materials designed to promote active learning in lectureŠ--Interactive Lecture Demonstrations (ILDs) [2], including those using clickers and video analysis. Research results on their effectiveness will also be presented.

1. E.F. Redish, Teaching Physics with the Physics Suite (Wiley, Hoboken, NJ, 2004). 2. David R. Sokoloff and Ronald K. Thornton, Interactive Lecture Demonstrations (Wiley, Hoboken, NJ, 2004).

### DA02: 9-9:30 a.m. ILDs and Other Strategies that Enable Students to Understand Newton's Third Law*

*Invited – Priscilla Laws, Department of Physics, Dickinson College, Carlisle, PA 17013; lawsp@dickinson.edu*

*David Sokoloff, University of Oregon*

*Ronald Thornton, Tufts University*

*Robert Teese, Rochester Institute of Technology*

*Kathy Koenig, University of Cincinnati*

Although most students who complete introductory physics courses can recite Newton's third law, very few understand the law or are aware of the fact that they don't believe it. In this talk, we compare normalized learning gains on Newton's third law questions for: (1) students who studied physics in traditional lecture/laboratory courses; (2) students who were exposed to Interactive Lecture Demonstrations (ILDs) at Tufts University and the University of Oregon; and (3) students in Workshop Physics (WP) classes during the first few years of its development. Next we demonstrate how the first ILD on Newton's third law is used as part of the WP curriculum. We then discuss why the addition of this single ILD when followed by student groups doing a series of related activities on their own leads to dramatic improvements of their learning gains. In addition we demonstrate how student completion of a short Interactive Video Vignette (IVV) on the third law in traditional introductory physics courses can also lead to significant improvements in student understanding of the third law. We conclude with some reflections on why ILDs and IVVs have such a positive effect on student understanding.*

*ILD and WP development was supported by FIPSE and NSF, and IVV development has been supported by the NSF DUE #1122828 and #1123118.

### DA03: 9:30-9:40 a.m. Preference Voting and Clickers*

*Contributed – Stephen C. Parker, Department of Physics, Saint Martin's University, 5000 Abbey Way SE, Lacey, WA 98503; parker@stmartin.edu*

*Carol B. Overdeep, Department of Mathematics, Saint Martin's University*

*James E. Overdeep, Integrated Technology Services, Saint Martin's University*

The use of clickers in the classroom has become a ubiquitous presence in many physics departments. The ability to poll students and receive instant feedback histograms has helped to guide the discussions in many of our classes. Instead of just voting for a single choice, we have explored the idea of using "preference voting" to rank the various options from worst to least. A computer program has been created to help compile the responses from the clicker software. It then uses a variety of different vote counting schemes to attempt to select the overall winner. In a cruel twist of the mathematical pen* though, the "winner" can vary depending on the method used to actually count the votes. With the use of clickers and the computer program, we can see this effect happen "live" with real time voting situations.

*Excursions in Modern Mathematics, 5th Edition, Peter Tannenbaum

## Session DB: Upper Division/Graduate Courses

**Location:** CC - Room 310
**Sponsor:** AAPT
**Date:** Tuesday, July 19
**Time:** 8:30-9:20 a.m.

*Presider: Karen Cummings*

### DB01: 8:30-8:40 a.m. Teaching Research in Traditional Classrooms: Why Make Graduate Students Wait?*

*Contributed – Lincoln D. Carr , Colorado School of Mines, 1232 West Campus Road, Golden, CO 80401; lcarr@mines.edu*

Physics graduate programs tend to divide the degree into (1) theory, taught in classes, almost totally divorced from the lab setting; and (2) research, taught in the research group, through hands-on lab experience and mentorship. In contrast, we begin research instruction in the classroom in the very first semester of graduate school. Students build their knowledge from hands-on projects, get immediate experience in the machine shop and electronics lab, and there are no formal lectures. They develop and present their own problems, teach and challenge each other in the classroom, and give conference-style presentations instead of exams. In contrast to polished lectures, both the instructor and the students together learn from their many public mistakes. As a result, students not only excel in analytical skills, but they also learn to tie theory to measurement, identify statistical and systematic errors, simulate computationally and model theoretically, and design their own experiments.

*Funded by NSF

### DB02: 8:40-8:50 a.m. Development of a Physics of Sustainability Course for Upper Level Students

*Contributed – D. Blane Baker, William Jewell College, 500 College Hill, Liberty, MO 64068-1896; bakerb@william.jewell.edu*

Over the past three years, we have been teaching a required upper-level course entitled Physics of Sustainability to our physics majors. We begin with questions related to sustainability and climate change. We then proceed with topics including electronics, wind and solar energy, nuclear energy, and solid state physics. A portion of the course also involves connecting with a community either in country or internationally to develop a collaborative project. Students participate in these projects and often travel to these locations to implement solutions developed in the course. A complete overview of the course will be presented.

### DB03: 8:50-9 a.m. Developing and Assessing Quantum Tutorials: Time Dependence and Measurements

*Contributed – Paul J. Emigh, University of Washington, 6028 215th Ave., NE, Seattle, WA 98053; paul.emigh@gmail.com*

*Gina Passante, Cal State Fullerton*

*Peter S. Shaffer, University of Washington*

The Physics Education Group at the University of Washington has developed a comprehensive set of tutorial curriculum for quantum mechanics at the sophomore and junior levels. The tutorials, which serve as a supplement to lecture instruction, are designed to improve student understanding of quantum mechanics by directly addressing common student difficulties identified by prior research. We will discuss the development and evolution of a particular sequence of tutorials focusing on concepts associated with quantum measurements and time dependence. We will also discuss the methods we have used to assess the effectiveness of these tutorials and compare our results over a period of several years.

### DB04: 9-9:10 a.m. Comparing Chinese and American Students' Understanding of Quantum Mechanics

*Contributed – Jue Wang, East China Normal University, Shanghai, 200241 China; wangjue-jane@foxmail.com*

*Guangtian Zhu, East China Normal University*

This talk discusses a comparative study on American and Chinese students' conceptual understanding of quantum mechanics. We administered the Quantum Mechanics Survey (QMS) to 200 students in China and the United States. The results show that the students in the top-ranking US universities outweigh their peers in the top-ranking Chinese universities. However, those in medium-ranking universities in both China and the U.S. have similar performance in QMS.

### DB05: 9:10-9:20 a.m. Application of Statistical Mechanics and Neural Networks for Large Databases*

*Contributed – Prabhakar Misra, Howard University, Department of Physics & Astronomy, 2355 6th St, NW, Washington, DC 20059; pmisra@howard.edu*

*Daniel Casimir, Raul Garcia-Sanchez, Howard University*

We have explored the application of statistical mechanical and thermodynamics aspects of neural networks to detect patterns in a large database POICN developed by START, a DHS Center of Excellence at the University of Maryland. The Hopfield Network consists of a fully connected cyclic array of neurons, where the output of each neuron is fed into other neurons. The neurons continuously transmit signals back and forth to one another until a stable equilibrium is reached. We have generated a plot of an activation map of the input data used in the creation of the Hopfield net based on POICN data, which can be displayed in the form of a heat map, where each pairwise unit of data likely to be a type B event (Possession/Use of CBRN) weapon is shaded in one color, and type A events (Attempted Acquisition of CBRN weapon) shaded a different color. *Financial support from the Department of Homeland Security MSI SRT program and the Howard University Graduate School are gratefully acknowledged.

*Financial support from the Department of Homeland Security MSI SRT program and the Howard University Graduate School are gratefully acknowledged.

## Session DC: Effective Practices in Educational Technologies - I

**Location:** CC - Room 311
**Sponsor:** Committee on Educational Technologies
**Date:** Tuesday, July 19
**Time:** 8:30-9:50 a.m.

*Presider: Andy Gavrin*

### DC01: 8:30-8:40 a.m. Usage of Web-based Personal Response System

*Contributed – Jing Han,* The Ohio State University, 191 W. Woodruff Ave., Columbus, OH 43210-1168; han.286@osu.edu*

*Zhao Fu, Joseph Fritchman, Lei Bao, The Ohio State University*

As more classrooms look to use clicker systems, the need for easy to use, cost-effective solutions grows. The vast majority of college students, and an increasing number of younger students, come to class with Internet-connected devices, making the use of a web-based clicker system to fulfill this role feasible. This study examines the practical and effective use of WebClicker.org as the personal response system in the physics classroom. Usage of WebClicker is free, requires minimal setup time for students and teachers, and allows multiple question and answer formats including the ability to create questions on the fly and share responses with the class. Results show that using web-based clickers achieves similar improvement on students' conceptual learning when compared to traditional clickers. Web-based personal response systems such as WebClicker provide a simple and robust way to promote interactive-engagement in the classroom.

*Sponsored by Lei Bao

### DC02: 8:40-8:50 a.m. Smartphone and Tablet Physics: Unanswered Questions in Educational Technology

*Contributed – Rebecca E. Vieyra, Vieyra Software, 225 C St. SE, Apt. B, Washington, DC 20003; rebecca.elizabeth.vieyra@gmail.com*

*Chrystian Vieyra,Vieyra Software*

Conversations about general educational technology frequently revolve more around "technology" than "education." This is especially true with the broad implementation of smartphone and tablet apps in K-12 education, and technology that is advancing more quickly than sound educational research to support it. Although there is a research base for the use of commercial probeware in the K-12 and higher education classroom, the educational technology world has given less attention to the use of personal mobile devices as tools for scientific inquiry. This presentation will briefly present some of the unanswered questions in tech ed research, relevant specifically to physics education research and student learning at the K-12 level.

### DC03: 8:50-9 a.m. Innovative Ways to Use Web-based Technologies in Introductory Physics

*Contributed – Thomas A. Moore, Pomona College, / Physics Dept / 610 N College Ave., Claremont, CA 91711; tmoore@pomona.edu*

Web-based technologies provide many novel opportunities for enhancing student learning in the introductory physics course. Web-based simulation apps and computerized grading systems represent well-known examples. In this talk, though, I will explore some more unusual applications of web-based technology in the introductory course, including targeted apps that allow students to perform calculations that would be otherwise impossible, and a system that supports an innovative student-centered approach to homework. I will also discuss the pedagogical philosophies behind these applications.

### DC04: 9-9:10 a.m. iTunes U and iBooks: Pathway to OER

*Contributed – Shahida Dar, Mohawk Valley Community College, 1101 Sherman Dr., Utica, NY 13501; sdar@mvcc.edu*

The attendees will learn about how to create interactive, dynamic documents using iBooks. The course management using iTunes U will also be explained. Presenter will show various examples of content creation and management. The use of iTunes U and iBooks in setting up Open Education Resources (OERs) will also be discussed.

### DC05: 9:10-9:20 a.m. Personalized Learning in Physics with Tabletkoulu Learning Environment

*Contributed – Hannu Turunen, Helsinki Metropolia University of Applied Sciences, Bulevardi 31, Helsinki, N/A 00100 Finland; hannu.turunen@metropolia.fi*

Engineering students have widely varying skill of physics. Lecturing to the whole group is not working. Some students could move forward more quickly while others would require a slower progression. Personalized learning solves that problem. I introduce a special E-learning environment (Tabletkoulu.fi) where every student can progress with own rate and the teacher is able to see students progression in real time. The teacher gives assistance to the student exactly when needed. The student moves to the new topic only after he masters the earlier content. The environment guides student to do self-assessment after each unit. Student will also take the quiz to test if he masters the content. If student do not pass test, he guides to study more that topic. Student go forward only when he pass the test. I will present how this environment can support personalized learning and how assessment can be done easily.*

*https://www.tabletkoulu.fi/pages/in_english

### DC06: 9:20-9:30 a.m. Space Taxi Paradigm for Freebody Analysis

*Contributed – Richard A. Zajac, Kansas State Polytechnic, 2310 Centennial Road, Salina, KS 67401-8196; rzajac@ksu.edu*

For years we have used this compelling 1980s computer game in the introductory course to establish a common experiential basis with which to frame Newton's laws. More than just a fun visualization tool, the shared experience has been found to serve as a powerful cue for triggering students to activate a Newtonian mindset when modeling real situations. Free-body diagrams and other conventional anlaysis tools emerge naturally from the game, not as imposed pedagogical formalism. Classroom experience and collected student feedback are discussed.

### DC07: 9:30-9:40 a.m. Two Visualizations of Momentum Conservation in Introductory Physics

*Contributed – Darrell F. Schroeter, Reed College, 3203 SE Woodstock Blvd., Portland, OR 97202; schroetd@reed.edu*

I will present two visualizations of momentum conservation used in the introductory physics course at Reed College. One uses Mathematica to simulate the motion of a handful of particles interacting with each other and display the vector sum of their individual momenta. The other uses video frames ripped from YouTube and a drawing program to demonstrate momentum conservation in a pool break. While these have been used as lecture demonstrations, they can both be straightforwardly reconfigured as hands-on activities.

### DC08: 9:40-9:50 a.m. Lesson Study as a Vehicle to Promote Active Learning in College Physics

*Contributed – Sachiko Tosa, Niigata University, Ikarashi-2-cho, 8050-banchi, Niigata, 950-2181 Japan; stosa@ed.niigata-u.ac.jp*

It is customary that university physics faculty is little trained in teaching, and they often follow their own way for teaching college physics classes. In this study, a collaborative faculty development scheme called lesson study is used to help physics faculty improve their teaching in a network system including seven universities in Japan. A mentor conducted regular discussion sessions with the participating faculty members through Skype. A survey and interviews are used to examine changes in participants' thoughts and beliefs about physics teaching. The results based on qualitative analysis indicated that discussion with the mentor plays an important role for helping them shift their view for teaching from instructor's side to students' side.

## Session DD: Leveraging Strengths of Diverse Populations

**Location:** CC - Room 312
**Sponsor:** Committee on Diversity in Physics
**Co-Sponsor:** Committee on Research in Physics Education
**Date:** Tuesday, July 19
**Time:** 8:30-10 a.m.

*Presider: Mel Sabella*

### DD01: 8:30-9 a.m. Creating Safe Spaces in Teaching and Learning Physics

*Invited – Konstantinos Alexakos,* Brooklyn College, CUNY 2900 Bedford Ave., Brooklyn, NY 11210-2889; kalexakos@gmail.com*

How can we facilitate emotionally safe spaces for our students, especially those from negatively stereotyped groups? In my presentation I will review my research on emotions and mindfulness in physics and science education. By undertaking this work and investigating how emotions impacts teaching and learning, I will provide a rationale for the use of mindfulness, breathing meditation, cogenerative dialogues, and heuristics (especially those dealing with thorny issues such as gender, race, and sexuality) as interventions to understand and minimize undesirable negative emotions in the classroom, produce more positive emotional climates and contribute to more healthy and successful teaching and learning practices.

*Sponsored by Mel Sabella

### DD02: 9-9:30 a.m. Who Do We Study, And How Inclusive Is Physics?

*Invited – Ximena C. Cid, California State University, Dominguez Hills, Department of Physics, 1000 E. Victoria St., Carson, CA 90747; xcid@csudh.edu*

Recently, a few supreme justices questioned, "What unique perspective does a minority student bring to a physics classroom?" This question created a lot of dialogue around diversity issues, minority issues, women issues etc. Though a majority of members in our Astronomy and Physics fields have responded with a very loud voice stating more diverse student populations are better for the field as a whole, fewer conversations describe what does diversity mean and how do we use it in physics? This talk will focus on how student populations have been described in the physics education literature and why we need to broaden our ideas of how we support diverse populations.

### DD03: 9:30-10 a.m. Physics Teaching and Education Research Guided by Anti-deficit Approaches

*Invited – Geraldine L. Cochran, American Physical Society, 1 Physics Ellipse, College Park, MD 20740; moniegeraldine@gmail.com*

*Chandra A. Turpen, University of Maryland, College Park*

Prior research has focused on documenting gaps in achievement and perceived deficits of African American, Latino(a) American, and Native American (AALANA) students fitting into a national rhetoric that emphasizes the "lack of preparation" of AALANA students in science education. Education researchers have called for a paradigm shift toward an anti-deficit framework, e.g., Harper (2010)'s reframing of the deficit-oriented question "Why are they so underprepared for college level mathematics and science courses?" to "How do STEM achievers from low resource high schools transcend academic underpreparedness and previous educational disadvantages?" In a similar vein, the speakers in this session have offered ambitious alternatives to the usual rhetoric by changing research practices and investigating classroom interventions that leverage students' strengths. Our talk will synthesize the themes from across these presentations. Lastly, we will think together about how these speakers offer us new visions of how physics education could be different.

## Session DE: Online Hybrid

**Location:** CC - Room 306
**Sponsor:** Committee on Physics in Two-Year Colleges
**Date:** Tuesday, July 19
**Time:** 8:30-9:40 a.m.

*Presider: Betsy Chesnutt*

### DE01: 8:30-9 a.m. Technology Enhanced Learning: UT Knoxville's Engage Engineering Fundamentals Program

*Invited – Amy K. Biegalski,* University of Tennessee at Knoxville, 1506 Middle Drive, 215 Perkins Hall, Knoxville, TN 37996; abiegals@utk.edu*

*Richard M. Bennett, William R. Schelter, Rachel McCord, Isaac A. Jeldes, University of Tennessee at Knoxville*

Technology is inseparable from engineering and the current generation of students; educators need to optimize the balance between face-to-face instruction and digital learning. In UT's interdisciplinary ENGAGE freshman engineering program, interaction and teamwork are merged with e-learning. In ENGAGE, students view online lectures and attend faculty team taught interactive lectures, and student teams collaborate in problem based labs and design projects supported by sensor and tablet technology. Our self-designed ENGAGE website brings cohesion to the program. The website includes an online homework system with feedback, daily supplemental materials, and lecture videos. The online discussion board allows students to get instructor assistance during off-hours. The increased student retention rate and student review data suggest that the program has been successful. The program is always in a transformative state and enhancing the student experience to stay at the forefront of best practices in the STEM higher education community.

*Sponsored by Betsy Chesnutt

### DE02: 9-9:30 a.m. Using HTML5 Simulations to Teach Conceptual Physical Science

*Invited – Bob Swanson, Itawamba Community College, 2176 South Eason Blvd., Tupelo, MS 38804; rsswanson@iccms.edu*

Are your online physical science students learning through reading and listening? Would they rather be watching and doing? Would you like your online students to have a learning experience that more closely resembles a traditional classroom? One way to supplement your existing online instruction is through the use of video demonstrations, video tutorials, and HTML5 simulations. Utilizing these tools may also create a path toward "flipping" your traditional classroom as well. In any case, transforming your online, hybrid or traditional classes should not require you to reinvent the wheel. This presentation will help you identify low-cost or freely available resources for video production and HTML5 simulations, as well as demonstrate their implementation in an online class setting.

### DE03: 9:30-9:40 a.m. Teaching Introductory Physics Labs in a Completely Online Environment

*Contributed – Samya Zain, Susquehanna University, 514 University Ave., Selinsgrove, PA 17870; zain@susqu.edu*

*Marie Wagner, Susquehanna University/Office of Information Systems*

*Robert Everly, Stephanie Schneider, Susquehanna University*

In the summer of 2014 due to student schedule limitations we decided to develop an algebra-based introductory physics I course. We wanted it to be a completely online course and labs are an integral part of the course. We recognize that in many online courses students feel unengaged so we tried to make the lab-components as interactive as possible. The labs included an introduction, a pre-lab, lab report and a quiz. The access to each component was contingent on the completion of the previous component. Labs were considered finished on completion of the quiz. For some labs additionally, videos were created to help students feel connected and to allow them to experience a more typical laboratory setting verses impersonal simulations. Subsequently videos were used for the analysis of the data as well. These strategies have delivered encouraging results and help develop stronger teacher-student connections for future online physics classes.

## Session DF: AAPT Opportunities for Middle and H.S. Teachers

**Location:** CC - Room 304/305
**Sponsor:** Committee on Physics in High Schools
**Co-Sponsor:** Committee on Teacher Preparation
**Date:** Tuesday, July 19
**Time:** 8:30-10 a.m.

*Presider: Jan Mader*

*There are many opportunities provided by members of AAPT for elementary, middle and high school teachers in physical science topics. Panelists will give a brief discussion of their professional development programs and answer questions.*

**Panelists:**

*Karen Jo Matsler, UT Arlington*

*Bruce Mason, University of Oklahoma*

*Colleen Megowan-Romanowizc, Sacramento, CA*

*Rebecca Vierya, AAPT, College Park, MD*

## Session DG: What Can We Learn From and Do with Science Centers

**Location:** CC - Room 301
**Sponsor:** Committee on Science Education for the Public
**Date:** Tuesday, July 19
**Time:** 8:30-10 a.m.

*Presider: Amber Stuver*

### DG01: 8:30-9 a.m. #AstroEverywhere – Engaging Audiences Inside and Outside Our Museum Walls

*Invited – Michelle Larson, Adler Planetarium, 1300 S. Lakeshore Dr., Chicago, IL 60605; mlarson@adlerplanetarium.org*

The Adler Planetarium celebrates #AstroEverywhere by inviting audiences to join us in exploring space both inside and outside our museum walls. We'll discuss some of our recent efforts like planetarium dome lectures simulcast live across the country, 'Scopes in the City', and a 300-mile Galaxy Ride, that demonstrate how we are leveraging our assets and expertise to meet people where they are, whether under our dome or in their neighborhoods. We will also discuss some key components to the success of these efforts, including partnerships, institutional culture, funding support, social media presence, and our new Space is Freaking Awesome marketing campaign.

### DG02: 9-9:30 a.m. Extracting Science from a Science Museum

*Invited – Paul Michael Doherty, Exploratorium, 2451 Tamalpais St., Mountain View, CA 94043-4129; pdoherty@exploratorium.edu*

Frank Oppenheimer created a great physics demonstration resource center, it is called the Exploratorium and people think of it as a science museum. I will share with you some great physics learning opportunities available at the Exploratorium and at similar science museums whether you visit in person, on the web, in virtual reality, or on an app. I will show you my favorite exhibits and tell the stories behind their creation. Knowing that the best exhibits captivate children and physics professors alike I will illustrate the physics that students and professors can take home with them.

### DG03: 9:30-10 a.m. Teachers & Museums: Views From an Ex-Physics Teacher/ Museum Professional*

*Invited – William Katzman,** 19100 LIGO Lane, Livingston, LA 70754; wkatzman@ligo-la.caltech.edu*

Early science museums used physics demonstrations that were made into exhibits, yet physics seems to be an under-represented discipline within the museum staff. This suggests that museums would welcome a physics teacher's help. They will – with Caveats. Science museums have moved beyond the canned physics demonstration towards more open-ended experiences. While teachers often say "we can explain to them," or "we can tell them" museums say "they can do this" and sometimes "they can tell us." The modern museum switches from explanation to exploration. Thoughts are still on what visitors gain from the experience, but the activity of the exploration becomes central to the experience, while the explanation is ancillary. Learn from an ex-physics teacher's & museum professional: What museums might want from you, and what you can learn from them.

*Funding provided by PHY-0757058 with some results from PHY-0917587

**Sponsored by Amber Stuver

## Session DH: APS/AAPT Joint Task Force on Undergraduate Education Physics Programs

**Location:** CC - Room 313
**Sponsor:** Committee on Physics in Undergraduate Education
**Date:** Tuesday, July 19
**Time:** 8:30-10 a.m.

*Presider: Ernest Behringer*

*This session will focus on the guidelines and recommendations being developed by the APS/AAPT Joint Task Force on Undergraduate Physics Programs. J-TUPP is studying how undergraduate physics programs might better prepare physics majors for diverse careers – Paula Heron and Theodore Hodapp.*

## Session DI: Physicists with Disabilities - A

**Location:** CC - Room 308
**Sponsor:** Committee on Women in Physics
**Co-Sponsor:** Committee on Diversity in Physics
**Date:** Tuesday, July 19
**Time:** 8:30-9:20 a.m.

*Presider: Rebecca Lindell*

### DI01: 8:30-8:40 a.m. Demonstration with One Leg to Stand on: Anecdotes on Different

*Contributed – David E. Sturm, University of Maine, Department of Physics & Astronomy, 5709 Bennett, Orono, ME 04469; sturmde@maine.edu*

We often prefer "differently-abled" to disabled for good reason. Many with disabilities have to think differently, to prepare and handle situations not experienced by the majority. What to do if a few minutes before your lecture, your condition befalls you? Does one call off class, or find a way to do things differently? In the middle of a demonstration you can't stand. What now? Certainly different. You're walking down a corridor and in the blink of an eye, you fall. Or, you find that a building has no elevator and only stairs and you're expected on the fourth floor in five minutes. You come out and find your car, legally parked in a handicapped space—blocked by unconcerned facilities workers. Ah, the joys of non-"normal" experiences! A sharing of anecdotes; but also antidotes.

### DI02: 8:40-8:50 a.m. Suddenly Handicapped, How my Life Changed After a Serious Accident

*Contributed – Erin Combs Sutherland, Kennesaw State University, 4206 Rockpoint Drive, Kennesaw, GA 30152-7726; esutherl@kennesaw.edu*

On August 2, 2013, I finished my classes for the day and got in my car to drive from Atlanta to Huntsville, Alabama, to meet some friends for dinner and a weekend of tennis. About halfway there, at the top of Lookout Mountain, I began to feel drowsy. I woke up a week later at Huntsville Hospital and my life has not been the same since. I spent another week in Huntsville Hospital, two weeks in a rehab hospital in Marietta, and three months bedridden at home and unable to bear weight on my shattered hip. It has been three years since the accident and I am still recovering and learning what it is like to have a disability that is not always obvious to others.

### DI03: 8:50-9 a.m. Surviving the Physics Classroom with ADHD

*Contributed – Jordan K. Steckloff, Purdue University - Department of Earth, Atmospheric, and Planetary Science, 550 Stadium Mall Drive, West Lafayette, IN 47907; jstecklo@purdue.edu*

ADHD does not negatively affect my ability to understand physics. However, as a student with ADHD, I faced a series of systemic challenges that seem to discourage me from continuing my studies in this field. In high school and undergrad, I was told repeatedly by classmates and instructors that ADHD doesn't exist, or is at best overdiagnosed (implying that I don't actually have it). Starting at the 300 level, courses started meeting twice a week for 80 minutes, rather than three times a week for 50 minutes, creating a struggle to focus for an additional half hour and engage with lecture content. Additionally, timed testing largely eliminated my ability to approach problems from time-consuming first principles (the way I had come to understand physics). I discuss the challenges I faced during my physics education, and how they are largely artificial, as they do not affect my ability to conduct research.

### DI04: 9-9:10 a.m. Am I Wanted: Disabled Undergraduate Student Experiences in Physics

*Contributed – Rosemary A. Carroll, 810 W Main St., Platteville, WI 53818; carrollr@uwplatt.edu*

I will present my experiences as a female student with unseen disabilities, how this affected my interactions with my professors and department, how this shaped my doubts and decisions to pursue graduate school, and my perspective on accommodations in physics education.

### DI05: 9:10-9:20 a.m. Exploring Best Practices in Accessible Design of Interactive Science Simulations

*Contributed – Elise C. Morgan, University of Colorado Boulder, The PhET Project, Boulder, CO 80309; elise.phet@gmail.com*

*Emily B. Moore, University of Colorado Boulder*

The PhET project has begun an initiative to increase the accessibility of its suite of science and mathematics simulations. In this work, we focus on the development of accessibility features that support students with visual impairments: keyboard navigation and auditory descriptions. Through an iterative process, we designed and implemented navigation and auditory descriptions for two physics PhET simulations. This process involved the use of interviews with college students and recent graduates with visual impairments. Here, we share results from these interviews focusing on best practices regarding keyboard navigation and auditory descriptions, shown by patterns in user interaction that have emerged. For example, our findings indicate that the inclusion of an easily navigable scene description upon the simulation first opening is crucial to users knowing what interactive elements are available. This research contributes to understanding how to develop physics education resources capable of supporting diverse students, including students with disabilities.

## Session DJ: Make, Play, Learn

**Location:** CC - Room 307
**Sponsor:** Committee on Physics in Pre-High School Education
**Date:** Tuesday, July 19
**Time:** 8:30-10 a.m.

*Presider: Gene Easter*

*Join in the fun as we construct science equipment exemplifying one of the most effective ways for K-12 students to learn: Active Engagement. Our crackerjack panel will kick-off this round-robin style share-a-thon with engaging "make n take" projects complete with excellent support activities. Participants will construct their own apparatus with the materials provided. Also, participants are highly encouraged to contribute their favorite classroom activities. Please bring sufficient materials and instructions to share with 25 other teachers.*

**Panelists:**

*Wendy K. Adams, University of Northern Colorado*

*Brian Jones, Little Shop of Physics, Colorado State University*

*Phyllis Westrup, Resource Area for Teaching, Sacramento*

*James Lincoln, Physics Video*

*Bill Reitz, Silver Lake, OH*

## Session DK: Other Papers

**Location:** CC - Room 317/318
**Sponsor:** AAPT
**Date:** Tuesday, July 19
**Time:** 8:30-9:40 a.m.

*Presider: Gen Long*

### DK01: 8:30-8:40 a.m. Arts + Physics = STEAMed Physix

*Contributed – Taoufik Nadji, Interlochen Arts Academy, 3552 Faculty Ln., Interlochen, MI 49643; NADJIT@INTERLOCHEN.org*

The presenter will share parts of a successful workshop conducted at MIAAPT's last fall meeting. He shall discuss/share how he has been incorporating various arts media to introduce physics concepts and encourage deeper reflections, better discussions, and richer writing within the physics curriculum.

### DK02: 8:40-9 a.m. Infinite Circuits Are Easy. How About Long Ones?

*Contributed – Mikhail Kagan, Penn State Abington, 1600 Woodland Rd., Abington, PA 19001-3918; mak411@psu.edu*

*Xinzhe Wang, Penn State*

A ladder circuit is composed of resistors with alternating connections in series and parallel. An infinite ladder circuit made of identical resistors is known to have a "golden ratio" equivalent resistance. Things get much more interesting when the circuit is not infinite and when resistors are not all identical. We show how to derive a general explicit expression for the equivalent resistance as a function of the number of repeating blocks, R(n). This expression provides an insight on some adjacent topics, such as Fibonacci numbers, continued fractions and a druncard's random walk in a street with a gutter. We also remark on a possible method of solving the non-linear recurrent relation between R(n) and R(n+1). This result can be easily incorporated in a hands-on lab activity.

### DK03: 8:50-9 a.m. Resonance in Long LC-Ladder Circuits

*Contributed – Elizabeth K. Seber,* Penn State Abington, 69 Anderson Road, Spring City, PA 19475; eks5194@psu.edu*

*Melanie L. Geiger, Penn State Abington*

*Mikhail Kagan, Penn State Abington*

We investigated long but finite "ladder" circuits composed of alternating identical inductors and capacitors connected in series and parallel and derived an expression for the equivalent impedance of such circuits. The impedance formula's remarkable simplicity allowed for the direct procurement of all resonance and anti-resonance frequencies. We tested our analytical results by constructing circuits ranging from one to 100 elements using the standard circuit simulation software (Multisim©), resulting in an equivalent impedance and voltage reading that agreed with our theoretical calculations. Additionally, we resolved the paradoxical phenomenon that for driving frequencies below some critical value, the impedance of a infinite purely reactive infinite circuit acquired a non-zero active part. Our formula revealed no paradox, and we investigated the behavior of the equivalent impedance as the circuit size increased. We did so for various representative values of driving frequency and again found our theoretical predictions in agreement with the modeled circuits.

*Sponsored by Mikhail Kagan

### DK04: 9-9:10 a.m. Solar Lantern Camp in Guatemala

*Contributed – Mary M. Brewer Sherer, William Jewell College, 500 College Hill, Liberty, MO 64068; brewerm@william.jewell.edu*

*Blane Baker, Macy Tush, Ian Langford, William Jewell College*

A team of physics faculty and students from William Jewell College spent four days with Mayan students in Guatemala teaching them to build solar lanterns for homes without electricity. The students developed the lanterns to be inexpensive, low maintenance, easy to assemble, and built form components that were either available in country or easily brought in. In conjunction with Xela AID, physics students held a four day science and technology camp that included teaching the Mayan students to build the lantern, including teaching electronics, soldering, and the basics of solar energy. Each student built their own lantern to take home.

### DK05: 9:10-9:20 a.m. Serving Our Students, Measuring Learning Instead of Teaching*

*Contributed – Gay B. Stewart, West Virginia University, PO box 6315, Morgantown, WV 26506-0006; gbstewart@mail.wvu.edu*

*John C. Stewart, West Virginia University*

How do we know if we are doing a good job in a physics course or program? Quantitative measures can seem impractical with small numbers of majors. Introducing innovative classroom techniques is not a guarantee of learning. Yet, there are concrete (if somewhat time consuming) measures that can allow us to improve our programs and demonstrate to our administrations that we are being effective. This sort of assessment can be very valuable in securing resources at your institution. The types of data every department should be keeping and how it impacts program development will be discussed.

*This work was partially supported as a part of a number of NSF-funded projects.

### DK06: 9:20-9:30 a.m. Outreach Program for High School Physics Students and Teachers

*Contributed – Michael F. Vineyard, Union College, Department of Physics and Astronomy, Schenectady, NY 12308; vineyarm@union.edu*

*Francis P. Wilkin, Union College*

Beginning in 2008, the Department of Physics and Astronomy at Union College has held an annual workshop for high school physics teachers and students. In this one-day workshop, five to seven teams of teachers and students perform experiments to measure fundamental physical constants and gain experience with modern instrumentation and laboratory techniques. The goals of the program are to stimulate students to study physics and pursue careers in STEM, provide teachers with an exciting and enriching professional development experience, and establish a network through which the Department can support local high school physics education. An average of 17 students and 6 teachers per year have participated in the program. The workshop has been supported by the NASA New York Space Grant, the New York State Section of the APS, and the department. We will describe the workshop and discuss the benefits to the students, teachers, and the department.

### DK07: 9:30-9:40 p.m. RECON – Citizen Science Investigation of the Outer Solar System

*Contributed – John M. Keller, Cal Poly San Luis Obispo, 1 Grand Ave., San Luis Obispo, CA 93407; jmkeller@calpoly.edu*

*Marc W. Buie, Southwest Research Institute*

The Research and Education Collaborative Occultation Network (RECON) is an innovative citizen science astronomy research effort involving over 50 high schools stretching across the Western U.S. (Buie & Keller, 2016, Astronomical Journal, 151:73). Through support from NSF, we have provided telescopes and training to teachers and amateur astronomers in communities from Washington, Oregon, California, Nevada, and Arizona to create a network for studying Trans-Neptunian Objects (TNOs). Using stellar occultations, which occur when TNOs pass in front of distant stars, we can learn about the sizes, shapes, and other characteristics of these primordial solar system bodies, including whether they have moons and rings. Established in spring 2015, the full RECON network plans to coordinate 6-8 TNO occultation campaigns each year. With a modest investment in camera and timing equipment, teams from across the country with existing telescope resources (8" or larger) are welcome to join our campaign efforts (www.tnoRECON.net)

## Session DL: PER Findings Related To Latin American Students

**Location:** CC - Room 314
**Sponsor:** Committee on International Physics Education
**Co-Sponsor:** Committee on Research in Physics Education
**Date:** Tuesday, July 19
**Time:** 8:30-9:30 a.m.

*Presider: Carolina Alvarado*

### DL01: 8:30-9 a.m. The Multi-faceted Nature of Building Successful Learning Communities for the Success of Hispanic Students

*Invited – Idaykis Rodriguez, Florida International University, 11200 SW 8th St., Miami, FL 33199; irodr020@fiu.edu*

Florida International University is a Hispanic-majority institution that has fostered thriving and successful learning communities for many underrepresented students in STEM majors. In physics, we implemented Modeling Instruction in introductory physics courses, hosted Modeling Instruction professional development workshops for local high school teachers, built a discipline-based education research group, and we have grown a large Learning Assistant (LA) program – all contributing to efforts to model a K-20 learning community that supports the success and persistence of all students. In this talk, I will highlight the long-term partnership between our local public school system and FIU in preparing and recruiting physics majors to the university system and present an examination of physics majors' persistence through to graduation. I will also discuss how reforms in active learning classrooms and the use of LAs have fostered success for our students.

### DL02: 9-9:30 a.m. Physics Education Research: The Case of Latin America

*Invited – Genaro Zavala, Tecnologico de Monterrey, Garza Sada 2501 Monterrey NL, NL 64849 Mexico; genaro.zavala@itesm.mx*

In the last decades in the United States, Physics Education Research has been a research field of physics that has produced many outcomes that has changed how we perceive the education of physics. In many cases these results have influenced the way instructors teach physics

## Awards Session

**Location:** Sheraton - Magnolia/Camellia
**Date:** Tuesday, July 19
**Time:** 10:30 a.m.–12 p.m.

*Presider: Mary Mogge*

**Stephen M. Pompea**
**National Optical Astronomy Observatory**
**Tucson, AZ**

### 2016 Millikan Medal: presented to Stephen M. Pompea, National Optical Astronomy Observatory, Tucson, AZ

### Knowledge and Wonder: Reflections on Ill-Structured Problem Solving

Most of my career has been in the pursuit of knowledge and wonder, used in the sense of the famous quote by Francis Bacon: "…. for all knowledge and wonder (which is the seed of knowledge) is an impression of pleasure in itself ….". Knowledge and Wonder was the title of a book by Victor Weisskopf that I read as a child that influenced me to take a broad view of scientific problem solving. In this talk, I'd like to highlight how several science teachers and colleagues have influenced my approach to some interesting ill-structured scientific, engineering, and educational problems. This type of problem challenges us to think about how complex systems work, to question our assumptions, and to find novel approaches and solutions. Although solutions to ill-structured problems often are exploratory, transitional, or even ephemeral, the problem-solving process can still be personally satisfying and of significant value to our students.

in the classroom. Although it is not completely widespread, this influence has been important in the high school and university level. In Latin America there are a number of efforts that are worth to mention. However, the impact has been very low if we compare to that in the U.S. Several factors can be mentioned in order to have this current result. This contribution will describe some cases of success of Physics Education Research in Spanish-speaking countries of Latin America and will discuss some of the factors that prevent Latin America of having much more cases of success.

## Session EA: The History of Accelerator Physics

**Location:** CC - Room 306
**Sponsor:** Committee on History and Philosophy in Physics
**Date:** Tuesday, July 19
**Time:** 1:30-3:30 p.m.

*Presider: Harvey Leff*

### EA01: 1:30-2 p.m. Homegrown Particle Accelerators

*Invited – Gabriela Quiros, KQED, 2601 Mariposa St., San Francisco, CA 94110; gquiros@kqed.org*

Physicists on the University of California, Berkeley, campus in the 1930s and at the Stanford Linear Accelerator Center, in Menlo Park, in the 1970s, created precursors to the Large Hadron Collider that led to key discoveries about the tiny constituents of the atom – from the nucleus all the way down to quarks.

### EA02: 2-2:30 p.m. Synchrotron Light Sources; Then and Now

*Invited – Herman Winick,* SLAC National Accelerator Laboratory, 2575 Sand Hill Road, Menlo Park, CA 94025; winick@slac.stanford.edu*

The more than 50 light sources now in operation around the world include facilities in Brazil, Korea, and Taiwan which started their programs in the 1980s when they were developing countries. They came on line in the 1990s and have since trained hundreds of graduate students locally, without sending them abroad and losing many of them. Regions of the world which now have no light sources are building them (e.g. SESAME in the Middle East which will start operation late in 2016) or planning them (e.g. Africa, Mexico). This talk will review the status of these and other facilities around the world. The value of a light source in a developing region was the topic of the SESAME session at the recent AAAS Annual Conference in Washington DC. See: http://www.aaas.org/news/quest-scientific-source-light-middle-east-nears-completion. Links to other light sources around the world are at: www.lightsources.org.

*Sponsored by Harvey S. Leff

### EA03: 2:30-3 p.m. Focus on Invention: Accelerator Developments in Lawrence's Laboratory*

*Invited – William Barletta, USPAS / MIT / UCLA, 6316 Bullard Drive, Oakland, CA 94611; barletta@mit.edu*

Beginning with Lawrence's transformation of Wideroe's linac into the cyclotron at the Radiation Laboratory originally on Berkeley's campus, Berkeley has been the home of remarkable advances in accelerator science. Lawrence's classical design soon gave way to the synchrocyclotron to reach higher energies. As the cyclotron's magnetic yoke became gargantuan, McMillan's discovery of phase stability enabled Berkeley to transform the synchrotron of Oliphant into America's largest weak focusing machine, the Bevatron. As its days for high-energy physics waned, the Bevatron was injected by Alvarez's heavy ion linac to form the Bevalac for nuclear physics. Berkeley did not neglect electrons; the induction linac technology of ERA was applied to heavy ions for inertial fusion. Berkeley proposed and built the first third generation light source using the permanent magnet undulators technology introduced by Halbach. The most recent inventions have accelerated accelerated to multi-GeV energies by wakefields induced in plasmas by powerful lasers.

### EA04: 3-3:30 p.m. A Bridge Too Far? The Demise of the SSC

*Invited – Michael Riordan, University of California, Santa Cruz, (retired), 106 Hilltop Lane, Eastsound, WA 98245; mriordan137@gmail.com*

In October 1993 the U.S. Congress terminated the Superconducting Super Collider; it was a disastrous loss for the nation's once dominant high-energy physics community. With the 2012 discovery of the Higgs boson at CERN's Large Hadron Collider, Europe has assumed world leadership in this field. A combination of fiscal austerity, continuing SSC cost overruns, intense Congressional scrutiny, lack of major foreign contributions, waning presidential support, and the widespread public perception of mismanagement led to the project's demise. Other major factors were changing U.S. scientific needs after the Cold War ended and the SSC's fiscal impact upon other worthy scientific research. As underscored by the Higgs boson discovery at a mass of 125 GeV, the SSC did not need to collide protons at 40 TeV to attain its premier physics goal. There were alternative projects the U.S. high-energy physics community could have pursued that did not involve building a gargantuan, multibillion-dollar collider at a green-field site in Texas.

*Sponsored by Harvey Leff. Research sponsored by NSF, DOE and the Richard Lounsbery Foundation

## Session EB: PER: Evaluating Instructional Strategies

**Location:** CC - Room 307
**Sponsor:** AAPT
**Date:** Tuesday, July 19
**Time:** 1:30-3:30 p.m.

*Presider: Joss Ives*

### EB01: 1:30-1:40 p.m. Effects of Animated Video Solutions on Learning and Metacognition

*Contributed – Jason W. Morphew, University of Illinois at Urbana-Champaign, 4112 Rayburn court, Champaign, IL 61822; jmorphe2@illinois.edu*

*Jose P. Mestre, University of Illinois at Urbana-Champaign*

Students preparing for physics exams must make decisions on what material to study, how to best prepare, and estimate their preparedness. Previous research has demonstrated that low performing students tend to over predict their learning and preparedness. Research has shown that simplifying the reading level in texts leads to gains in comprehension as well as larger gains in confidence in comprehension. We present data where low performing students in an introductory mechanics course completed an animated video solution intervention. Participants completed a pre-test, viewed video solutions, then completed a post-test. Confidence judgements were made after attempting each problem and after viewing the video solutions. Data will show whether or not students are able to learn from viewing video solutions for previously solved problems. We also present data about students' prediction of their performance. We discuss the educational implications of our findings.

### EB02: 1:40-1:50 p.m. Comparison of Lecture/Laboratory Format with SCALE-UP Classes

*Contributed – Zeynep Topdemir, Georgia State University, One Park Place, 4th Floor, Atlanta, GA 30303; ztopdemir1@gsu.edu*

*Ebru Oncul, David N. Trusty, Brian D. Thoms, Georgia State University*

In this study, we have examined the differences of lab and lecture activities in Lecture/Laboratory format and SCALE-UP classes for algebra-based introductory physics. Also, we have investigated the effects of these differences on success and withdrawal rates, student conceptual learning as measured by the Force Concept Inventory (FCI), and student attitudes as measured by Colorado Learning Attitudes about Science Survey (CLASS). Even though SCALE-UP algebra-based physics classes show no significant increase in FCI gains over traditional classes, SCALE-UP intervention shows a significant improvement in CLASS favorable scores for both Conceptual Understanding and Problem Solving categories.

### EB03: 1:50-2 p.m. Evaluating JiTT and Peer Instruction Using Clickers in a Quantum Mechanics Course

*Contributed – Ryan T. Sayer, University of Pittsburgh, 6311 Morrowfield Ave., Pittsburgh, PA 15217; rts36@pitt.edu*

*Emily Marshman, Chandralekha Singh, University of Pittsburgh*

Just-in-Time Teaching (JiTT) is an instructional strategy involving feedback from students on pre-lecture activities in order to design in-class activities to build on the continuing feedback from students. We investigate the effectiveness of a JiTT approach, which included in-class concept tests using clickers in an upper-division quantum mechanics course. We analyze student performance on pre-lecture reading quizzes, in-class clicker questions answered individually, and clicker questions answered after group discussion, and compare those performances with open-ended retention quizzes administered after all instructional activities on the same concepts. In general, compared to the reading quizzes, student performance improved in individual concept tests administered using clickers after lecture focusing on student difficulties found via electronic feedback. The performance on the group concept tests administered after the individual concept tests and on retention quizzes also showed improvement. We discuss possible reasons for the improvement in performance from pre-lecture quizzes to post-lecture concept tests and from individual to group concept tests and retention quizzes.

### EB04: 2-2:10 p.m. Using and Improving Mastery-Style Online Homework in a Large Introductory Course

*Contributed – Brianne N. Gutmann, University of Illinois - Urbana Champaign, 307 W Elm St., Urbana, IL 61801; bgutman2@illinois.edu*

*Gary Gladding, Timothy Stelzer, Noah Schroeder, University of Illinois - Urbana Champaign*

The successful implementation of mastery-style online homework into our preparatory mechanics course has been a long-term project, currently in its second year. By requiring students to perfect a single unit of defined competencies before moving on to its successive unit (with intervening narrated animated solutions for instructional support), this homework delivery method replaced traditional immediate feedback online homework for the class of about 500 students. After the first year of data collection and analysis, significant revisions were made to the system's delivery, content, and messaging. The impact of these changes and second year data will be presented.

### EB05: 2:10-2:20 p.m. Measuring the Impact of Mastery Inspired Activities in Introductory Physics

*Contributed – Tim J. Stelzer, University of Illinois, 1110 W Green St,., Urbana, IL 61801; tstelzer@illinois.edu*

*Ferrona Lie, Noah Shroeder, University of Illinois*

We have introduced mastery inspired activities into our introductory electricity and magnetism course. These activities provide students an opportunity to develop basic skills through repeated practice and feedback. In this talk we will present results on the impact these activities had on student learning in a large introductory electricity and magnetism class at the University of Illinois.

### EB06: 2:20-2:30 p.m. Toward Instructional Design Principles: Inducing Faraday's Law with Contrasting Cases

*Contributed – Eric P. Kuo, Stanford University, 450 Serra Mall, Bldg 160, Wallenberg Hall, Stanford, CA 94305; erickuo@stanford.edu*

*Carl E. Wieman, Stanford University*

In discussion sections of a large, introductory physics course, a pair of studies compare two instructional strategies for teaching Faraday's law: having students (i) explain a set of contrasting cases or (ii) apply and build on previously learned concepts. We show that contrasting cases not only lead to better performance on subsequent Faraday's law questions, but also prepare students to better learn related topics, such as Lenz's law. We argue that early exposure to contrasting cases better focuses student attention on a key feature: change in magnetic flux. Importantly, the benefits of contrasting cases are enhanced for students who did not first attend a Faraday's law lecture, suggesting that being told the answer can circumvent the benefits of its discovery. These studies illustrate an experimental approach for understanding how the structure of classroom activities affects learning and performance outcomes, a first step toward design principles for effective instructional materials.

### EB07: 2:30-2:40 p.m. The Effects of Group Structure in an Introductory Studio Classroom

*Contributed – Kristine E. Callan, Colorado School of Mines, 1232 West Campus Rd., Golden, CO 80401-1843 ;kcallan@mines.edu*

*Samuel A. Spiegel Colorado School of Mines*

At Colorado School of Mines, we teach introductory physics using a hybrid lecture-studio model. In studio, students are split into groups of three to work through scaffolded problems and experiments. We want to know whether heterogeneous or homogenous group structures yield the most effective learning in our particular context. Each group structure has its own set of advantages (e.g., diversity of understandings and skills vs. ease of communication) and disadvantages (e.g., difficulty of communication vs. potential lack of understandings and skills). To explore the answer to this question, we assigned half of each studio class to groups with mixed physics proficiency and gender, and the other half to groups with matched physics proficiency and gender. We evaluate the performance of each group type according to the students' scores and responses on the FMCE, common course exams, the CLASS, and an internal survey about their studio groups.

### EB08: 2:40-2:50 p.m. Students' Investigation of Thermal Radiation with Infrared Cameras

*Contributed – Jesper Haglund,* Uppsala University, Department of Physics and Astronomy, Box 516, Uppsala, 75120 Sweden; jesper.haglund@physics.uu.se*

First-year university physics students (N = 42) were engaged in an open-ended laboratory module of a thermodynamics course, with a focus on understanding a chosen phenomenon or the principle of laboratory apparatus, such as thermal radiation or a heat pump. In the practical investigation, students had at their disposal handheld infrared (IR) cameras. Students' interaction with the laboratory exercises and oral presentations were video recorded, and three episodes were selected for qualitative analysis. Students used IR cameras in the investigation of interaction of thermal radiation with matter, e.g. metals, glass or whiteboard surfaces. For instance, the function of a glass window is to let through visible light, but reflect radiation in the IR range for insulation purposes. Students were intrigued to find black- and white-painted surfaces to have similar thermal emissivity. As an implication, IR cameras were found to be useful tools in open practical thermodynamics exercises.

*Sponsored by Bor Gregorcic

### EB09: 2:50-3 p.m. Specifications Grading in a Large Enrollment ISLE Physics Class

*Contributed – David T. Brookes, California State University, Chico, 400 W. First St., Chico, CA 95929-0202; dtbrookes@gmail.com*

I will report on an experiment to implement a specifications grading* approach to assessment in a large-enrollment (130 students) introductory algebra-based physics course at California State University, Chico. In specifications grading, criteria for adequate performance need to be clearly specified, and all criteria are graded pass/fail. In adapting this assessment approach to the Investigative Science Learning Environment (ISLE) philosophy, I created homework and exam questions that that tested different (sometimes overlapping) clusters of scientific abilities. Students needed to perform adequately on all the specified scientific abilities in order to pass that particular question. This allowed for a more process-focused approach to assessment while still emphasizing key physics content. I will report on the effectiveness of this approach to assessment as gauged by quantitative shifts in students' attitudes and gains in conceptual understanding as well as qualitative data from student interviews.

* Nilson, L. B. (2015). Specifications Grading. Sterling, Virginia: Stylus Publishing, LLC.

### EB10: 3-3:10 p.m. Reform Introductory Quantum Mechanics: Three Years In*

*Contributed – R. Daryl Pedigo, University of Washington, Box 351560, Seattle, WA 98195; pedigo@phys.washington.edu*

*Gina Passante, California State University Fullerton*

*Paul J Emigh, University of Washington*

During the 2012-13 academic year, a small team at the University of Washington began development of a thoroughly revamped sophomore-level introduction to quantum mechanics course for physics majors. The course was first taught in the summer of 2013, and has been revised continuously since that time. Over 400 students have taken this course to date. An outline of the course structure and materials will be presented, along with one set of pre-/post-test results plus commentary on what seems to work and what does not.

*with contributions from several graduate TAs, most notably Michelle Storms and Tong Wan.

### EB11: 3:10-3:20 p.m. Pathways Through Introductory Physics: Effects of Switching Between Course Formats*

*Contributed – Jacquelyn J. Chini, University of Central Florida, 4111 Libra Dr., Orlando, FL 32816; jchini@ucf.edu*

*Matthew Wilcox, Jarrad W.T. Pond, University of Central Florida*

*Zeynep Topdemir, Georgia State University*

As part of a project to explore the varying success of studio-mode courses, we are investigating institutional barriers that may lead to different student outcomes. As institutions adopt new instructional models, some may embrace the change more slowly, such that students have the option to take courses in multiple formats. We explore the pathways of students through the introductory physics sequence at two universities that have transformed some of their sections into studios, such that students may take the first semester course in either lecture-mode or studio-mode and then choose to stay with that mode or switch for the second semester. We report on correlations between first semester student outcomes on their choice to "switch" or "stay" and subsequent outcomes in the second semester as measured by conceptual and attitudinal surveys.

*This work was funded by the National Science Foundation (Grant No. DUE-1347515).

### EB12: 3:20-3:30 p.m. Natural Language vs. Multiple Choice Format in Computer-Based Practice

*Contributed – Ryan C. Badeau, The Ohio State University, 191 W Woodruff Ave., Columbus, OH 43210-1168; ryan.badeau@gmail.com*

*Andrew F. Heckler, The Ohio State University*

In order to evaluate the relative effectiveness of different question formats and levels of interaction during computer-based practice, students from two introductory-level mechanics classes were trained on the concepts of force and motion as part of one of four different training conditions. The training conditions varied the format of student responses (short answer, natural language versus multiple choice format) and the level of interaction in the feedback provided (a single, provided explanation versus constructive follow-up questions). Overall, the natural language format with follow-up dialog provided the largest gains over control, with retention over a month after training. In addition, we see some evidence that the effectiveness of the different formats varies based on initial student knowledge.

## Session EC: Innovative Uses of Technology Enabled Spaces

**Location:** CC - Room 304/405
**Sponsor:** Committee on Educational Technologies
**Date:** Tuesday, July 19
**Time:** 1:30-2:40 p.m.

*Presider: Ben Van Dusen*

### EC01: 1:30-2 p.m. Appreciating the "Space" in Technology Enabled Spaces

*Invited – Edward Price, California State University San Marcos, 333 South Twin Oaks Valley Rd., San Marcos, CA 92096; eprice@csusm.edu*

Technology is increasingly available in our physics classrooms and instructional labs—from dedicated infrastructure to one-to-one computing to smart phones carried by nearly every student. Educators must consider how to use this technology effectively, if they choose to use it at all. This talk will catalog ways classroom technology can support physics education, including structuring participation and interaction; enabling sharing, archiving, and review of material generated in-class; collecting and analyzing data; supporting the use and coordination of multiple representations; and providing access to resources such as simulations. I will discuss these uses in various physical and technological spaces, including studio-style rooms with dedicated computers, instructional labs with tablets, and standard classroom spaces where students have smartphones. Across these cases, I argue that choosing a particular technology is less important than ensuring alignment between the technology's affordances and the instructor's pedagogical goals, and that the physical configuration of the classroom space has a strong influence on both the technology and pedagogy.

### EC02: 2-2:30 p.m. Leveraging "Teaching-to-Learn" with Technology to Enhance Student Learning

*Invited – Susan Nicholson-Dykstra,* University of Colorado at Boulder, School of Education, Boulder, CO 80309; susie.dykstra@gmail.com*

*Mary Beth Cheversia, Lincoln Middle School & University of Colorado*

*Julie Thompson, Boulder High School & University of Colorado*

When students participate in Teaching to Learn (TtL) experiences, in which they learn new content, learn about the process of teaching and learning, and apply their understanding of both the content and pedagogy to develop a lesson, they demonstrate greater conceptual understanding of the content. Students can harness technology to create TtL products, such as screencasts, stop-go videos, interactive posters, and animations, in order to communicate scientific ideas to authentic audiences of peers and digital communities. These studies investigate how educators in three different tech-enriched environments utilize TtL products as tools for evaluating student proficiency in language and content understanding. Additionally, these studies examine the role that technology-infused TtL projects play in increasing student engagement and confidence in explaining scientific ideas, and in development of a collaborative scientific community, due to a heightened sense of accountability to peers and community.

*Invited by Ben Van Dusen

### EC03: 2:30-2:40 p.m. Smartphones in Labs Don't Have to Be "Black Boxes"

*Contributed – Colleen L. Countryman, North Carolina State University, 2401 Stinson Dr., Raleigh, NC 27695; Colleen_Countryman@ncsu.edu*

The internal sensors within students' smartphones can be used to collect data in introductory mechanics labs. Our free "MyTech" app provides students with meaningful laboratory experiences that positively impact their attitudes about physics. Our project includes the development of a curriculum, the creation of a mobile app, and the determination of the impact of students' smartphones on their learning of physics concepts, attitudes regarding their laboratory experience and use of the devices outside of class. In addition to enhanced abilities to make "real world connections," students using the MyTech app were also more adept at describing how their laboratory equipment collected data when using the smartphone app and its corresponding curriculum. We posit the reasoning for this improved understanding of how the devices collect data. We will discuss these results and how instructors can utilize the app and curriculum in their own classroom.

## Session ED: Upper Division Undergraduate

**Location:** CC - Room 310
**Sponsor:** AAPT
**Date:** Tuesday, July 19
**Time:** 1:30-3:40 p.m.

*Presider: David Jackson*

### ED01: 1:30-1:40 p.m. Educational Trips for Undergraduate Physics Majors

*Contributed – Sathya Guruswamy, University of California, Santa Barbara, Department of Physics, Santa Barbara, CA 93106; sathya.guruswamy@ccs.ucsb.edu*

In this talk, we discuss the important role of field trips to research facilities in the education of a physics major. We discuss our experience of field trips within the context of an introduction to research class developed by the author. We discuss the benefits of a well-timed trip which include firsthand experience of textbook physics applied in a cutting-edge lab, finding inspiration for upper-level elective classes in physics or related fields, identification of research interests and not least of all, shared memories.

### ED02: 1:40-1:50 p.m. Faraday Isolators and the Second Law of Thermodynamics

*Contributed – Carl E. Mungan, U.S. Naval Academy, Physics, Mailstop 9b, Annapolis, MD 21402-1363; mungan@usna.edu*

Consider a Faraday isolator: two optical linear polarizers whose transmission axes are oriented 45 degrees relative to each other, between which is located a magnetic rotator that turns the plane of polarization of a beam of light by 45 degrees in the same direction regardless of the direction of propagation of the light. That constitutes a one-way light valve, used to protect lasers from harmful back-reflections. Now place a sample inside a cavity whose walls are made of this stuff. Light gets out but not back in, right? If so, the sample would radiate away all its energy and cool down to absolute zero! How do we save the second law from this catastrophe?

### ED03: 1:50-2 p.m. Modeling Heat Transfer in Undergraduate Thermal Physics*

*Contributed – Larry Engelhardt, Francis Marion University, 4822 E. Palmetto St., Florence, SC 29501-0547; lengelhardt@fmarion.edu*

Students learn early on that Q=mc Delta T; the EFFECT of heat transfer is to change the temperature of an object. It is not unreasonable to also expect students to learn that the conduction of heat is CAUSED by a temperature difference between two objects; Fourier's law of heat conduction, dQ/dt = k A dT/dx. By combining these two equations, I will describe how students can build and use models of increasing sophistication--starting with paper and pencil and ending with computer simulations--in order to understand the phenomenon of heat transfer.

*This project is funded by NSF IUSE grant DUE-1525062.

### ED05: 2:10-2:20 p.m. Applying Poynting's Energy Flux to Hydrodynamic Systems

*Contributed – Francis L. Curzon, Dept. of Physics & Astronomy, University of B.C., 285 Laura Point Road, Mayne Island, BC V0N 2J1 Canada; CURZON@PHAS.UBC.CA*

*Albert E. Curzon, Dept. of Physics, Simon Fraser University*

By applying Poynting's reasoning to time-independent laminar flows of incompressible viscous fluids we show that the energy flux for such systems can also be described by a Poynting vector. We discuss two examples of the Poynting model of energy flux: the familiar case of a constant electric current flowing through a wire and a new hydrodynamic case of vertical tube which drains a constant depth reservoir which is filled with a viscous fluid. Finally, we present often ignored physical constraints which these systems have to obey and modify Poynting vector so that it can be used, consistently, in order to obtain the actual energy flux for the two systems.

### ED06: 2:20-2:30 p.m. Classical Dynamics of a Particle in a One-dimensional Exponential Potential

*Contributed – Satinder S. Sidhu, Washington College (Emeritus), 103 Sutton Way, Chestertown, MD 21620; ssidhu2@washcoll.edu*

Surprises lurk in the seemingly simple situation of a particle moving in one dimension, with potential energy increasing exponentially with distance from the origin. Force on such a particle also depends exponentially on the position coordinate. Since the magnitudes of potential and restoring force increase monotonically with distance from the origin, the time a particle released from rest takes to reach the origin is expected to show a similarly monotonic dependence on initial distance. The problem can be solved analytically, with the closed-form expression for this travel time involving only elementary transcendental functions. Surprise lies in the fact that this time first grows with the initial distance, reaches a maximum, and then declines for release points farther away. Implications of such a point-of-slowest-return for a classical non-linear oscillator consisting of a particle moving in a symmetrical potential well will be described via computational and analytical models.

### ED07: 2:30-2:40 p.m. Entanglement Isn't Just Spin

*Contributed – Daniel V. Schroeder, Weber State University, 2508 University Circle, Ogden, UT 84408-2508; dschroeder@weber.edu*

Schroedinger coined the term "entanglement" in 1935, but it took another 70 years for this vivid and useful word to make its way into most quantum mechanics textbooks. Even today we typically teach entanglement only in the context of spin systems, rarely mentioning the word when we discuss spatial wave functions. Meanwhile, when discussing wave functions of more than one variable, we almost always focus on those that factor into a product of single-variable functions, with no more than a passing mention of the vast variety of nonseparable wave functions. Yet for a two-particle system, these nonseparable wave functions are none other than the entangled states! Therefore, with only a minor modification to our teaching we can accomplish two important goals: avoid the common misconception that all wave functions are separable, and give students a more accessible introduction to entanglement.

### ED08: 2:40-2:50 p.m. Framing Difficulties in Quantum Mechanics

*Contributed – Bahar Modir, Kansas State University, Dept. of Physics, 116 Cardwell Hall, Manhattan, KS 66506; bahar@phys.ksu.edu*

*John D. Thompson, Eleanor C. Sayre, Kansas State University*

Researchers in student understanding of quantum mechanics have used the Difficulties framework to assess student reasoning, creating long lists of difficulties that span many topics in quantum mechanics. We seek an underlying structure to these difficulties. Using the lens of epistemological framing, we mapped descriptions of published difficulties into errors in epistemological framing and resource use. We analyzed descriptions of students' problem solving to find their frames, and compared students' framing to framing (and frame shifting) required by problem statements. We found three categories of error: mismatches between students' framing and problem statement framing; inappropriate or absent transitions between frames; and insufficient resource activation within an appropriate frame. Given this framework, we can predict the kinds of difficulties that will emerge for a given problem in quantum mechanics: a possible deeper structure to student difficulties.

### ED09: 2:50-3 p.m. Highlighting Two Prevalent Student Difficulties in Graduate Level Quantum Mechanics

*Contributed – Christopher D. Porter, The Ohio State University, 191 W Woodruff Ave., Columbus, OH 43210; porter.284@osu.edu*

*Abby Bogdan, Andrew Heckler, The Ohio State University*

In our work with physics graduate students at The Ohio State University, we have examined several prevalent misunderstandings that persist well into graduate-level quantum mechanics. Here we focus on two difficulties: drawing bound states in an asymmetric well, and the confusion between symmetry under particle exchange and reflection symmetry (parity). Difficulties in drawing bound states were noted at the graduate level as early as 2008. But we find the asymmetric well reveals a new class of misunderstandings, including the fundamental misuse of axes and symmetry. We note also that students have difficulty interpreting drawings of bound states. The confusion between exchange symmetry and parity is demonstrated with multiple types of student data including quizzes and conceptual assessments. Our efforts suggest that simple awareness of the issue and precision of language may be sufficient to correct the problem.

### ED10: 3-3:10 p.m. Is There Room for Computation in Undergraduate Physics Courses?

*Contributed – Kelly R. Roos, Bradley University, 1501 West Bradley Ave., Peoria, IL 61625; rooster@bradley.edu*

In making the case for the integrated inclusion of computation into virtually every undergraduate physics course (I think it should be done!), I am often confronted with the (very reasonable) protest that there is critically important material that would have to be dropped in order to accommodate computer problem-solving and all the attending programming platform baggage. I believe that there is, in reality, much that can be dropped from the traditional typical undergraduate physics course, especially upper level ones, to make room for the important marketable skill-building benefits of computation, without profoundly betraying the students' undergraduate physics preparation. Indeed, computation can, in many cases, provide better access to physical principles than a purely analytical approach. I will briefly describe a prototypical example, from the realm of quantum mechanical scattering, of a topic whose traditional mode of instruction should be dropped in favor of a computational treatment.

### ED11: 3:10-3:20 p.m. Learning About Liouville's Theorem with ODE Solver Algorithms

*Contributed – Todd K. Timberlake, Berry College, 2277 Martha Berry Hwy., NW Mount Berry, GA 30149-5004; ttimberlake@berry.edu*

In this talk we will discuss a way to teach students about algorithms for solving systems of ordinary differential equations while also teaching them about Liouville's Theorem. One way of stating Liouville's theorem is that in conservative systems the dynamics of the system preserves the area of a region of phase space. Liouville's theorem can be illustrated by using the Maxima computer algebra system to implement the non-symplectic Euler algorithm and the symplectic Euler-Cromer algorithm for the case of a 1D simple harmonic oscillator. The Euler-Cromer algorithm preserves the phase space area occupied by an ensemble of particles, while the Euler algorithm results in an increasing phase space area. This result is closely connected to the fact that the Euler-Cromer algorithm conserves the average energy over each oscillation while the Euler algorithm results in an increasing average energy. The numerical errors in the Euler algorithm behave like a driving force, effectively adding energy to the system and making the algorithm unstable. These examples help students learn that not all ODE solver algorithms are equally good while also helping students develop a qualitative understanding of Liouville's theorem.

### ED12: 3:20-3:30 p.m. The Effectiveness of "Pencasts" in Undergraduate Curriculum

*Contributed – Nandana J. Weliweriya Liyanage, Kansas State University, Dept. of Physics, 116 Cardwell Hall, Manhattan, KS 66506; nandee122@ksu.edu*

*Eleanor C. Sayre, Dean Zollman, Kansas State University*

Pencasts are videos of problem solving with narration. Pedagogically, instructors can use pencasts to model problem solving for their students, uploading the videos for students to watch outside of class. Alternately, students can create pencasts to illustrate their own problem solving to the instructor or to their peers. In this talk, we describe the use of pencasts in an upper-division Electromagnetic Field course usually taken by junior or senior physics majors. For each homework students created and submitted pencasts of ordinary homework problems several days before the problem set was due. We compare students' performance in the class (grades for pencast submission excluded) with the pencast submission rate. Students who submit more pencasts do better in the course. We conclude with some practical suggestions for implementing pencasts in other courses.

### ED13: 3:30-3:40 p.m. Multiple-Choice Assessment for Upper-Division Electrodynamics

*Contributed – Qing Xu Ryan, California State Polytechnic University, Pomona, 3801 W Temple Ave., Pomona, CA 91768; xuqing12357@gmail.com*

*Cecilia Astolfi, Charles Baily, University of St. Andrews*

*Steven Pollock, University of Colorado Boulder*

Multiple-choice assessments are a standard tool for achieving reliable measures of certain aspects of students' conceptual learning in large introductory physics courses. It is harder to develop a multiple-choice assessment for upper-division physics because it involves greater emphasis on assessing students' reasoning in addition to their conceptual knowledge. A coupled-response format employed by the multiple-choice CUE (Colorado Upper-division Electrostatics) diagnostic has achieved great success. We further investigate this new testing format in upper-division electrodynamics content. Our goal is to preserve the insights afforded by the existing open-ended assessment, the CURrENT (Colorado UppeR-division ElectrodyNamics Test), while exploiting the logistical advantages of an objectively gradable instrument. We present the development, scoring, and preliminary analysis of validity and reliability of this multiple-response version of the CURrENT.

## Session EE: Professional Skills for Graduate Students

**Location:** CC - Room 311
**Sponsor:** Committee on Graduate Education in Physics
**Co-Sponsor:** Committee on Research in Physics Education
**Date:** Tuesday, July 19
**Time:** 1:30-3 p.m.

*Presider: Claudia Fracchiolla*

*This interactive panel focuses on developing professional skills for graduate students and other early-stage researchers. This session will address professional concerns brought up by graduate students during the past Crackerbarrels/Topical Group Discussions. Topics covered may include: preparing for careers after graduate school, becoming integrated with the community, developing research skills, and disseminating your work.*

### Panelists:

*Lin Ding, The Ohio State University*

*Valerie Otero, University of Colorado Boulder*

## Session EF: Physics Teaching for Social Justice

**Location:** CC - Room 308
**Sponsor:** Committee on Research in Physics Education
**Date:** Tuesday, July 19
**Time:** 1:30-3:30 p.m.

*Presider: Amy Robertson*

*This session will include three invited speakers and a half hour for discussion.*

### EF01: 1:30-2 p.m. What Could It Look Like?: A Case Study of Physics Teaching for Social Justice

*Invited – Moses Rifkin, 5705 Phinney Ave. N, Seattle, WA 98103; mrifkin@universityprep.org*

Only 4% of professional physicists identify as black or African American, a number far smaller than the 12% of the Americans that do, and this underrepresentation is more dramatic in physics than it is in most scientific disciplines. I have developed a curriculum that uses these and other statistics as a jumping-off point for my high school students to explore issues of race, access, and culture in physics. I will share my experiences from a decade of using the curriculum, including how my students respond, how I address the challenges that have arisen, and how this curriculum has evolved. In doing so, I hope both to model the integration of physics teaching and social justice and to motivate attendees to take steps in their own classes.

### EF02: 2-2:30 p.m. Responsive Teaching and Power: Toward Practice of Anti-Oppressive Science Pedagogy

*Invited – Daniel M. Levin, University of Maryland, College Park, 2311 Benjamin Building, College Park, MD 20742-2421; dlevin2@umd.edu*

*Anita Sanyal Tudela, University of Maryland, College Park*

*Matty Lau, New York Hall of Science*

In this paper, we strive to bring together emerging research on responsive science teaching and a conceptual framework of power and anti-oppressive pedagogy in education. We present an argument that responsive teaching may support progress towards anti-oppressive pedagogy, which attends to and interrupts traditional power relationships in teaching. We analyze discourse in a high school physics class around problems of free-falling bodies through lenses of responsive teaching and power. We demonstrate how foundational practices of responsive teaching are consistent with a vision for anti-oppressive pedagogy and useful for understanding how anti-oppressive pedagogy might develop in the science classroom and impact classroom culture.

### EF03: 2:30-3 p.m. Epistemic Messaging and Epistemic Injustice in Science Classrooms

*Invited – Rosemary S. Russ, University of Wisconsin, Madison, 225 N. Mills St., Madison, WI 53706-1380; rruss@wisc.edu*

For decades, one of the central goals of science education has been to help students develop sophisticated understandings of the ways that scientific knowledge is constructed. In this talk, I discuss how the ways teachers attend and respond student thinking can send tacit, in-the-moment messages about the types of knowledge and knowledge construction that are valued in the science classroom. I argue that although these meta-messages are subtle, they can nonetheless have dramatic short- and long-term effects on students' epistemologies and engagement in science learning. As such, these messages may be a powerful lever for (in)equity and (in)justice in science classrooms. I explore the implications of such inequity for both individuals and for the classroom epistemic community. I present data from two research projects to demonstrate the intuitive plausibility of these claims and to illustrate the potential productivity of highlighting the messages for elementary pre-service teachers.

## Session EG: Addressing Race and Ethnicity

**Location:** CC - Room 312
**Sponsor:** Committee on Diversity in Physics
**Co-Sponsor:** Committee on Research in Physics Education
**Date:** Tuesday, July 19
**Time:** 1:30-3:30 p.m.

*Presider: Dimitri Robert Dounas-Frazer*

### EG01: 1:30-2 p.m. Obstacles to Writing about Race: Lessons from Mathematics Education Research

*Invited – Amy Parks,* 620 Farm Lane, East Lansing, MI 48824-2320; parksamy@msu.edu*

Drawing on a critical literature review, this presentation will highlight four major obstacles faced by mathematics education researchers who want to write seriously about race and ethnicity. These obstacles are: (1) the marginalization of discussions of race and ethnicity; (2) the reiteration of race and ethnicity as independent variables; (3) absence of race and ethnicity from mathematics education research; and (4) the minimizing of discussions of race and ethnicity even within equity-oriented work. Using video from mathematics assessment interviews, the presentation will then offer some examples of ways to overcome these obstacles before participants are invited into a conversation about ways that research within the field of physics education presents both similar and different challenges than those in mathematics education for researchers who want to bring race into their analyses.

*Sponsored by Dimitri Robert Dounas-Frazer

### EG02: 2-2:30 p.m. Gender and Race in PER: Beyond the Binary and Reconsidering Our Past

*Invited – Ramon Barthelemy, American Association for the Advancement of Science AAAS, Washington, DC 20003; ramon.s.barthelemy@gmail.com*

Physics Education Research has been approaching the topics of race and gender for many years. In recent history this work has become the content of dissertations and the subject of focused collections. However, the community has scarcely used resources from works in critical theory and women's studies to better inform our work. My talk will present a constructive critique of the current research on gender and race and PER. I will explore broader definitions of race and gender and discuss how the world view of our work needs to shift from wanting to change students to wanting to change the way physics is being taught and done.

### EG03: 2:30-3 p.m. Creating Counter-Space: Deliberate Strategies Faculty Can Use to Create Environments Where Women of Color Thrive

*Invited – Angela Johnson, PO Box 301, Leonardtown, MD 20650; acjohnson@smcm.edu*

*Apriel Hodari, Eureka Scientific*

Counterspaces are academic or social safe havens where the experiences of underrepresented students, such as women of color, are validated and seen as critical, and where deficit notions of people of color and women are challenged (Solórzano, Ceja, & Yosso, 2000). Counterspaces, often located at the margins of academia, serve to counter isolation, microaggressions, and discrimination that women of color often experience in mainstream education spaces in higher education, like departments, classrooms, and laboratories. In this paper, we explore the possibility of extending the standard notions of counterspaces to include the mainstream space of physics departments. We ask: Can physics departments be counterspaces for women of color, and if so, how? In two parallel studies that focus on women of color students who are thriving in physics, astrophysics, engineering, math and computer science at predominantly white institutions, the authors examine strategies that administrators and faculty use to make their departments counterspaces that support women of color. Strategies include: a zero-tolerance policy against racial or gender discrimination; a critical mass of students of color; deliberate recruitment of both male and female faculty members committed to creating inclusive majors; frequent faculty assertions that success in STEM majors results from hard work rather than innate ability; interactive classes and universal use of group work; and expressed faculty beliefs that they want to support all students. The paper describes the cultural contexts in which physics counterspaces may be created, and policies and practices that ensure their maintenance.

### EG04: 3-3:30 p.m. Understanding the Relationship Between Physics and Racial Identity for Black Students

*Invited – Simone Hyater-Adams, University of Colorado Boulder, 390 UCB, Boulder, CO 80309; simone.hyateradams@colorado.edu*

*Noah Finkelstein, Claudia Fracchiolla, Kathleen Hinko, University of Colorado Boulder*

The underrepresentation of black students in physics is well known, yet there is still much space for further understanding of the causes. Identifying with a discipline is an important aspect of participation in it, so understanding how students develop an identity in physics is key to cultivating physics students. While there are programmatic efforts to support representation of black students, as well as studies on student identity, little have been done to link the two. We look to understand the experiences of black students in physics programs as well as in informal spaces through examining how identity in physics is impacted by cultural and racial identities. In this study, we interview black students currently in the field of physics and use a developing framework that pulls from literature on experiences of students of color in STEM to construct an understanding around the relationship between these identities.

## Session EH: Climate Change

**Location:** CC - Room 313
**Sponsor:** Committee on Physics in Two-Year Colleges
**Date:** Tuesday, July 19
**Time:** 1:30-3 p.m.

*Presider: Tom Carter*

### EH01: 1:30-2 p.m. Climate Physics in the Classroom

*Invited – Michael Wiescher, University of Notre Dame, 225 Nieuwland Hall, Notre Dame, IN 46556; mwiesche@nd.edu*

The question of climate and climate change is dominated by emotional discussion and by ideological agendas. A new course was developed to investigate the science conditions that determine climate and that instigate climate change. The presentation will provide an overview on motivation and content of the course which includes topics such as energy physics of climate, the microphysics of climate, the atmospheric and hydrospheric physics of climate, climate history, climate proxies and signatures, closing with possible methods for climate stabilization.

### EH02: 2-2:30 p.m. Climate Change and California: Potential Impacts and Solutions

*Invited – Guido Franco, Research Division, California Energy Commission, 1516 Ninth St., MS-29, Sacramento, CA 95814-5512; Guido.Franco@energy.ca.gov*

California's climate is changing and will continue to evolve in the foreseeable feature at a rapid rate driven mostly by the increased concentration of greenhouse gases in our atmosphere. This talk will describe how our climate is changing in California and how these changes are just a prelude to what is expected to occur in the rest of this century. The presentation will also describe what is known about the potential impacts of climate change on the different sectors of our economy and on the energy sector in particular. Finally, the presenter will describe the actions that California is taking to both reduce greenhouse gas emissions and to prepare for the impacts that are no longer avoidable.

### EH03: 2:30-2:40 p.m. Climate Change Films for the Physics Classroom

*Contributed – Jeffrey R. Groff, Shepherd University, PO Box 5000, Shepherdstown, WV 25443-5000; jgroff@shepherd.edu*

Film can be a powerful medium for engaging, informing, and inspiring students. This talk will highlight climate-change-themed films suitable for screening in a physics class. The showcased films have all been official selections of the American Conservation Film Festival in Shepherdstown, WV, and are accompanied by an online resource kit for instructors. This resource kit includes film summaries, suggested topics for discussion, and a mapping between the content of each film and specific units encountered in the physics curriculum.

### EH04: 2:40-2:50 p.m. A Selection of Climate Myths from AAPT Posters

*Contributed – Gordon J. Aubrecht, Ohio State University, Marion Campus, 193 N. Washington St., Delaware, OH 43015-1609; aubrecht.1@osu.edu*

Posters outlining climate myths arising almost exclusively from letters to the editor of my small-town newspaper have been a feature of previous and the current meeting. I present a selection of "greatest hit" myths in this short talk.

### EH05: 2:50-3 p.m. Physics of Climate

*Contributed – Celia Chung Chow, (CSU), 9 Andrew Drive, Weatogue, CT 06089; cchungchow@comcast.net*

While the global climate pattern is changing drastically, we physics teachers need to update our knowledge constantly in order to understand the Nature and to cope with her. Above all, we will share our understanding with students. Some concepts and models of climate will be presented.

## Session EI: Developing Experimental Skills at all Levels I

**Location:** CC - Room 314
**Sponsor:** Committee on Laboratories
**Date:** Tuesday, July 19
**Time:** 1:30-3:20 p.m.

*Presider: Mary Ann Klassen*

### EI01: 1:30-2 p.m. Developing Scientific Communication Skills Using Lab Notebooks

*Invited – Jacob Stanley, University of Colorado, Boulder, Department of Physics, 390 UCB Boulder, CO 80309; jacob.stanley@colorado.edu*

*Heather J. Lewandowski, University of Colorado, Boulder*

In experimental physics, the use of lab notebooks for scientific documentation is an essential part of the research process. For all of the ubiquity of lab notebooks, little formal attention has been paid to addressing what is considered "best practice" and how researchers come to learn these practices. To explore the role of lab notebooks in table-top experimental physics, we conducted interviews with physics graduate students at a large research university. From these interviews, we gained insight into their experiences with lab notebooks in their undergraduate and graduate education, as well as what features of their lab notebooks they felt were essential for their research. I will present some of the common themes in the interviewees' experiences and the broad guidelines for what constitutes authentic scientific documentation, which emerged from the interviews. Additionally, I will provide some pedagogical suggestions for how to incorporate these guidelines into a lab course setting.

### EI02: 2-2:30 p.m. Physics Laboratory Activities for Prehealth and Life Science Students*

*Invited – Elliot Mylott, Portland State University, SRTC, 1719 SW 10th Ave., Room 134, Portland, OR 97214; emylott@pdx.edu*

*Justin C. Dunlap, Ralf Widenhorn, Portland State University*

As part of our work in reforming undergraduate physics education for pre-health and life science students at Portland State University, we have developed multiple laboratory activities that present important physical concepts in a biomedical context. Each activity explores the fundamental physics principles behind aspects of physiology or common medical equipment. The biomedical subjects of the activities include radiography, computed tomography, pulse oximetry, bioelectrical impedance analysis, electrocardiograms, and the optics of the human eye. The laboratories teach multiple physical concepts including: how electromagnetic radiation interacts with matter, the Beer-Lambert Law, electronic amplification and filtering, AC circuits, and image formation. By framing the physical application of these concepts in a biomedical context, the activities effectively convey to students the relevance of physics to medicine and the life sciences.

*This work was supported by grants (DUE-1141078 and DUE-1431447) from the National Science Foundation.

### EI03: 2:30-2:40 p.m. Implementation of a Laboratory Activity Designed to Promote Scientific Practice

*Contributed – Abhilash Nair,* Michigan State University, 500 W Lake Lansing Rd., Apt B6, East Lansing, MI 48823; nairabhi@msu.edu*

*Marcos D Caballero, Michigan State University*

In the context of transforming a second-semester introductory physics lab course to better align with scientific practice, we investigate the alignment of student work with the envisioned goals of an activity that took place in the pilot semester. We first highlight learning goals of the two-week activity as well as broader course goals that were collected through interviews with the designers of the transformation. We then present analysis of small group work to consider the implications of such a design in helping promote practices such as students in working collaboratively in a group, developing a systematic approach to experimental design, understanding how to utilize different measurement devices, and understanding the uncertainties involved in measurements. We use these results to consider how to iterate on the design of course structures and lab activities to better support students in achieving the learning objectives.

*Sponsored by Marcos Daniel Caballero

### EI04: 2:40-2:50 p.m. From Cookbook to Authentic Research – What Skills Should They Be Learning

*Contributed – Natasha G. Holmes, Stanford University, 382 Via Pueblo Mall, Stanford University, Department of Physics, Stanford, CA 94305-1684; ngholmes@stanford.edu*

*Carl Wieman, Stanford University*

The positive outcomes of undergraduate research experiences have been well categorized in a variety of disciplines and many institutions are beginning to try and replace standard lab courses with more authentic research-like experiences. I will present our recent work evaluating the cognitive decisions and processes that students carry out during both undergraduate research experiences and in a variety of lab courses. These comparisons can guide the curricular goals and designs for lab courses, either to better prepare students for research, or to provide a more authentic alternative to research experiences.

### EI05: 2:50-3 p.m. Assignment Sequences for Experimental Skill Development in Physics Advanced Lab

*Contributed – Sean P. Robinson, MIT, 77 Massachusetts Ave., Room 4-362, Cambridge, MA 02139-4307; spatrick@mit.edu*

I will describe how the concept of assignment sequences — preparatory online work, followed by a hands-on in-lab exercise, followed by a detailed homework exercise — is applied in the MIT Physics Junior Lab course to help develop various professional skills both horizontally and vertically. Examples of skill domains include data analysis and basic test bench instrumentation.

### EI06: 3-3:10 p.m. Changes in Lab Curriculum to Develop Lab Skills

*Contributed – David Kardelis, Utah State University, Eastern 451 E 400 N Price, UT 84501; david.kardelis@usu.edu*

Labs currently use equipment ranging from the low-tech stop watch timings and a ruler to data loggers and video analysis. This seemingly random mix of high and low tech is being modified to bring a more coherent approach to have students gaining lab skills throughout the semester. For example, the changes have included bringing back some classic labs such as Hooke's law but with more emphasis on graphing and meanings obtained from the data less on confirming Hooke's law. Other labs bring in newer technology such as video analysis, to help illustrate other aspects of data taking, such as distributions of measurements and uncertainty. A few of the changes and the desired outcomes from these labs will be discussed.

### EI07: 3:10-3:20 p.m. Design, Build, Measure!: "Do-It-Yourself Experimental Atmospheric Physics"

*Contributed – Holly Maness, University of California Berkeley, McCone Hall, Berkeley, CA 94720; maness@berkeley.edu*

"Do-It-Yourself Experimental Atmospheric Physics" is designed to introduce sophomore students to the full cradle-to-grave process underpinning modern observational experiment. Organized around four interdependent projects, students design, build, and deploy instruments constructed from basic components like photodiodes, filters, polarizers, lenses, and gratings to measure fundamental properties of the atmosphere including opacity, polarization, and composition. Through construction of a radiative transfer code, students learn the basics of experimental design — how to ask a scientific question, estimate instrument requirements, and identify components. Students learn later how to build, calibrate, and test their resulting instruments, gaining proficiency with basic lab equipment like electronics test gear, optomechanical components, and computer-aided fabrication tools. Ultimately, students deploy their instruments in the field and interpret their measurements statistically in the context of their model predictions. Completion of this course arms young undergraduates with the skills, knowledge, and confidence necessary to tackle current research questions of their choice.

## Session EJ: PER: Examining Content Understanding and Reasoning

**Location:** CC - Room 315
**Sponsor:** AAPT
**Date:** Tuesday, July 19
**Time:** 1:30-3:10 p.m.

*Presider: James Laverty*

### EJ01: 1:30-1:40 p.m. Examining Student Reasoning with Multi-variable Expressions*

*Contributed – Mila Kryjevskaia, North Dakota State University, Department of Physics, Fargo, ND 58108-6050; mila.kryjevskaia@ndsu.edu*

*Cody R. Gette, North Dakota State University*

*Paula R. L. Heron, University of Washington*

*Andrew Boudreaux, Western Washington University*

*MacKenzie R. Stetzer, University of Maine*

It has been shown that students encounter significant reasoning difficulties when interpreting and applying multi-variable expressions. For example, students often argue that because the frequency of a periodic wave is expressed in terms of wavelength and propagation speed, the frequency must change when the speed changes. Similarly, many students think that the capacitance of a parallel-plate capacitor will change if the potential difference between its plates is varied. In this talk, we report on an investigation of the extent to which problematic reasoning approaches are related to (1) the level of abstractness of a presented situation and (2) the specific features of the task itself.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, 1431940, 1432052, and 1432765.

### EJ02: 1:40-1:50 p.m. Examining Students' Abilities to Follow and Evaluate Qualitative Reasoning Chains*

*Contributed – William N. Ferm, University of Maine, Physics and Astronomy, 120 Bennett Hall, Orono, ME 04469; william.ferm@maine.edu*

*John C. Speirs, MacKenzie R. Stetzer, University of Maine*

While there has been a large body of work investigating the effectiveness of scaffolded, researched-based physics instruction, much less is known about the development of students' reasoning abilities in these instructional environments. As part of a larger collaborative project, we have been examining the ability of students to construct qualitative reasoning chains. In particular, we have been designing and implementing tasks to assess the extent to which introductory physics students are able to logically follow and characterize hypothetical student reasoning in a variety of physics contexts. In one task, for example, students are asked to infer the conclusions that would be drawn from different lines of reasoning articulated by hypothetical students. In this presentation, we will discuss the development of such tasks and share preliminary results.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432765, DUE-1432052, and DUE-0962805.

### EJ03: 1:50-2 p.m. Examining Students' Multi-step Reasoning in Energy Contexts*

*Contributed – Andrew Boudreaux, Western Washington University, 516 High St., Bellingham, WA 98225-9164; andrew.boudreaux@wwu.edu*

*Beth Lindsey, Penn State Greater Allegheny*

As part of a multi-institution collaboration, we are examining students' multi-step, qualitative reasoning in physics. An important part of this work is developing methods for disentangling conceptual understanding from reasoning. In this talk, we present and analyze responses on tasks in which students apply energy concepts to simple situations. One such task involves a hand moving a book with changing speed through a uniform gravitational field. Most students struggle to coordinate the energy input (work done by the hand) and the energy changes (changes in kinetic energy and in gravitational potential energy). At the 2016 Winter AAPT meeting, Lindsey described the reasoning of introductory physics students at Penn State Greater Allegheny; this talk follows up by presenting results from interviews with pre-service teachers and upper-division physics students at Western Washington University.

*This work was supported in part by the National Science Foundation under Grant Nos. DUE-1432052 and DUE-1431541.

### EJ04: 2-2:10 p.m. Probing Student Ability to Construct Reasoning Chains: A New Methodology*

*Contributed – J. Caleb Speirs, University of Maine, 19 Getchell St., Brewer, ME 04412; caleb.speirs@gmail.com*

*William N. Ferm Jr., MacKenzie R. Stetzer, University of Maine*

*Beth A. Lindsey, Penn State Greater Allegheny*

Students are often asked to construct qualitative reasoning chains during scaffolded, research-based physics instruction. As part of a multi-institutional effort to investigate and assess the development of student reasoning skills in physics, we have been designing tasks that probe the extent to which students can create and evaluate reasoning chains. In one task, students are provided with correct reasoning elements (i.e., true statements about the physical situation as well as correct concepts and mathematical relationships) and are asked to assemble them into an argument that they can use to answer a specified physics problem. In this talk, the task will be described in detail and preliminary results will be presented.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432765, DUE-1432052, and DUE-0962805.

### EJ05: 2:10-2:20 p.m. Student Ability to Use Complex Numbers in Quantum Mechanics

*Contributed – Tong Wan, University of Washington, Department of Physics, Seattle, WA 98195-0001; tongwan@uw.edu*

*Paul J. Emigh, Gonzaga University*

*Gina Passante, California State University, Fullerton*

*Peter S. Shaffer, University of Washington*

The Physics Education Group at the University of Washington has been investigating student ability to use complex numbers in quantum mechanics. Complex numbers are essential to quantum mechanics. In particular, the relative phases of quantum states, which can be represented by complex numbers, are critical to understanding quantum concepts such as interference and time dependence. We present data from sophomore and junior-level quantum mechanics courses to illustrate some of the errors that students encounter in using complex numbers.

### EJ06: 2:20-2:30 p.m. Student Construction and Use of Three-Dimensional Coordinate System Differential Elements*

*Contributed – Benjamin P. Schermerhorn, University of Maine, Department of Physics and Astronomy, Orono, ME 04469; benjamin.schermerhorn@maine.edu*

*John R. Thompson, University of Maine*

As part of an effort to examine students' understanding of the structure of non-Cartesian coordinate systems and the differential elements associated with these systems when using vector calculus in electricity and magnetism (E&M), students in junior E&M were interviewed in pairs. In one task, students were asked to determine differential length and volume elements for an unconventional spherical coordinate system. While all pairs eventually arrived at the correct differential elements, some students unsuccessfully attempted to reason by recalling and/or mapping from elements in spherical or Cartesian coordinates, only to recognize their error later when checking their work. We have documented several ideas that students use, and certain actions they undertake, while working through the task. Across-interview comparisons allow for characterization of student successes and difficulties in terms of whether these ideas are present and how they are grouped and ordered.

*This work was supported in part by NSF Grant PHY-1405726.

### EJ07: 2:30-2:40 p.m. Student Difficulties with Expectation Values in Quantum Mechanics

*Contributed – Chandralekha Singh, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu*

*Emily Marshman, University of Pittsburgh*

To investigate the difficulties that upper-level undergraduate and graduate students have with expectation values of physical observables in the context of Dirac notation, we administered free-response and multiple-choice questions and conducted individual interviews with students. We find that advanced students display common difficulties with expectation values. Results will be discussed. We thank the National Science Foundation for support.

### EJ08: 2:40-2:50 p.m. Student Difficulties with Quantum Operators Corresponding to Observables

*Contributed – Emily M. Marshman, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu*

*Chandralekha Singh, University of Pittsburgh*

To investigate the difficulties that upper-level undergraduate and graduate students have with quantum operators in the context of Dirac notation, we administered free-response and multiple-choice questions and conducted individual interviews with students. We find that students display common difficulties with these topics. Results will be discussed. This work is supported by the National Science Foundation.

### EJ09: 2:50-3 p.m. Student Ideas About Coordinate Systems in the Upper Division

*Contributed – Brian D. Farlow, North Dakota State University, NDSU, Dept. 2755 P.O. Box 6050, Fargo, ND 58108; brian.farlow@ndsu.edu*

*Mike Loverude, Marlene Vega, California State University Fullerton*

*Warren Christensen, North Dakota State University*

As part of a broader study on student thinking about mathematics in the undergraduate physics curriculum, we report on students' ideas about coordinate systems in the upper division. Early evidence suggests that upper-division physics students struggle to answer conceptual and pictorial questions requiring the use of Cartesian and non-Cartesian coordinate systems. Specifically, students have difficulty identifying the motion of objects using plane polar coordinates. Not recognizing that both radial displacement and polar angle change with respect to time for motion along non-circular paths is a specific example of this difficulty. We report findings from one-on-one interviews that used a think-aloud protocol designed to shed light on student thinking within this domain.

### EJ10: 3-3:10 p.m. Student Reasoning with Vectors through the Physics Curriculum*

*Contributed – Michael E. Loverude, California State University Fullerton, Dept. of Physics, MH611 Fullerton, CA 92834; mloverude@fullerton.edu*

*Marlene Vega, California State University Fullerton*

The vector concept is used in physics instruction beginning in the introductory level. While initial encounters with vectors are firmly grounded in experience, (e.g., a displacement vector in two- or three-dimensional space, with magnitude and a direction), the vector concept grows to include far more abstract ideas. As part of an NSF-supported research and curriculum development project, we have studied student reasoning across several upper-division physics courses, including mathematical methods. For this presentation, we describe theoretical and empirical views of the development and expansion of the vector concept, with examples of student responses and a discussion of implications for instruction.

*Supported in part by NSF grant PHYS-1405616.

## Session EK: Supporting Women in Physics: How Everyone Can Play a Role

**Location:** CC - Room 301
**Sponsor:** Committee on Women in Physics
**Co-Sponsor:** Committee on Professional Concerns
**Date:** Tuesday, July 19
**Time:** 1:30-3 p.m.

*Presider: Daniel M. Smith Jr.*

### EK01: 1:30-2 p.m. Learning About Cross-Cultural Mentoring From My Students at Chicago State University

*Panel – Mel S. Sabella, Chicago State University, 9501 S. King Drive - SCI 309, Chicago, IL 60628; msabella@csu.edu*

In 2001 I started my position at Chicago State University (CSU). CSU is roughly 70% female and 80% African American, with the majority of our students coming from the southside of Chicago and being the first in their families to attend college. The first group of students that I got to know well graduated in the 2003-2004 academic year. These four students were all African American and three of the four were female. The culture and population in my physics community at CSU is quite different than the culture and population of where I grew up in Queens-NY and the physics communities I experienced at my undergraduate and graduate institutions. I will share my experiences supporting and collaborating with female

# Plenary Session

**Location:** Sheraton - Magnolia/Camellia
**Date:** Tuesday, July 19
**Time:** 4–5 p.m.

*Presider: George Amann*

Neil Gershenfeld

## From Bits to Atoms, by Neil Gershenfeld, *The Center for Bits and Atoms, Massachusetts Institute of Technology, Cambridge, MA*

Physicists use computers, and computers use physics. The historical separation of computer science and physical science masks a much more fundamental reciprocity between bits and atoms. I will present emerging research on turning information into things and things into information, and explore the broader implications of anyone being able to make (almost) anything.

students of color and describe how my teaching and mentorship has evolved as a result of what I have learned from my students through these partnerships.

**EK02: 2-2:30 p.m. A Model of Allyship: My Current Best Understanding**

*Panel – Dimitri Dounas-Frazer, University of Colorado Boulder, Department of Physics, 390 UCB, Boulder, CO 80309-0390; dimitri.dounasfrazer@colorado.edu*

Sexism, racism, and other forms of oppression have emotional and physical costs for women, female-presenting people, people of color, people experiencing other forms of marginalization, and people whose identities span multiple marginalized groups. As a white queer man, my understanding of what it means to be an ally is in continual evolution as I try to understand my own multifaceted role in oppression. I mean "multifaceted" in the sense that I benefit from, contribute to, and organize against sexism and racism—as do other aspiring allies. I will discuss a model of allyship that centers working to end *isms, requires ongoing self-education, and makes room for imperfection (with LARGE caveats). I will share examples of how I organize against *isms. I will also share anecdotes about those times when I was "imperfect" in my allyship. How did I impact others, what did I learn, and what was the cost?

**EK03: 2:30-3 p.m. My Role in RIT's Women in Science Group: Privilege and Pitfalls**

*Panel – Scott Franklin, Rochester Institute of Technology, 1 Lomb Memorial Drive, Rochester, NY 14623-5603; svfsps@rit.edu*

"Authentic help means that all involved help each other mutually... Only when those who help and those being helped help each other simultaneously is the act of helping free from the distortion of helper dominating the helped." This quote by Paulo Freire captures both the opportunities and pitfalls of being a male ally. As the lone man on Executive Board of RIT's Women in Science (WISe), I bring with me privileges and opportunities unfairly denied to other members. This has allowed me to advocate for the group and individuals in important ways. But, it has also resulted in numerous inadvertent offenses, as culturally developed behaviors come into conflict with creating a supportive community. Recognizing the latter, and the opportunities for my personal growth, has brought about the mutually supportive community envisioned by Freire. I will present examples of my privileges and pitfalls, and describe the activities and processes by which WISe developed.

To view the abstracts for
**Session EL: The Great American Eclipse of 21 August 2017: Preparing for Maximum Impact,**
please see the abstracts on pages 141-142.

## PST2: Posters

**Location:** Sheraton - Gardenia
**Sponsor:** AAPT
**Date:** Tuesday, July 19
**Time:** 5–6:30 p.m.

*Poster presenters are asked to mount their posters by 8 a.m. The posters will remain available for viewing until 6:30 p.m. Persons with odd-numbered posters will present their posters from 5 to 5:45 p.m; those with even-numbered posters will present from 5:45 to 6:30 p.m..*

### Pre-college/Informal and Outreach

**PST2A02: 5:45-6:30 p.m. Repurposing a Cathode Ray Tube to Demonstrate the Photoelectric Effect**

*Poster – John Avallone, Stuyvesant High School, 345 Chambers St., New York, NY 10282; john.avallone@gmail.com*

This poster presentation will show how a cathode ray tube, laser pointers and an ammeter can be used to demonstrate, in "real life", the photoelectric effect. It is a simple, possibly accessible demonstration of a topic that, in high school classrooms, may otherwise only be heard about and "demonstrated" through PhET applet of the like. I have found it an exciting and attention grabbing "mystery" for my students to solve, that sets the stage for a deeper discussion of the topic.

**PST2A03: 5-5:45 p.m. STEM Ambassadors: An Undergraduate Powered Outreach Program**

*Poster – Edward Price, California State University San Marcos, 333 South Twin Oaks Valley Road, San Marcos, CA 92096; eprice@csusm.edu*

*Charles De Leone, Debbie DeRoma, California State University San Marcos*

*Chandra Turpen, University of Maryland*

At California State University San Marcos (CSUSM), in the last five years we have reached more than 10,00 students and teachers from local school districts with a K12 outreach program powered by CSUSM undergraduates. The San Diego area, where CSUSM is located, is ethnically diverse and many local K12 students would be first-generation college students. In this context, the outreach program is designed to provide local youth with STEM experiences and connections to near-peer mentors who are positive role models, and, more broadly, foster linkages between the university and community. The undergraduate STEM Ambassadors are highly qualified and ethnically diverse undergraduate science and math majors who lead outreach activities. The program includes sustained efforts such as after school Making programs, and one-shot activities such as classroom demonstrations, STEM Cafes, and campus visits. Program outcomes include increased numbers of students applying and admitted to CSUSM STEM majors (compared to high schools without Ambassadors). Although K12 students are the primary audience, the Ambassadors themselves are positively impacted, including increased technical and leadership skills. This poster describes the STEM Ambassadors program activities and outcomes.

### PST2A04: 5:45-6:30 p.m. 3D Printing Astronomy Lessons in Minecraft

*Poster – Natasha Collova, Siena College, 951 Garibaldi Place, Township of Washington, NJ 07676; ne24coll1@siena.edu*

*Michele McColgan, Siena College*

Minecraft is able to 3D print worlds using a program called Mineways. With this program, worlds are selected and exported as an STL file. With this in mind, we will present a Minecraft world where middle school students were asked to scale the entire solar system and build the planets in Minecraft. Their planets were individually printed and the students were asked to spread them out at the scale at which they were printed. The different challenges that students encountered will be described and the results of a pre-and post-survey will be presented.

### PST2A05: 5-5:45 p.m. Plasma Outreach to Teachers and Students: The DPP Model

*Poster – Paul M. Miller, West Virginia University, PO Box 6315, Morgantown, WV 26506-6315; paul.miller@mail.wvu.edu*

For more than 25 years, members of the American Physical Society's Division of Plasma Physics (DPP) have offered free plasma physics outreach to teachers and students near the location of the annual DPP meeting. This effort is centered on two events. Teachers Day is a day of workshops for secondary teachers. Each teacher attends "Plasma 101" and two more workshops based on interest. Plasma physics is presented not as a new topic to add, but rather a hook by which teachers can enhance topics they already teach. The Plasma Sciences Expo educates busloads of students with interactive science education. Learn about our time-tested approach to outreach at this poster, and consider joining us in San Jose this fall. (This outreach is supported in part by the US Department of Energy under Grant No. DE-SC0012498 and by the APS Division of Plasma Physics.)

## Physics Education Research

### PST2B01: 5-5:45 p.m. Development of a Survey to Assess Transformative Experience in an Introductory Calculus-based Mechanics Course*

*Poster – Steven F. Wolf, East Carolina University, C-209, Howell Science Complex, Tenth St., Greenville, NC 27858-4353; wolfs15@ecu.edu*

*David Donnelly, Texas State University*

At Texas State University and East Carolina University, we have been implementing many research-based curricula in our introductory physics classes, and have developed a survey to assess the degree of Transformative Experience in our students. The survey was modeled after one used by Pugh, and is similar to those developed by Frank and Atkins. Our pilot survey was administered to a total of 209 students during the 2014-15 academic year and has been revised and readministered during the 2015-16 academic year. We will present data related to the reliability of this instrument and plans for coordinating this assessment with other assessments common in PER such as the FCI.

*B. Frank and L. Atkins, presented at the Physics Education Research Conference 2013, Portland, OR, 2013.

### PST2B02: 5:45-6:30 p.m. Differential Impacts of Aligning Epistemological Expectations in Introductory Physics Labs

*Poster – Kelsey M. Funkhouser, Michigan State University, Biomedical & Physical Sciences Bldg., 567 Wilson Road, East Lansing, MI 48824-2320; kfunkh@msu.edu*

*Vashti Sawtelle, William M. Martinez, Marcos D. Caballero, Michigan State University*

There has been an abundance of work done to study students' epistemological beliefs in physics lecture classes but much less has been done in the laboratory classes. The introductory physics laboratory courses at Michigan State University are currently undergoing a transformation. One goal of the transformation is to align the students' epistemological expectations of how to succeed in a lab with what the faculty want students to get out of the lab experience. This work looks at shifts in student attitudes as measured by the Colorado Learning Attitudes about Science Survey for Experimental Physics (E-CLASS). We will present analysis of how particular goals of the lab transformation align (or not) with shifts in student attitudes with an emphasis on gender differences.

### PST2B03: 5-5:45 p.m. Educational Data Mining for Discovering Learning Patterns in High School Physics Students

*Poster – Daniel Sanchez, INSTITUTO POLITÉCNICO NACIONAL Legaria, No. 694, Col. Irrigación, Mexico City, MX 11500 México; dsanchezgzm@gmail.com*

*Darly Yurani Charry Sanchez, INSTITUTO POLITÉCNICO NACIONAL*

Educational Data Mining has been used since 2006 in many educational contexts, but in physics education it has not been well explored, present work tries to show the use of EDM in Physics Education Research (PER) experiments and the potential of its use for analyzing relevant data that can be useful for teachers, students, parents and policy makers. We present the clustering and classification algorithms applied in two PER experiments applied with high-school students of physics.

### PST2B04: 5:45-6:30 p.m. Effect of Active Learning on Student Attitudes Towards Learning Physics

*Poster – Liang Zeng, The University of Texas-Rio Grande Valley, 1201 W. University Drive, Edinburg, TX 78539; liang.zeng@utrgv.edu*

*Guang Zeng, Texas A&M University-Corpus Christi*

Most professors at the University of Texas-Rio Grande Valley, an Hispanic Serving Institution, perceive pre-med majors to have relatively weak backgrounds in high school physics and math and have little interest in learning physics profoundly. They also feel many students only want to get high grades to improve their transcripts. Through implementing various active learning methods in my General Physics I class in fall 2015, including aligning curriculum with MCAT standards, employing classroom demonstrations, solving problems within various contexts, realizing just-in-time teaching with clickers, and encouraging small-group discussions, we found dramatically improved student attitudes towards learning physics, as measured by the CLASS survey on 19 students in the beginning and the end of the semester. This pilot study calls for a continuous study on the effect of active learning. It also directs other STEM educators to conduct similar research to improve quality of education in introductory-level classes.

### PST2B05: 5-5:45 p.m. Evaluating Just-in-Time Teaching and Peer Instruction Using Clickers in a Quantum Mechanics Course

Poster – Ryan T. Sayer, University of Pittsburgh, 6311 Morrowfield Ave., Pittsburgh, PA 15217; rts36@pitt.edu

Emily Marshman, Chandralekha Singh, University of Pittsburgh

Just-in-Time Teaching (JiTT) is an instructional strategy involving feedback from students on pre-lecture activities in order to design in-class activities to build on the continuing feedback from students. We investigate the effectiveness of a JiTT approach, which included in-class concept tests using clickers in an upper-division quantum mechanics course. We analyze student performance on pre-lecture reading quizzes, in-class clicker questions answered individually, and clicker questions answered after group discussion, and compare those performances with open-ended retention quizzes administered after all instructional activities on the same concepts. In general, compared to the reading quizzes, student performance improved in individual concept tests administered using clickers after lecture focusing on student difficulties found via electronic feedback. The performance on the group concept tests administered after the individual concept tests and on retention quizzes also showed improvement. We discuss possible reasons for the improvement in performance from pre-lecture quizzes to post-lecture concept tests and from individual to group concept tests and retention quizzes.

## PST2B06: 5:45-6:30 p.m. Evaluating the Workshop for New Physics and Astronomy Faculty

Poster – Stephanie Chasteen, sciencegeekgirl enterprises, LLC 247 Regal St., Louisville, CO 80027; stephanie@sciencegeekgirl.com

Since 1996, the AAPT, APS, and AAS have hosted the Workshop for New Physics and Astronomy Faculty (NFW) to introduce new faculty to research-validated instructional techniques; these workshops have been very influential in encouraging faculty to try teaching methods like Peer Instruction. This poster will focus on the workshop evaluation, including survey design and analysis, characterization of the participants, analysis of learning gains, and the common challenges faced in workshop implementation (such as cognitive overload, providing breadth as well as interactivity, avoiding being seen as "selling" evidence-based practice, and giving faculty participants the tools necessary for success). The poster should be of interest to evaluators and implementers of various professional development programs.*

* See separate posters/talks on other aspects of the NFW, including virtual Faculty Online Learning Communities (FOLCs) and research on faculty development practices. This work is supported in part by NSF DUE IUSE Grants 1431638,1431681,1431779, and 1431454.

## PST2B07: 5-5:45 p.m. Examining Engineering Course Work Looking for Breadcrumbs

Poster – Thomas Foster, Southern Illinois University Edwardsville, Department of Physics, Edwardsville, IL 62026; tfoster@siue.edu

John Peters, Southern Illinois University Edwardsville

In our introductory physics courses we teach, more often than not, to students who will go into engineering. However, our engineering colleagues tend to teach mechanics in their Statics and Dynamics courses. Have you ever wondered if what you taught shows up in that statics class when the students revisit essentially the same material? With the help of an engineering undergraduate research student, we were able to interpret trends in the students work which group with previous courses. Our preliminary results will help you sleep at night knowing that what you teach students does show up in when asked similar questions.

## PST2B08: 5:45-6:30 p.m. Examining the Effects of Testwiseness Using the FCI and CSEM

Poster – Seth T. DeVore, West Virginia University, 135 Willey St., Morgantown, WV 26506-0002; stdevore@mail.wvu.edu

John Stewart, West Virginia University

Testwiseness is generally defined as the set of cognitive strategies used by a student and intended to improve their score on a test regardless of the test's subject matter. To improve our understanding of the potential effect size of several well-documented elements of testwiseness we analyze student performance on questions present in the Force Concept Inventory (FCI) and Conceptual Survey on Electricity and Magnetism that contain distractors, the selection of which can be related to the use of testwiseness strategies. Additionally we examine the effects of the position of a distractor on its likelihood to be selected in 5-option multiple choice questions. We further examine the potential effects of several elements of testwiseness on student scores by developing two modified versions of the FCI designed to include additional elements related to testwiseness. Details of the effect sizes of these various aspects of testwiseness will be discussed.

## PST2B09: 5-5:45 p.m. Examining the Pedagogical Fidelity of an Adopted Curriculum

Poster – Kevin D. Hartman, San Jose State University, 73 S 8th St.,San Jose, CA 95112; kevin.hartman96@gmail.com

Casaandra A. Paul ,San Jose State University

Instructor-researchers at San José State University (SJSU) have implemented the Collaborative Learning through Active Sense-making in Physics (CLASP) curriculum in our algebra-based, introductory physics course. Originally developed at UC Davis, CLASP is characterized by the use of models and integrated discussion-labs where hands-on, small-group activities promote sense-making and problem-solving skills. Previous research has shown that while instructors employ various interaction techniques, CLASP is, considerably more interactive than traditional lab or lecture environments. Using the Real-time Instructor Observing Tool (RIOT), we examine the similarities and differences between CLASP implementation at the two institutions and explore the degree to which CLASP curriculum is successful with each population. These results have implications for those who plan to adapt curriculum for a different environment and population.

## PST2B10: 5:45-6:30 p.m. Explicit Incentives to Correct Mistakes in Quantum Mechanics Can Substantially Improve Performance on the Same Problems Repeated a Second Time

Poster – Chandralekha Singh, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu

Ben Brown, University of Pittsburgh

Andrew Mason, University of Central Arkansas

An earlier investigation found that the performance of advanced students in a quantum mechanics course did not automatically improve from midterm to final exam on identical problems even when they were provided the correct solutions and their own graded exams. Here, we describe a study, which extended over four years, in which upper-level undergraduate students in a quantum physics course were given four identical problems in both the midterm exam and final exam. Approximately half of the students were given explicit incentives to correct their mistakes in the midterm exam. In particular, they could get back up to 50% of the points lost on each midterm exam problem. The solutions to the midterm exam problems were provided to all students in both groups but those who corrected their mistakes were provided the solution after they submitted their corrections to the instructor. The performance on the same problems on the final exam suggests that students who were given incentives to correct their mistakes significantly outperformed those who were not given an incentive. The incentive to correct the mistakes had greater impact on the final exam performance of students who had not performed well on the midterm exam. We thank the National Science Foundation for support.

## PST2B11: 5-5:45 p.m. Exploring One Aspect of Pedagogical Content Knowledge of Physics Instructors and Teaching Assistants* Using the Force Concept Inventory

Poster – Alexandru Maries, 3405 Telford St., Cincinnati, OH 45220; mariesau@ucmail.uc.edu

Chandralekha Singh, University of Pittsburgh

The Force Concept Inventory (FCI) has been widely used to assess student understanding of introductory mechanics concepts by a variety of educators and physics education researchers. One reason for this extensive use is that many of the items on the FCI have strong distractor choices that correspond to students' alternate conceptions in mechanics. Instruction is unlikely to be effective if instructors do not know the common alternate conceptions of introductory physics students and explicitly take into account students' initial knowledge state in their instructional design. Here, we discuss research involving the FCI to evaluate one aspect of the pedagogical content knowledge of both instructors and teaching assistants (TAs): knowledge of introductory student difficulties related to mechanics as they are revealed by the FCI. We used the FCI to design a task for instructors and TAs that would provide information about their knowledge of common student difficulties and used FCI pre-test and post-test data from a large population (~900) of introductory physics students to assess this aspect of pedagogical content knowledge of physics instructors and TAs. We find that while both physics instructors and TAs, on average, performed better than random guessing at identifying introductory students' difficulties with FCI content, they did not identify many common difficulties that introductory physics students have, even after traditional instruction. Moreover, the ability to correctly identify students' difficulties was not correlated with the teaching experience of the physics instructors or the background of the TAs.

*Work supported by the National Science Foundation

### PST2B12: 5:45-6:30 p.m. Exploring One Aspect of Pedagogical Content Knowledge of Teaching Assistants Using the Test of Understanding Graphs in Kinematics*

*Poster – Alexandru Maries, University of Cincinnati, 3405 Telford St.,Cincinnati, OH 45220; mariesau@ucmail.uc.edu*

*Chandralekha Singh, University of Pittsburgh*

The Test of Understanding Graphs in Kinematics (TUG-K) is a multiple choice test developed by Beichner in 1994 to assess students' understanding of kinematics graphs. Many of the items on the TUG-K have strong distractor choices which correspond to students' common difficulties with kinematics graphs. We evaluate one aspect of the pedagogical content knowledge of first year physics graduate students enrolled in a teaching assistant (TA) training course related to topics covered in the TUG-K. We used the TUG-K to design a task forTAs that would provide information about their knowledge of common student difficulties and used the TA data and the data from Beichner's original paper for introductory physics students (which was collected from over 500 college and high-school students) to assess this aspect of the pedagogical content knowledge (PCK) of the graduate students, i.e., knowledge of student difficulties related to kinematics graphs as they are revealed by the TUG-K. We find that, although the graduate students, on average, performed better than random guessing at identifying introductory student difficulties on the TUG-K, they did not identify many common difficulties that introductory students have with graphs in kinematics. In addition, we find that the ability of graduate students to identify the difficulties of introductory students is context dependent and that discussions among the graduate students improved their understanding of student difficulties related to kinematics graphs. Moreover, we find that the ability of American graduate students in identifying common student difficulties is comparable with that of foreign graduate students.

*Work supported by the National Science Foundation

### PST2B14: 5:45-6:30 p.m. Exploring the Role of Design Problems in the Physics Classroom

*Poster – Paul C. Hamerski,* Carnegie Mellon University, 5000 Forbes Ave., Pittsburgh, PA 15213; paulhamerski@gmail.com*

*Paul W. Irving, Marcos D. Caballero, Michigan State University*

A feature missing in many physics courses is design work, which would better prepare science and engineering students for future work where design plays a bigger role. This realization has already led to significant changes in K-12 curricula, and we are exploring the role of design problems at a post-secondary level, where incorporating such problems allows for unique opportunities for students to create and adjust models of physics principles. This investigation takes a close look at how groups of students in a section of introductory physics at Michigan State University approach design problems, and how learning is affected. In order to inform and assist instructors and researchers, we have adapted a framework traditionally used in engineering design to characterize the problem-solving steps we observed. Our investigation highlights the utility of design, and offers up some additional questions and possible explanations on the impact of design problems in the physics classroom.

*Sponsored by Paul Irving, Marcos Caballero

### PST2B15: 5-5:45 p.m. Extending Psychometric Analysis of Gender Differences on the FCI

*Poster – Alexis Papak, University of Illinois Urbana Champaign, Department of Physics, 1110 West Green St., Urbana, IL 61801; papak2@illinois.edu*

*Adrienne Traxler, Wright State University*

*Rebecca Lindell, Purdue University*

Despite decades of research using the Force Concept Inventory (FCI), its psychometric properties have been only lightly documented. Psychometric theory tells us that it is essential for inventory developers to establish the fairness of an instrument for any population for which it is intended. Many physics courses are strongly gender-imbalanced, which can obscure gender effects when field-testing items for appropriateness. In a preliminary analysis that disaggregated by gender, we found that up to 15 items might be discarded from the FCI for falling outside acceptable ranges of item difficulty or discrimination. This result is almost entirely buried when the tests are only run on the overall (male-dominated) sample. Here we extend the analysis to a larger data set and progress to additional psychometric tests, attending to other buried gender effects that may appear.

### PST2B16: 5:45-6:30 p.m. Faculty Expectations of Dimensional Analysis

*Poster – MacKenzie Lenz, 301 Weniger Hall, Corvallis, OR 97330; lenzm@oregonstate.edu*

*Elizabeth Gire*

Although dimensional analysis is often considered a fundamental skill in physics, surprisingly little research has examined how instructors teach it or expect their students to do it. Eight faculty from Oregon State University were interviewed to better understand how they think about and teach dimensional analysis. These faculty teach introductory, upper division and graduate courses, and have diverse research backgrounds. Dimensional analysis was identified as either a tool for deriving formulas or answer checking, some preferred to think of the latter mode as "unit checking." Students are expected to be able to check units/dimensions at all levels (introductory through graduate) of their physics education. Many faculty commented that, although they may demonstrate dimensional analysis, they do not explicitly discuss strategies for doing it or require students to practice it in course assignments.

### PST2B17: 5-5:45 p.m. Gender, Network Analysis, and Conceptual Gains in Introductory Physics

*Poster – Sarah T. Hierath, Wright State University, 3640 Colonel Glenn Hwy., Dayton, OH 45435-0001; hierath.2@wright.edu*

*Emily N. Sandt, Adrienne L. Traxler, Wright State University*

Social Network Analysis (SNA) is an important tool in studying classroom dynamics because it can be used to map the social structure of a classroom's interactions and to aid in understanding how students work and study together. This study presents network diagrams, statistics, and centrality measures for several sections of introductory physics. Sections vary in size and structure, from traditional lecture to very interactive. Networks were analyzed in aggregate and by gender to look for gender effects in network participation. Centrality measures were calculated from survey data in which students listed the names of their study partners within the class. These centrality measures will be correlated with success on the Force Concept Inventory (FCI), which was administered to students at the beginning and end of the semester. We will look for connections between network position and conceptual gains, both overall and by gender.

### PST2B18: 5:45-6:30 p.m. Helping Students Master Uncertainties in Measurements

*Poster – Scott W. Bonham, Western Kentucky University, 1906 College Heights Blvd. #11077, Bowling Green, KY 42101; Scott.Bonham@wku.edu*

*Brian G. Luna, Kolton Jones, Western Kentucky University*

Uncertainties are an important part of scientific measurement, but one with which many students struggle. We present a set of activities that we have implemented in introductory physics laboratory sessions to help students understand the concept, mechanics, and importance of uncertainties. These activities seek to help students visualize the meaning of the standard deviation of the mean/standard error, give them practice calculating the standard error and propagating uncertainties through multiple calculations, and recognize the need for uncertainties in a "real life" application. For this, students measure parameters of a plastic "boat," "cargo" it is to carry, and its "sea," to calculate the maximum cargo—with uncertainties—that will not sink. We find that the full set of instructional interventions leads the majority of the students to consistently report the uncertainties of their measured and calculated values in their reports for most of the rest of the semester.

### PST2B19: 5-5:45 p.m. How Students Combine Knowledge Elements While Learning

*Poster – AJ Richards, The College of New Jersey, 2000 Pennington Rd., Ewing, NJ 08628; aj.richards@tcnj.edu*

*Darrick C. Jones, Eugenia Etkina, Rutgers University*

We recorded pre-service physics teachers learning about the physics of solar cells. Using a knowledge-in-pieces theoretical framework, we analyze their interactions in order to make inferences about the elements of prior knowledge they call upon as they build understanding of how these devices function. Of special interest are the instances when a student makes a significant conceptual breakthrough. We find that students who combine different aspects of their prior knowledge in specific ways may be more likely to make breakthroughs. We will discuss what instructors can do to prime learners to combine knowledge in productive ways so they are better able to achieve these breakthroughs.

### PST2B20: 5:45-6:30 p.m. Impacts of Lecture-based Teaching and Faculty Disconnection on STEM Majoring

*Poster – Melissa Dancy, University of Colorado, Dept. of Physics, Boulder, CO 80309; melissa.dancy@gmail.com*

*Katherine Rainey, University of Colorado*

*Elizabeth Stearns, Roslyn Arlin Mickelson, Stephanie Moller, UNC - Charlotte*

Over 300 university seniors were interviewed about their experiences pursuing a major. The students were either STEM majors, had left a STEM major or had considered but never pursued a STEM major. The majority of students interviewed were from an underrepresented group, i.e. women and/or racial minority. Students reported a preference for interactive teaching yet experienced high levels of lecturing in college classes. Additionally, they report positive influences of high school teachers but rarely of college faculty in their decisions to pursue or continue a STEM major. Students report particularly negative experiences in physics. Poor college level teaching appears to disproportionately impact underrepresented groups.

### PST2B22: 5:45-6:30 p.m. Improving Student Understanding of Time-Dependence of Expectation Values in Quantum Mechanics via Larmor Precession of Spin

*Poster – Chandralekha Singh, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu*

*Ben Brown, University of Pittsburgh*

*Guangtian Zhu, East China Normal University, Shanghai*

We conducted research on student difficulties and developed and evaluated a quantum interactive learning tutorial (QuILT) on Larmor precession of spin to help students learn about time-dependence of expectation values in quantum mechanics. The QuILT builds on students' prior knowledge and strives to help them develop a good knowledge structure of relevant concepts related to time-dependence of expectation values using a simple two-state system. It adapts visualization tools to help students develop intuition about these topics and focuses on helping them integrate qualitative and quantitative understanding. We discuss the development of the QuILT starting with investigation of student difficulties and concluding with the findings from the evaluation of the QuILT. We thank the National Science Foundation for support.

### PST2B23: 5-5:45 p.m. In-class Surveys: Time Well Spent or Simply Inefficient?

*Poster – Ben Van Dusen, 2354 Farmington Ave., Chico, CA 95928; bvandusen@csuchico.edu*

*Eleanor Close,Texas State University*

This study investigates differences in student responses to in-class and online administrations of the Force Concept Inventory (FCI), Conceptual Survey of Electricity and Magnetism (CSEM), and the Colorado Learning Attitudes about Science Survey (CLASS). Over 700 physics students from six classes were instructed to complete the concept inventory relevant to their course, either the FCI or CSEM, and the CLASS. Each student was randomly assigned to take one of the surveys in class and the other survey online using the LA Supported Student Outcomes system. Our analysis examines item level and overall performance differences on the surveys across administration settings. Student demographic information will also be used to identify potential variations across gender, ethnicity, and racial variables.

### PST2B24: 5:45-6:30 p.m. Infrared Cameras Provide Disciplinary Affordance to Thermal Phenomena

*Poster – Jesper Haglund, Uppsala University, Department of Physics and Astronomy, Box 516, Uppsala, 75120 Sweden; jesper.haglund@physics.uu.se*

Infrared (IR) cameras are a flexible technology for visualization of thermal phenomena. With decreasing prices, handheld IR cameras are becoming a viable option in physics education. In our physics education research, we have developed, implemented, and evaluated a range of practical laboratory exercises with IR cameras for different age groups. For high school teaching, exercises are based on the predict-observe-explain (POE) design, through which students have investigated phenomena such as heat conduction through different materials, and temperature increases due to friction and inelastic collisions. At university thermodynamics courses, students engage in open-ended laboratory investigation of apparatus such as a Leslie's cube, a heat pump or a fire extinguisher. Students have been found to use the technology in "instant inquiry" of thermal phenomena. We conclude that IR cameras have disciplinary affordance in the area of thermal science.

### PST2B25: 5-5:45 p.m. Insights into Undergraduate Thesis Writers: Motivation, Beliefs, and Self-efficacy

*Poster – Jason E. Dowd, Duke University, 137 Bio Sciences Building, Durham, NC 27708; jason.dowd@duke.edu*

*Robert J. Thompson, Jr., Julie A. Reynolds, Duke University*

Synthesizing data that have been collected across science departments from several institutions over three years, we share findings regarding (1) the relationships among students' motivation, self-efficacy in science and writing, and epistemic beliefs about the nature of scientific knowledge, (2) changes to those relationships throughout one semester of a writing-intensive capstone thesis course, and (3) relationships between such characteristics and other learning outcomes. Specifically, we carry out cluster analyses to gain insights about undergraduate thesis writers. Previous work indicates that scaffolding the writing process in a thesis-writing course can be an effective strategy for promoting these characteristics and related learning outcomes. Building on that work here, we endeavor to better understand the influence of writing on individual students' learning. Our ability to assess scientific reasoning and writing in students' undergraduate theses is a critical aspect of this work. Ultimately, our analysis will be used to motivate institution- and department-specific changes.

### PST2B26: 5:45-6:30 p.m. Instrumentation for Video-based Research in Physics Education

*Poster – Benedikt W. Harrer, San José State University, One Washington Square, San José, CA 95192-0106; benedikt.harrer@sjsu.edu*

Interest in video-based research in physics education is greater than ever. With increasing affordability and ever-advancing specifications, audio and video recording equipment of exceptional quality is now readily available for every budget. However, with the large variety of available recording devices, file formats, computer programs, etc., and also with increasingly complex recording and analysis situations, it can be difficult to find the right equipment and recording strategies. We present some of our insights and findings from designing a video-based physics education research laboratory, the Productive Interactions and Ideas in Physics Laboratory (PI/IP Lab) at San José State University.

### PST2B27: 5-5:45 p.m. Introductory Astronomy: Epistemological Beliefs and Scientific Reasoning

*Poster – Shannon D. Willoughby, Montana State University, EPS 264, Bozeman, MT 59717; shannon.willoughby@montana.edu*

*Keith Johnson, Montana State University*

Over the course of four semesters we administered the 5-axis Epistemological Beliefs about the Physical Sciences (EBAPS) survey as a pre-test and a post-test in our introductory Astronomy course. This baseline data revealed significant declines along several axes regarding student epistemological beliefs. Course modifications have since halted these significant declines with an exception to axis 5: Students' views about whether learning science is persistent or malleable. During the 2015-2016 academic year we implemented an online homework system in order to give students further opportunities to explicitly address axis 5 by encouraging them to practice their understanding via the online homework system. Measurements of student formal reasoning were also conducted to provide additional insight into these belief structures. Statistical comparisons between the latest pre-test and post-test EBAPS data are presented, as well as correlations between student formal reasoning abilities and epistemological beliefs.

### PST2B28: 5:45-6:30 p.m. Introductory Physics Students' Perception of Worked-Out Problem Solutions

*Poster – Shih-Yin Lin, National Changhua, University of Education, No. 1 JinDe Rd., Changhua 500. Taiwan; hellosilpn@gmail.com*

Worked examples are common instructional tools used in the teaching and learning of problem solving. As part of a larger study to explore how worked examples could be designed and used effectively to facilitate student learning, we investigate how students perceive features in worked examples that are designed to model expert-like problem solving strategies. Thirty students enrolled in an introductory physics course were provided with different instructor solutions for the same physics problem and asked to discuss the features they noticed from these solutions. They were also asked to discuss how important each of these features was when solving physics problems as well as whether they would like to see these features included in worked out examples provided to them. We will present the findings.

### PST2B29: 5-5:45 p.m. Investigating Grading Beliefs and Practices of Graduate Student Teaching Assistants Using a Rubric

*Poster – Ryan T. Sayer, University of Pittsburgh, 6311 Morrowfield Ave., Pittsburgh, PA 15217; rts36@pitt.edu*

*Emily Marshman, Chandralekha Singh, University of Pittsburgh*

*Charles Henderson, Western Michigan University*

*Edit Yerushalmi Weizmann, Institute of Science*

Teaching assistants (TAs) are often responsible for grading student solutions. Since grading communicates instructors' expectations, TAs' grading practices play a crucial role in shaping students' approaches to problem solving. However, TAs may be inconsistent in their grading practices and may benefit from using a rubric when grading. We implemented a sequence of instructional activities in a TA training course which involved grading student solutions of introductory physics problems. We investigated the TAs' grading criteria and practices at the outset of a professional development program and after completing instructional activities involving grading with a rubric. We will discuss the findings.

### PST2B31: 5-5:45 p.m. Investigating Student Use of Angular Momentum Operators in Quantum Mechanics

*Poster – Chrystin Green, California State University Fullerton, 800 N. State College Blvd., Fullerton, CA 92831-3599; chrystingreen@yahoo.com*

*Gina Passante, California State University Fullerton*

This study focuses on student difficulties in the use of quantum mechanical operators, specifically operators relating to angular momentum, in a senior-level quantum mechanics course. Interview data is collected and analyzed to better understand the errors that we find many students make when using operators to solve problems that involve commutation relations, expectation values, and the uncertainty in angular momentum. The results of this investigation will allow us to more clearly articulate the difficulties students have with the mathematical formalism in quantum mechanics and will inform the creation of curricula to address these difficulties and facilitate the development of robust conceptual understanding.

### PST2B32: 5:45-6:30 p.m. Investigating Students Understanding Early Atom Models via Model-Based Inquiry

*Poster – Tugba Yuksel, Purdue University, 525 Northwestern Ave., West Lafayette, IN 47907-2040; tyuksel@purdue.edu*

This research is part of a larger study that examines students' cognitive structures and reasoning of fundamental quantum mechanics concepts as they engage in a model-based inquiry instruction. In this research, I will investigate how undergraduate freshmen level students' cognitive understanding about atomic structure and behavior of electrons evolve when they are encourage pursuing early scientists' approach. Individuals construct their knowledge and develop models to represent their understanding as they share ideas and communicate with others. A model-based framework for this project is adopted along with history and philosophy of science (HPS) in science education to facilitate students to acquire comprehensive understanding as well as develop interest in science learning. With hands on materials and computer-based simulations, students had a chance to imitate Thomson and Rutherford experiments. By doing that, they were also encouraged to think how technological equipment and philosophical and historical background in early '90s affected scientists' discoveries.

### PST2B33: 5-5:45 p.m. Investigating the Impact of Task Design on Student Reasoning*

*Poster – Cody Gette, North Dakota State University, 4214 9th Ave. S, Fargo, ND 58103; cody.gette@ndsu.edu*

*Mila Kryjevskaia, North Dakota State University*

*MacKenzie Stetzer, University of Maine*

*Andrew Boudreaux, Western Washington University*

*Sara Julin Whatcom, Community College*

As part of ongoing investigation of student reasoning in physics, we have been exploring a particularly puzzling phenomenon: students often demonstrate competent reasoning on one task, but not on other, closely related tasks. Some students seem to abandon the formal knowledge and skills in favor of more appealing intuitive ideas. In order to probe the nature of such inconsistencies in student performance, we developed a sreening-target question methodology that allows us to disentangle various factors that may influence student reasoning approaches. In this presentation we will focus on factors that are perhaps rooted in the task design. In particular, we modified screening questions and examined the impact of this modification on student performance on a target question. Screening questions differed in metacognitive prompts, perceived cognitive ease, and the level of abstractness.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1245999, DUE-1245993, DUE-1245313 and DUE-1245699.

### PST2B35: 5-5:45 p.m. Key Factors in Introductory Physics Performance: A Four-year Study

*Poster – Brian D. Thoms, Georgia State University, 25 Park Place, Suite 605, Atlanta, GA 30303; bthoms@gsu.edu*

*Saif Ali, Donna Babihuga, Alexander Coston, Georgia State University*

The effects on introductory physics students' conceptual learning of student demographics and educational history as well as characteristics of instructors and course design have been investigated. The data used in this study was collected over four years from students in introductory algebra- and calculus-based physics courses and includes scores from diagnostics of conceptual understanding (FCI and CSEM), student demographics (major, age, gender, race/ethnicity, native language), student educational history (previous physics and math experience), and students' answers to a lab survey as well as course instructor information. During this four-year period algebra-based physics was taught in both traditional lecture format and in SCALE-UP format. Also during this period the calculus-based physics underwent a major laboratory reform. We will present results showing key factors affecting student success as measured by conceptual inventories.

### PST2B36: 5:45-6:30 p.m. Learning of Heat and Thermic Energy Concepts in Tonala, Mexico

*Poster – Jose L. Santana Fajardo, Universidad de Guadalajara, Juarez #976, Guadalajara, JAL 44100 México; icedsor@gmail.com*

*Mario H. Ramírez, Instituto Politécnico Nacional*

The Tonala High School of the University of Guadalajara has a unique program of teaching ceramics in Mexico, which tries to rescue the culture of the region and to develop scientific and technological skills. In this particular case, the learning of concepts of heat and temperature are presented because they are a fundamental part in the consolidation of ceramic products. This paper shows Project-Oriented Learning (POL), implemented in courses within the curriculum of the Bachillerato Tecnológico en Cerámica (BTC). To show its benefit we need to evaluate their incidence to reach the learning of physical concepts by middle education students. We expose the application of a teaching sequence that involves the POL and situations centered in ceramics. We use Hake's and concentration factor to measure the quality of instruction, applied to the results obtained from a pre-test and post-test designed specifically to this course.

### PST2B37: 5-5:45 p.m. Learning Orientations Towards Physics Problem Solving: Additional Potential Variables

*Poster – Andrew J. Mason, University of Central Arkansas, 201 S. Donaghey Ave., Conway, AR 72035-0001; ajmason@uca.edu*

*Charles A. Bertram, University of Central Arkansas*

Introductory algebra-based physics students who are predominately biology majors and health science majors may have different pedagogical goals with regard to their respective majors. This in turn may affect their approach to physics problem solving skills and, more generally, overall course performance. Previous research[1] identified learning orientations (framework-oriented, performance-oriented, vague-oriented) and examined preliminary evidence of how these orientations might influence student attitudes towards physics problem solving, and in turn influence learning of elements of physics problem solving and overall course performance. A follow-up investigation, with an increased sample size of three semesters (including eight laboratory sections) of introductory algebra-based physics students, identifies potential variables which may influence these learning orientations.

1. Sources: A. Mason, "Potential Relationship of Chosen Major to Problem Solving Attitudes and Course Performance," 2015 PERC Proceedings (Eds: A. Churukian, D. Jones, and L. Ding), pp. 215-218, © 2015; A. Mason and C. Bertram, "Epistemic Impact on Group Problem Solving for Different Science Majors," US-China Education Review A 4(12), 873-879, © 2014.

### PST2B38: 5:45-6:30 p.m. Listening to Student Conversations During Group Exams

*Poster – Joss Ives, UBC, Department of Physics and Astronomy, 2329 West Mall, Vancouver, BC V6T 1Z4 Canada; joss@phas.ubc.ca*

*Nutifafa Sumah, UBC Department of Physics and Astronomy*

We use video analysis to study the dynamics of group interactions during a group exam. Of particular interest are the contributions of low-performing and high-performing students in groups of students with various mixes of student performance.

### PST2B39: 5-5:45 p.m. New Resources on PhysPort: Supporting Physics Teaching with Research-based Resources

*Poster – Sarah B. McKagan, American Association of Physics Teachers, 124 28th Ave., Seattle, WA 98122; sam.mckagan@gmail.com*

*Adrian M. Madsen, American Association of Physics Teachers*

Physics education researchers have created research results, teaching methods, curricula, and assessments that can dramatically improve physics education. PhysPort (www.physport.org) is the go-to place for ordinary physics faculty to find resources for research-based teaching and assessment. First released in 2011 as the PER User's Guide, PhysPort has undergone re-branding, redesign, and expansion, including many new resources: overviews of over 50 research-based teaching methods and over 50 research-based assessment instruments, Expert Recommendations, the Virtual New Faculty Workshop, the Periscope collection of video-based TA training and faculty professional development materials, and the Assessment Data Explorer, an interactive tool for faculty to get instant analysis and visualization of their students' responses to research-based assessment instruments including the FCI, BEMA, and CLASS, and compare their results to national averages and students like theirs. The development of PhysPort includes research to determine faculty needs and usability testing to ensure that we meet those needs.

### PST2B40: 5:45-6:30 p.m. Non-traditional Student Status, Conceptual Gains and Centrality in Introductory Physics

*Poster – Emily N. Sandt, Wright State University, 3640 Colonel Glenn Highway, Dayton, OH 45435; sandt.2@wright.edu*

*Sarah T. Hierath, Adrienne L. Traxler, Wright State University*

Undergraduate universities are transitioning to a more hands-on cooperative learning environment where peer interaction plays a large role in students' learning. Does this model work equally for all students? Do non-traditional students show the same increase in gaining conceptual knowledge as traditional students despite their social differences (such as age, full-time employment, family life, etc.)? The Force Concept Inventory (FCI) was utilized as a pre- and post-course diagnostic exam to determine conceptual gains and an online social network survey gathered data about student connections. The network was plotted and several centrality measures were calculated. The FCI score gains were correlated to each of the centrality values. Non-traditional and traditional student data subsets were compared to determine if any significant differences between the two groups' results were present.

### PST2B41: 5-5:45 p.m. Open-ended Design and Peer Review in NEXUS/Physics IPLS

*Poster – Kimberly A. Moore, University of Maryland, 6525 Roosevelt St., Falls Church, VA 22043; MoorePhysics@gmail.com*

UMD-PERG's NEXUS/Physics for Life Sciences laboratory curriculum, piloted in 2012-2013 in small test classes, has been implemented in large-enrollment environments at UMD 2013-present, and adopted at several institutions beginning in 2014. These labs address physical issues at biological scales using microscopy, image and video analysis, electrophoresis, and spectroscopy in an open, non-protocol-driven environment. In the 2015-2016 iteration, we have added peer review elements to the second semester course. We have collected a wealth of data (surveys, video analysis, etc.) that enables us to get a sense of the students' responses to this curriculum at UMD. In this poster, we will provide a broad overview of what we have learned and a discussion of the challenges in integrating simultaneous interdisciplinary and pedagogical reforms. Special emphasis will be placed on successes and challenges accompanying this scaling-up, both at UMD and beyond.

### PST2B42: 5:45-6:30 p.m. Pathways to a Physics Degree: A Statistical Story

*Poster – John M. Aiken, Helmholtz Centre Potsdam GFZ, German Research Centre for Geosciences, Helmholtzstrasse Potsdam, Br 14473 Germany; johnm.aiken@gmail.com*

*Marcos D. Caballero, Michigan State University*

Michigan State University (MSU) has collected a wide body of data on students for over 10 years allowing for a robust, statistical picture to be painted of how students enter and exit the physics world. This data includes course grade, gender, ethnicity, student major choices, etc. and can help us paint a pathway of every student who has received a physics bachelor's degree at MSU. While this data set contains over 100,000 students who have taken math and physics courses at MSU only 2% of these students have declared a physics major and only 0.5% of students have gone on to graduate with a bachelors in physics. Students who declare physics and then move away from the major perform poorly in introductory courses and are demographically different from the typical physics graduate.

### PST2B44: 5:45-6:30 p.m. Physics Teachers' Questioning Patterns and the Reasoning Behind Them

*Poster – Brianna Santangelo, The College of New Jersey, 16 Maryland Ave., West Long Branch, NJ 07764; santanb1@apps.tcnj.edu*

*AJ Richards, The College of New Jersey*

One of teachers' greatest tools in the classroom is questioning. It has long been theorized that higher level questioning leads to students developing a better understanding of the material but no one has examined the types of questions asked in physics classrooms in great detail. We used Bloom's revised taxonomy to classify the questions asked by high school physics instructors and surveyed them on what they believe their questioning patterns to be. By analyzing the distribution of question types and the teachers' self-perceived questioning patterns we take a first step to better understanding the use of questioning in physics classrooms.

### PST2B45: 5-5:45 p.m. Preparing Undergraduates for Solving Problems in PhD-level Research

*Poster – Jarrett M. Vosburg, State University of New York at Geneseo, 9027 County Road 3, Freedom, NY 14065; jmv8@geneseo.edu*

*Anne E Leak, Javier Olivera, Kelly N, Martin, Ben M. Zwickl. Rochester Institute of Technology*

While "problem solving" is a task that is heavily emphasized in the undergraduate physics curriculum and often cited as a skill needed in 21st century STEM careers, it is unclear how the problem solving experiences of undergraduates compare to those encountered in scientific research and careers. One way to better understand problem solving in authentic scientific research settings and how it relates to undergraduate preparation, is to explore the perspectives of graduate students. We conducted semi-structured interviews with 10 graduate students to determine what problems they encountered in their research, what strategies they used to solve these, and how problem solving in their graduate research compared to their undergraduate experiences. We coded these interviews using emergent and grounded theory approaches. Our findings include a taxonomy and context for problems and problem solving strategies, along with implications for problem solving opportunities in the undergraduate curriculum.

### PST2B46: 5:45-6:30 p.m. Prevalence of College Student Conceptions about Buoyancy

*Poster – DJ Wagner, Grove City College ,100 Campus Drive, Grove City, PA 16127; djwagner@gcc.edu*

*Shannon Armstrong, Randon Hoselton, Grove City College*

We have developed a taxonomy of alternate conceptions concerning buoyancy, and we are investigating the prevalence of many of those conceptions in the college student population at Grove City College (GCC) and other collaborating institutions. This poster will present preliminary data describing the most, and least, prevalent conceptions in our sample.

### PST2B47: 5-5:45 p.m. Promoting Student Engagement in Scientific Practice in an Introductory Laboratory

*Poster – Abhilash Nair,* Michigan State University, 500 W Lake Lansing Rd. Apt B6, East Lansing, MI 48823; nairabhi@msu.edu*

*Marcos D. Caballero, Michigan State University*

In light of recent calls for aligning introductory physics activities with scientific practice (AAPT 2014) as well as a push for the development of a set of recommended practices for life science majors (AAMC-HHMI, 2009), we report on a transformation of a second semester introductory lab course for non-physics majors (life science majors making up the vast majority). The transformed lab was designed with specific course structures to support students in working collaboratively in a group, developing a systematic approach to experimental design, understanding how to utilize different measurement devices, and understanding the uncertainties involved in measurements.
We present analysis of small group work that took place in the pilot semester of this transformation highlighting instances where students engaged in these scientific practices in the presence of these supports. We discuss potential improvements to the course structures to better support students in achieving the learning objectives outlined above.

*Sponsored by Marcos Daniel Caballero

### PST2B48: 5:45-6:30 p.m. Quantitative Exploration of the GaussGun and its Chemistry Connection

*Poster – Bradley S. Moser, University of New England, 11 Hills Beach Rd., Biddeford, ME 04005-9988; bmoser@une.edu*

*Reed Macey, University of New England*

Energy spans all scientific disciplines, yet physics courses rarely venture beyond traditional mechanical energy examples. Introductory Physics for the Life Sciences (IPLS) courses have recently attempted to make connections with topics in undergraduate biology and chemistry courses. As an example, the gauss gun receives attention as a system for exploring exothermic chemical reactions. Most inquiries of this system have been qualitative, emphasizing analogies. Due to this incomplete depiction of the gauss gun, introductory physics students at the University of New England found the system perplexing. To enhance comprehension, our study uncovers quantitative aspects including kinetic energy via photogates, magnetic energy from force measurements, and conservation of energy analysis. This analysis generated a new graphical and diagrammatic matrix model, as well as illustrations applied to specific chemical reactions and the photoelectric effect. These new models might increase the value of this demonstration.

### PST2B49: 5-5:45 p.m. Self-Efficacy in Introductory STEM Majors

*Poster – Cabot Zabriskie, West Virginia University, 135 Willey St., Morgantown, WV 26506-0002; cazabriskie@mix.wvu.edu*

*Rachel Henderson, Lynnette Michaluk, Seth Devore, John Stewart, West Virginia University*

With the growing emphasis on the importance of STEM fields, understanding the factors that are involved in students completing STEM degrees has become a vibrant topic of study. One such factor believed to be linked to collegiate academic success is students' feeling of self-efficacy. This study adapted the "Self-Efficacy for Learning and Performance" subscale of the Motivated Learning Strategies Questionnaire (MLSQ) developed by Pintrich et al. to various college and professional environments: the student's planned profession, classes in their major, mathematics classes, science classes, and physics classes. Changes in self-efficacy were investigated as students matriculated through the first and second semester introductory, calculus-based physics classes from fall 2015 through spring 2016. We present here our preliminary findings on the effects of this factor as part of a larger study on factors effecting STEM retention.

### PST2B50: 5:45-6:30 p.m. Sense-making with Inscriptions in Quantum Mechanics*

*Poster – Erin Ronayne Sohr, University of Maryland College Park, Rm 1322, Physics Building, College Park, MD 20742; erinsohr@gmail.com*

*Benjamin W. Dreyfus, Ayush Gupta, Andrew Elby, University of Maryland*

In this presentation, we focus on students' sense-making with a graphical representation commonly used in quantum mechanics textbooks; that of overlaid potential energy and wavefunction plots in the context of quantum well(s) and barriers. Previous research has pointed to a conflation of the energy and wavefunction axes as leading to common student difficulties in understanding phenomena such as tunneling. The existence of this difficulty has influenced QMCS survey items and design choices in several PhET simulations. We add to this research by investigating how students use and interact with this graphical representation while sense-making. Through fine-timescale analysis of video data from clinical interviews with engineering majors in a modern physics course, we document that the inscription can play both communicative and generative roles in the student's reasoning. We report the different ways in which the inscription gets embedded in students' reasoning and potential instructional implications.

*This work is supported by NSF-DUE1323129.

### PST2B51: 5-5:45 p.m. Sensemaking with Layers of Epistemic Games

*Poster – Michael Vignal, Oregon State University, Corvallis, OR 97331-8507; vignalm@oregonstate.edu*

*Elizabeth Gire, Oregon State University*

The epistemic games framework has been used productively to understand problem-solving behavior in physics. The epistemic games that have been identified in physics span a wide range of grain sizes. We exploit the concept of grain-size to consider concurrent epistemic games played by advanced undergraduate physics majors attempting to complete a single task. We identify differing layers of epistemic games in interviews with three groups of students, and we explore relationships and interactions between these layers in order to understand how the groups are (or are not) engaged in physics sensemaking.

### PST2B52: 5:45-6:30 p.m. Shut Up and Calculate: Becoming a Quantum Physicist

*Poster – Anders Johansson,* Department of Physics and Astronomy, Uppsala University & Centre for Gender Research, Uppsala University Box 516, Uppsala, 751 20 Sweden; anders.johansson@physics.uu.se*

*Staffan Andersson, Department of Physics and Astronomy, Uppsala University*

*Minna Salminen-Karlsso,n Centre for Gender Research, Uppsala University*

*Maja Elmgren, Department of Chemistry – Ångström, Uppsala University*

Educating new generations of physicists is often seen as a matter of attracting good students, teaching them physics and making sure that they graduate. Sometimes, questions are also raised about what could be done to increase diversity in recruitment. Our qualitative study of introductory quantum physics courses in Sweden, instead asks what it means to become a physicist, and whether certain ways of becoming a physicist and doing physics is privileged in this process. The results show that, although students have high and diverse expectations of the courses, a pronounced focus on techniques of calculation seem to place students in a position where the only right way of doing quantum physics is "shutting up and calculating." This raises questions of how best to accommodate varying student motivations and make different ways of being a physicist possible.

*Sponsored by Bor Gregorcic

### PST2B53: 5-5:45 p.m. Social Positioning and Consensus Building in "Board" Meetings With Disagreements

*Poster – Brant Hinrichs, Drury University, 729 N. Drury Lane, Springfield, MO 65802; bhinrichs@drury.edu*

*David T. Brookes, California State University, Chico*

This poster describes a whole-class whiteboard meeting and analyzes several examples from a college calculus-based introductory physics course taught using modeling instruction. One section was divided into six groups of 4-5 students each. Each group created a solution to the same problem on a 2'x 3' whiteboard. The groups then formed a large circle in the center of the classroom with their whiteboards resting against their knees facing in to the rest of the group. The instructor was outside the circle and interjected rarely. Examples are given of conversations where students did and did not overcome sharp disagreements to eventually reach whole-class consensus. We examine how social positioning contributed to students either successfully examining and resolving different ideas or failing to do so. That is, how students who "hedged" their statements seemed to "open up" the space for discussion, while those who were more direct seemed to "close it down."

### PST2B54: 5:45-6:30 p.m. Splits in Students' Attitudes Toward Classical and Quantum Physics*

*Poster – Benjamin William Dreyfus, University of Maryland College Park, Department of Physics, College Park, MD 20742-2421; dreyfus@umd.edu*

*Jessica Hoy, University of Colorado Boulder*

*Erin Ronayne Sohr, Ayush Gupta, Andrew Elby, University of Maryland*

Instruments that measure students' attitudes and epistemological beliefs about physics often assume implicitly that "physics" is monolithic. That is, while there are multiple dimensions to student attitudes, physics itself is treated as a single discipline. We administered a survey in modern physics courses for engineering students, with modified CLASS (Colorado Learning Attitudes about Science Survey) survey items in which "physics" was changed to "classical physics" and "quantum physics," and found significant splits between students' self-reported attitudes toward classical and quantum physics, both pre- and post-instruction. Specifically, students display greater evidence of real-world connections and problem-solving sophistication with classical than with quantum physics. We also found that, under some conditions, quantum physics instruction was associated with a pre/post shift in attitudes toward classical physics.

*This work is supported by NSF-DUE 1323129 and 1322734.

## Lecture/Classroom

### PST2C01: 5-5:45 p.m. Geometric Constructions as Mnemonics in Classical Physics

*Poster – Satinder S. Sidhu, Washington College (Emeritus), 103 Sutton Way, Chestertown, MD 21620; ssidhu2@washcoll.edu*

Although some of the most original minds in physics are reputed to have been geometrical thinkers, the results obtained by them are today most compactly and elegantly expressed in the language of algebra

and analysis. Yet, these same results can often be encapsulated in easily remembered geometric constructions. Students find these re-expressions particularly helpful, not only in memorizing but also in understanding quantitative interrelationships. Examples from familiar results in oscillations, waves, electromagnetic fields, and special relativity will be used to illustrate the methods.

### PST2C02: 5:45-6:30 p.m. Power Boxes: A New Tool for Understanding Circuits

*Poster – Daryl McPadden, Florida International University, 11200 SW 8th St., Miami, FL 33199; dmcpadden621@gmail.com*

*Jason Dowd, Duke University*

*Eric Brewe, Florida International University*

In order to clarify and provide a conceptual understanding of energy use in circuits, we introduce a new representation for analyzing DC circuits – Power Boxes. Although DC circuits are not generally considered to be the most insidious topics in introductory physics courses, understanding the role of energy in such circuits can be deceptively challenging. Oftentimes, students see circuits as an infinite source of energy and many mechanical energy analogies only further this idea. Instead, Power Boxes allow us to discuss and illustrate the role of electric potential energy in circuits at a given time, while simultaneously building upon (rather than competing with or writing over) representations of energy established in mechanics. Power Boxes can provide an intermediate, conceptual step between drawing a circuit diagram and writing equations.

### PST2C03: 5-5:45 p.m. STEM Connections: A Cohort Model for First Year Students*

*Poster – Joseph F. Kozminski, Lewis University, One University Pkwy., Romeoville, IL 60446; kozminjo@lewisu.edu*

*Jason J. Keleher, Lewis University*

The Lewis University STEM Connections Program is a cohort program for first-year students planning to major in a program offered by the departments of Physics and Chemistry. First year students take a common curriculum of Chemistry, Physics, and Calculus designed to bring out the interconnectedness of these disciplines. The laboratories are inquiry-based with an emphasis on developing students' experimental skills. Students also have the opportunity to explore real-world research problems in their first year. An overview of the program's goals and of the first year STEM Connections experience will be discussed.

*Supported in part by NSF S-STEM award 1458353.

### PST2C04: 5:45-6:30 p.m. Stochastic Simulations and Finite Difference Models for the Life Sciences

*Poster – Peter Hugo Nelson, Benedictine University, 6601 Fernwood Drive, Lisle, IL 60532; pete@circle4.com*

Life-science students are introduced to modeling and simulation using a simple kinetic Monte Carlo (kMC) simulation of diffusion. The model is first introduced as a physical "marble game" and then implemented as a kMC simulation. Students work through a self-study guide introduction to Excel and write their own simulation from scratch in a blank spreadsheet. In a guided-inquiry exercise students discover that Fick's law of diffusion is a consequence of Brownian motion. Subsequent activities introduce students to: algorithms and computational thinking; exponential decay in drug elimination and radioactive decay; half-life and semi-log plots; finite difference methods (and calculus); the principles of scientific modeling; model validation and residual analysis; and osmosis. Analysis of published clinical data and Nobel Prize winning osmosis research is featured in an active learning environment. Because the materials are self-contained, they can be used in a flipped-classroom approach. Sample chapters are available for free at http://circle4.com/biophysics/chapters/

### PST2C05: 5-5:45 p.m. Study Habits, Observed Habits, and Performance in a Physics MOOC

*Poster – David E. Pritchard, MIT, 26-241 MIT, Cambridge, MA 02139-4307; dpritch@mit.edu*

*Sait Golkap, Han Wan, ZhongZhou Chen, MIT*

Standard surveys of student's study habits generally correlate with overall GPA at the 0.20 – 0.45 level. 246 questions from several such surveys were condensed to 17 online questions in four categories: motivation, concentration, time management, and study methods. 122 students (18 female, 113 male, mean age 33) who received certificates answered these 17 questions in our Advanced Introductory Classical Mechanics MOOC. The four categories typically correlated significantly with each other, and with other course/student related variables (most from the exit survey) typically at around 0.2 – 0.3. Moreover time management correlated with several measures of effort in the course. Most noteworthy is that we see no statistically significant correlation between MOOC performance and any of the four categories, although performance correlated with some individual questions. However, students who finished 60% of their first homework a day prior to the deadline did 41% percent better in the course than those who didn't.

### PST2C06: 5:45-6:30 p.m. TAPIR (Teaching Activities for Physics Inclusion Resources): Enhancing Diversity in Introductory Physics

*Poster – Nathan Agarwal, Physics Department, Colorado College, 14 E. Cache la Poudre, Colorado Springs, CO 80903-3294; bwhitten@ColoradoCollege.edu*

*Emiliano Morales, Brooks Thomas, Barbara Whitten, Physics Department, Colorado College*

Even among STEM disciplines, physics stands out as unusually white- and male-dominated. AIP reports that only 14% of physics faculty are women, and 6% are underrepresented minorities. Rachel Ivie of AIP has studied the pipeline for women in physics, and has identified the transition from high school to college as the most important "leak point" for women. We are approaching this problem by addressing inclusiveness in the calculus-based introductory physics course, the gateway to the undergraduate physics major. While most physics books have a plethora of problems at the end of each chapter, they are focused on contexts like sports and the military, which are not of particular interest to women or students of color, and send the message that physics is not for them. Many young faculty who are interested in diversity would like to present a broader variety of contexts. But, pressed for time, they too often fall back on already prepared topics. We are preparing a database of materials that illustrate the important concepts of introductory physics, but in different contexts that we intend will interest a broader range of students. These might include problems, in-class activities, test problems, paper and discussion topics. We intend these materials for use in the calculus-based physics class, but they will be adaptable to algebra-based and high school classes as well. By making these available to faculty at Colorado College and elsewhere, we hope to encourage women and students of color to major in physics, and eventually increase the diversity of the physics community.

### PST2C07: 5-5:45 pm. The Impact of Language on Learning Physics

*Poster – Matt Olmstead, King's College, 133 North River St., Wilkes Barre, PA 18711; matthewolmstead@kings.edu*

One difficulty in learning physics is that many physics terms have precise meaning but are used casually in conversation like acceleration, velocity, and speed. Other subjects, including chemistry and biology, have new language that students actively spend time learning on their own, sometimes using notecards or other techniques. The important point is that they make it a point to learn the terminology so that they understand the material. I get the impression that they feel they know the physics vocabulary well enough and do not make the effort learning the terminology they do in other classes. One of the things I would like to determine is if there is a noticeable difference in other languages that do not casually interchange some of the physics terminology. I would also like to look at the amount of time students spend learning the vocabulary in physics compared to other courses.

### PST2C08: 5:45-6:30 p.m. Two Stage Exams: Designing Effective Questions

*Poster – Kristi D. Concannon, King's College, 133 North River St.,Wilkes Barre, PA 18711; kristiconcannon@kings.edu*

The process of peer instruction is crucial in helping students to identify and confront their misconceptions and to critically apply the fundamental principles learned in lecture to different and more complex situations. In most cases, though, peer learning ends at exam time. I have recently begun implementing two-stage exams in my courses under the premise that learning can and should take place throughout the entire semester, not just in compartmentalized chunks; hence, exams can both be an opportunity for students to demonstrate what they have learned and an opportunity for students to continue to increase their understanding of the course material. In this poster, I will outline what I have learned about writing effective collaborative exam questions.

### PST2C09: 5-5:45 p.m. Using Blocks and Money to Understand Temperature

*Poster – Gerardo Giordano, King's College, 133 N River St., Wilkes Barre, PA 18711-0801; gerardogiordano@kings.edu*

I describe the implementation of a class activity and discussion that uses blocks and money to explain temperature in a one-semester, introductory, conceptual physics class. The activity and subsequent conversation attempt to explain temperature as a measure of the average translational kinetic energy per particle, its role in heat flow direction, its lack of dependence on the quantity of a substance, how a thermometer measures it, and why it has a lower limit but no upper limit. I expect that the addition of the group activity to the clicker-question lecture discussion will give students a better feel for temperature's part in thermodynamics. I investigate the effects of the activity on the students' comprehension by means of a survey and related course exam results across several semesters.

### PST2C11: 5-5:45 p.m. What Can It Look Like?: Physics Teaching for Social Justice

*Poster – Moses Rifkin, University Prep, 5705 Phinney Ave. N, Seattle, WA 98115; mrifkin@universityprep.org*

Only 4% of professional physicists identify as black or African American, a number far smaller than the 12% of the Americans that do, and this underrepresentation is more dramatic in physics than it is in most scientific disciplines. I have developed a curriculum that uses these and other statistics as a jumping-off point for my high school students to explore issues of race, access, and culture in physics. I will share my experiences from a decade of using the curriculum, including how my students respond, how I address the challenges that have arisen, and how this curriculum has evolved. In doing so, I hope both to model the integration of physics teaching and social justice and to motivate attendees to take steps in their own classes.

### PST2C12: 5:45-6:30 p.m. A New IPLS Course at UNC – Fluids, E&M, Optics, Nuclear*

*Poster – Alice D. Churukian, The University of North Carolina at Chapel Hill, Department of Physics and Astronomy, Chapel Hill, NC 27517; adchuruk@physics.unc.edu*

*Duane L. Deardorff, David P. Smith, Colin S. Wallace, Laurie E. McNeil, The University of North Carolina at Chapel Hill*

This is the second of two posters describing the complete transformation of our large-enrollment introductory physics course for life science (IPLS) majors. All sections of the course are now offered in the new format, utilizing the lecture-studio model with content focused on aligning introductory physics concepts with authentic biological applications. In this poster, we will provide an overview of what the second-semester course now looks like and our assessment of its implementation. Specifically we will highlight materials that we have developed in many topics that are important for life science majors, but are not part of the traditional introductory physics curriculum, including life at low Reynolds number, absorption and fluorescence, and DNA diffraction. *This work has been supported in part by the National Science Foundation under Grant No. DUE-1323008 and AAU Undergraduate STEM Education Initiative.

*This work has been supported in part by the National Science Foundation under Grant No. DUE-1323008 and AAU Undergraduate STEM Education Initiative.

### PST2C13: 5-5:45 p.m. A New IPLS Course at UNC – Mechanics, Energy, Thermodynamics

*Poster – Duane L. Deardorff, University of North Carolina at Chapel Hill, Campus Box 3255, Chapel Hill, NC 27599-3255; duane.deardorff@unc.edu*

*Alice D. Churukian, David P. Smith, Colin S. Wallace, Laurie E. McNeil, University of North Carolina at Chapel Hill*

This is the first of two posters describing the complete transformation of our large-enrollment introductory physics course for life science (IPLS) majors. All sections of the course are now offered in the new format, utilizing the lecture-studio model with content focused on aligning introductory physics concepts with authentic biological applications. In this poster, we will provide an overview of what the first-semester course now looks like and our assessment of its implementation. Specifically we will highlight materials that we have developed in many topics that are important for life science majors, but are not part of the traditional introductory physics curriculum, including scaling, stress and strain, diffusion, and chemical energy.

This work has been supported in part by the National Science Foundation under Grant No. DUE-1323008 and AAU Undergraduate STEM Education Initiative.

### PST2C14: 5:45-6:30 p.m. Active Learning and Learning Assistant Support Predictors of Student Success

*Poster – Leanne Doughty, University of Colorado Denver, 1380 Lawrence St., Denver, CO 80204; leanne.doughty@ucdenver.edu*

*Paul Le, Amreen Nasim, Laurel Hartley, Robert M. Talbot, University of Colorado Denver*

We are currently engaged in a project designed to investigate how active learning methods and undergraduate Learning Assistant (LA) support contribute to the learning gains, achievement, retention, and persistence of students enrolled in introductory and upper-division biology, chemistry, and physics courses. As part of this work, we aim to build quantitative models that will help to parse the relative contribution of different activities and other predictors on student outcomes. Independent predictor variables will exist at both the class level (e.g. nature and amount of active learning employed in the class, nature of LA support, and size of class) and student level (e.g. gender, ethnicity, major, and perceived value of active learning). We will present some preliminary models based on initial data collection and the results will be interpreted and backed with qualitative descriptions of the different observed active learning methods.

### PST2C15: 5-5:45 p.m. Comparison between Two Active Methodologies: Hands-on Experiments and Interactive Simulations

*Poster – Diana Berenice Lopez Tavares, CICATA-Legaria Instituto Politécnico Nacional Calzada Legaria No. 694, Miguel Hidalgo, Irrigación. Mexico City, MEX 11500 México; dianab_lopez@hotmail.com*

*Daniel Sánchez Guzman, Ricardo Garcia Salcedo, CICATA-Legaria Instituto Politécnico Nacional*

The use of active learning methodologies in science has demonstrated its effectiveness. But, is there any advantage if we use hands-on experiments or interactive simulations? How much of any physical concept is learned if they do an experiment or if they use an interactive simulation? Present work tries to take us closer to the answers of these questions. We designed two learning sequences combining hands-on experiments and interactive-simulation activities. These sequences were applied in two groups of high school students, one group used hands-on experiments and another group used interactive simulations. The Electric Circuits Concept Evaluation (ECCE) was applied as pre-test and post-test for analyzing the concepts learned using normalized gain and concentration factor tools. Preliminary results shown that the concepts were acquired similarly by students, even we applied a retention test three weeks after instruction and the simulations group obtained a bigger gain than hands-on experiments group.

## Upper Division and Graduate

### PST2D01: 5-5:45 p.m. Development of an Interactive Tutorial on Quantum Key Distribution

*Poster – Seth T. DeVore, West Virginia University, 135 Willey St., Morgantown, WV 26506-0002; stdevore@mail.wvu.edu*

*Chandralekha Singh, University of Pittsburgh*

We describe the development of a Quantum Interactive Learning Tutorial (QuILT) on quantum key distribution, a context that involves a practical application of quantum mechanics. The QuILT helps upper-level undergraduate students learn quantum mechanics using a simple two-state system and was developed based upon the findings of cognitive research and physics education research. One protocol used in the QuILT involves generating a random shared key over a public channel for encrypting and decrypting information using single photons with non-orthogonal polarization states, and another protocol makes use of two entangled spin-½ particles. The QuILT uses a guided approach and focuses on helping students build links between the formalism and conceptual aspects of quantum physics without compromising the technical content. We also discuss findings from a preliminary in-class evaluation. Supported by the NSF

### PST2D02: 5:45-6:30 p.m. Flipping an Upper Division Electricity and Magnetism Course

*Poster – James J. Butler, Pacific University, 2043 College Way, Forest Grove, OR 97116; jjbutler@pacificu.edu*

The upper division Electricity & Magnetism course at Pacific University has been "flipped" so that students watch lecture videos as part of their pre-class work. Additional pre-class work includes traditional textbook reading assignments and "web warm-ups" (a form of Just-in-Time Teaching). Class time is spent on active engagement strategies, such as tutorials and Peer Instruction, and as recitation time for homework help. The course also has a laboratory component in which students do a variety of inquiry-based labs as well as an extensive project. The Colorado Upper-Division Electrostatics (CUE) Diagnostic Quiz has been administered in multiple class sections. Preliminary results show significant gains in a 'flipped' section compared to 'regular' sections.

### PST2D03: 5-5:45 p.m. Improving Student Understanding of Addition of Angular Momentum in QM

*Poster – Jue Wang, East China Normal University, Shanghai, 201204 China; wangjue-jane@foxmail.com*

*Guangtian Zhu, East China Normal University*

*Chandralekha Singh, University of Pittsburgh*

We describe the difficulties advanced undergraduate and graduate students have with concepts related addition of angular momentum in quantum mechanics. We also describe the development and implementation of a research-based learning tool, Quantum Interactive Learning Tutorial (QuILT), to reduce these difficulties. The preliminary evaluation shows that the QuILT related to the basics of the addition of angular momentum is helpful in improving students' understanding of these concepts.

### PST2D04: 5:45-6:30 p.m. Improving Students' Understanding of Quantum Measurement

*Poster – Jue Wang, East China Normal University, Shanghai, 201204, China; wangjue-jane@foxmail.com*

*Guangtian Zhu, East China Normal University*

*Chandralekha Singh, University of Pittsburgh*

We describe the difficulties that advanced undergraduate and graduate students have with quantum measurement within the standard interpretation of quantum mechanics. We explore the possible origins of these difficulties by analyzing student responses to questions from both surveys and interviews. Results from this research are applied to develop research-based learning tutorials to improve students' understanding of quantum measurement.

### PST2D05: 5-5:45 p.m. Investigating Transfer of Knowledge in an Upper-Level Quantum Mechanics Course*

*Poster – Alexandru Maries, University of Cincinnati, 3405 Telford St., Cincinnati, OH 45220; mariesau@ucmail.uc.edu*

*Ryan Sayer, University of Pittsburgh*

*Chandralekha Singh, University of Pittsburgh*

Transfer of learning from one context to another is considered a hallmark of expertise. Physics education research has often found that students have great difficulty transferring knowledge from one context to another. We examine upper-level and graduate students' facility with questions about the interference pattern in the double-slit experiment with single photons and polarizers in various orientations placed in front of one or both slits. Answering these questions correctly in the context of the double-slit experiment requires transfer of knowledge of concepts students had learned in the context of a tutorial on Mach-Zehnder Interferometer (MZI) with single photons and polarizers in various paths of MZI. We discuss the extent to which students who worked through the MZI tutorial were able to transfer their knowledge gained in that context to another context involving the double-slit experiment.

*Work supported by the National Science Foundation

### PST2D07: 5-5:45 p.m. Neural Networks and Matlab Algorithms for Pattern Recognition in Databases*

*Poster – Raul Garcia-Sanchez, Howard University, Department of Physics & Astronomy, 2355 6th St., NW, Washington, DC 20059; raul.garcia.3826@gmail.com*

*Daniel Casimir, Prabhakar Misra, Howard University*

*Gary Ackerman, Markus Binder, University of Maryland*

Our research makes use of physical and mathematical approaches to pattern recognition associated with large databases pertaining to terrorism-related events. The comprehensive databases (e.g. GTD, POICN & PIRUS) developed by START at the University of Maryland contain a wide array of information and variables and our research was aimed at not only finding potential patterns in this data, but also developed a way to address missing variable data entries. Our Matlab script driven efforts focused on three fronts: (1) the improvement of pattern recognition neural network computation times and classifications, (2) the development of an algorithm that uses a nested approach to determine as much missing data for all variables as possible, and (3) the development of an user interface that allows users to make queries and perform pattern recognition operations on selected variables.

*Financial support from the Department of Homeland Security MSI SRT Program and the Howard University Graduate School are gratefully acknowledged.

### PST2D08: 5:45-6:30 p.m. Picturing Quantum Mechanics

*Poster – Daniel V. Schroeder, Weber State University, 2508 University Circle, Ogden, UT 84408-2508; dschroeder@weber.edu*

Dirac saw no need for illustrations in his definitive monograph on quantum mechanics, and Weinberg has continued this tradition in his new graduate-level textbook. For us mortals, though, pictures are essential--and the pictures we give to our students can guide their conceptual understanding. But what are the essential images that encapsulate the concepts of quantum mechanics? In this poster I will collect some of the best candidates, and document which ones are getting the prominence they deserve and which ones aren't.

### PST2D09: 5-5:45 p.m. Self Perception of Undergraduate and Graduate Students as Educators

*Poster – Alexander P. Becker, Boston University, 590 Commonwealth Ave., Boston, MA 02215; apbecker@bu.edu*

*Bennett Goldberg, Manher Jariwala. Boston University*

At Boston University, CIRTL promotes graduate student involvement with the "Teaching Fellow Peer Mentoring" program (TFPM) and the "Teaching as Research" fellowship (TAR). The TFPM is a student-run program within the physics department, supporting incoming students during their first steps in graduate school and in their teaching mission. As a mentee in my first year and a mentor in my second year of graduate school at BU, I offer a perspective on the benefits and challenges of this program. Using these experiences, I have designed a Teaching-as-Research project examining the perception teaching assistants and undergraduate learning assistants have of themselves in their roles as educators. I will present the process of conceiving and developing this project within the framework of TAR seminars as well as first results of this still ongoing research.

### PST2D10: 5:45-6:30 p.m. Tutorials on Thinking about Quantum Entities*

*Poster – Erin Ronayne Sohr, University of Maryland College Park, Rm. 1322, Physics Building, College Park, MD 20784; erinsohr@gmail.com*

*Jessica Hoy, Kathleen Hinko, Noah D. Finkelstein, University of Colorado Boulder*

*Benjamin W. Dreyfus, University of Maryland College Park*

We have developed a set of tutorials at the University of Maryland and the University of Colorado, to support students in transforming their ontological conceptions about quantum phenomena: their sense of whether something is a particle, a wave, or some other kind of thing. In addition, the tutorials are intended to support students' metacognitive awareness of their own ontological conceptions: thinking about their own thinking, and deciding which ontologies to use when. In most cases these tutorials are not designed to introduce new content, but can be used alongside other course materials and can help students be more reflective about the physics content. Some of the tutorials are based on fundamental quantum concepts such as tunneling, while others are based on engineering applications such as LEDs.

*This work is supported by NSF-DUE1323129

### PST2D11: 5-5:45 p.m. Visualizing the Electromagnetic Field with Differential Forms

*Poster – Roberto B. Salgado, University of Wisconsin - La Crosse, 1725 State St., La Crosse, WI 54601; rsalgado@uwlax.edu*

*Tobias A. Nelson, University of Wisconsin - La Crosse*

Although vector calculus has been the traditional mathematical tool for electromagnetism, some authors (Deschamps [1981], Burke [1985], Bamberg and Sternberg [1988], Warnick [1995], Hehl [2003]) have advocated the use of differential forms. We review how the electromagnetic field and the Maxwell Equations are formulated and visualized with differential forms in three-dimensional space. We then present our attempt to show how this arises from differential forms in (3+1)-dimensional spacetime.

### PST2D12: 5:45-6:30 p.m. Can Classical Mechanics Tutorials Help Approach Other Upper-Level Courses?

*Poster – Andrew J. Mason, University of Central Arkansas, 201 S. Donaghey Ave., Conway, AR 72035-0001; ajmason@uca.edu*

Several excellent research-based tutorials exist for upper-level undergraduate physics topics, e.g. quantum mechanics and thermodynamics. It may therefore be particularly useful to consider the design of tutorials for classical mechanics, a course that discusses topics that may be bridged into conceptual and mathematical methods topics (e.g. Hamiltonian transformations, Fourier series, tensor mechanics) which are referenced in other upper-level physics courses. Initial tutorials of mechanics courses, modeled after lessons within Taylor's "Classical Mechanics" text[1], are currently under development for the purposes of improving conceptual understanding and mathematical methods techniques featured within the text. Future considerations from background literature in research-based tutorials and other mechanics tutorials, are being consulted to improve instruction and better inform pedagogical goals.

[1] Source: J. R. Taylor, "Classical mechanics," University Science Books (2005).

### PST2D13: 5-5:45 p.m. Comparing Chinese and American Students' Understanding of Quantum Mechanics

*Poster – Jue Wang, East China Normal University, Shanghai, 200241 China; wangjue-jane@foxmail.com*

*Guangtian Zhu, East China Normal University*

This poster discusses a comparative study on American and Chinese students' conceptual understanding of quantum mechanics. We administered the Quantum Mechanics Survey (QMS) to 200 students in China and the United States. The results show that the students in the top-ranking U.S. universities outweigh their peers in the top-ranking Chinese universities. However, those in medium-ranking universities in both China and the U.S. have similar performance in QMS.

### PST2D14: 5:45-6:30 p.m. Core Graduate Courses: A Missed Learning Opportunity?*

*Poster – Alexandru Maries, University of Cincinnati, 3405 Telford St., Cincinnati, OH 45220; mariesau@ucmail.uc.edu*

*Chandralekha Singh, University of Pittsburgh*

An important goal of graduate physics core courses is to help students develop expertise in problem solving and improve their reasoning and meta-cognitive skills. We explore the conceptual difficulties of physics graduate students by administering conceptual problems on topics covered in undergraduate physics courses before and after instruction in related first-year core graduate courses. Here, we focus on physics graduate students' difficulties manifested by their performance on two qualitative problems involving diagrammatic representation of vector fields. Some graduate students had great difficulty in recognizing whether the diagrams of the vector fields had divergence and/or curl but they had no difficulty computing the divergence and curl of the vector fields mathematically. We also conducted individual discussions with various faculty members who regularly teach first year graduate physics core courses about the goals of these courses and the performance of graduate students on the conceptual problems after related instruction in core courses. *Work supported by the National Science Foundation.

*Work supported by the National Science Foundation

## Technologies

### PST2E01: 5-5:45 p.m. Five Smartphone Physics Lessons for Teaching NGSS' DCI Forces and Motion

*Poster – Rebecca E. Vieyra, Vieyra Software, 225 C St. SE, Washington, DC 20003; rebecca.elizabeth.vieyra@gmail.com*

*Chrystian Vieyra, Vieyra Software*

*Philippe Jeanjacquot, Ecole Normal Superieur, French Institute of Education, France*

*Arturo Marti, Universidad de la Republica, Uruguay*

*Martin Monteiro, Universidad ORT Uruguay, Uruguay*

This poster presents five challenges that you can use with your students in the classroom or at home to engage them in understanding force and motion as one component of the Next Generation Science Standards. Learn how to use your smartphone to (1) measure acceleration due to gravity, (2) estimate force on your body in an elevator, (3) directly measure acceleration on an Atwood's machine, (4) measure centripetal acceleration and tangential velocity while dancing, and (5) locate the accelerometer inside of your smartphone using a record player. Additional resources for smartphone labs will be provided.

### PST2E02: 5:45-6:30 p.m. ggrade: Using Google Forms and Python to Administer/Grade Quizzes

*Poster – Sara E. Mahar,* Siena College, 515 Loudon Road, Loudonville, NY 12211; se30maha@siena.edu*

*Matthew Bellis, Siena College*

Providing prompt feedback to students on exams and quizzes is important not just so students can quickly evaluate their strengths and weaknesses, but also feel that the instructor is actively engaged in the assessment process. Delays between assignments/quizzes and receiving a grade can lead to frustration and a tendency to "check out" on the part of the students. However, this can take time, which is often in short supply. One way to tackle this problem is to move these assessments to an online environment, but the cost of some current solutions, combined with clunky interfaces, can make this frustrating for the instructor. As an alternative, we have created "ggrade," a set of Python libraries and scripts that grade online assignments administered via Google Forms, and supplemented by features in Google Apps for Education. We discuss the implementation and our experience with its use in the classroom.

*Sponsored by Matthew Bellis https://github.com/mattbellis/ggrade

### PST2E03: 5-5:45 p.m. Introducing Coarse-Graining Part 1: From Molecular Dynamics to Random Walks

*Poster – Edit Menuha Yerushalmi, Weizmann Institute of Science, 10 Haim Haviv St., Jerusalem, 96788 Israel; edit.yerushalmi@weizmann.ac.il*

*Haim Edri, Bat-Sheva Eylon, Samuel Safran, Nava Schulmann, Weizmann Institute of Science*

Applying physics to understand structure formation in chemical and biological systems often requires coarse-graining which averages over the short time and length scales of the system. This allows one to focus on a more limited number of degrees of freedom. We present an instructional sequence intended to introduce this concept to introductory level students. The sequence involves comparison between several computational models for diffusion differing in their length and time scales. At the shortest scales one can treat all the interacting particles in the many-body system using deterministic mechanical laws (Molecular Dynamics). While this provides complete information, coarse-grained models are needed to reduce complexity and to obtain physical intuition: In the Langevin model, where the mechanical laws are applied only to the colloidal particles while the solvent is accounted for by friction and stochastic forces. At even larger scales, random walk on a lattice model, involving only the colloidal particles.

### PST2E04: 5:45-6:30 p.m. iPads in Intro Labs

*Poster – David Abbott, Buffalo State College, 1300 Elmwood Ave., Kenmore, NY 14217; abbottds@buffalostate.edu*

*Dan MacIsaac, Andrew Roberts, Buffalo State College*

Over the last year, Buffalo State College has included video analysis labs using iPads in introductory physics courses. Students took and analyzed data using Vernier's Video Physics and Graphical Analysis for iPad. Lab topics include 1-d kinematics, force and rotational dynamics. We report student learning, instructor feedback, challenges (some with solutions) and lessons learned. This work is supported by SUNY IITG and Buffalo State College.

### PST2E05: 5-5:45 p.m. Making iPad Videos to Learn Physics

*Poster – Andrew J. Roberts, SUNY Buffalo State College, 471 Colvin Ave., Buffalo, NY 14216; ajroberts17@gmail.com*

*Dan MacIsaac, David Abbott, Florian Genz, University of Cologne*

We describe the development of the iPad video physics project at SUNY Buffalo State College over the past year. Beginning in summer 2015, graduate students and in-service teachers were tasked with explaining concepts and/or experiments through the creation of short videos, labeled physics content multimedia presentations. These bear many similarities to videos on the YouTube channels minutephysics and Veritasium, but are not meant to achieve the same production quality. Conceptual learning is the intention of the assignment, not a professional video. Instead, videos are produced on the iPads using filming, editing, and voiceover features of apps like iMovie and iMotion. We will present and discuss suggestions, rubrics, guidance, and lessons learned for teachers wishing to assign and evaluate expository physics videos produced by students for credit. This work was supported by the NSF, SUNY IITG and the University of Cologne as well as SUNY Buffalo State Physics.

### PST2E06: 5:45-6:30 p.m. Moving Phones Tick Slower

*Poster – Bret Underwood, Pacific Lutheran University, Department of Physics, Tacoma, WA 98447; bret.underwood@plu.edu*

*Yunxiao Zhai, Pacific Lutheran University*

Smartphones and tablets are packed with sensors, essentially making them mobile physics labs. Simple app creation environments, such as MIT's App Inventor, can put the ability to create and configure physics apps within the reach of students. We discuss the use of App Inventor to create an Android app, "Time Dilation Calculator," which uses a mobile device's Global Positioning System receiver to calculate the time dilation effect of special relativity. As an illustration, we used the app to demonstrate the so-called "twin-paradox" experiment: one mobile device was left stationary, while another traveled some distance in a car and returned. When the phones were reunited, the travelling phone accumulated 0.2 picoseconds less time. This simple app provides a tangible introduction to time dilation as well as an illustration of the power of smartphones for physics.

### PST2E07: 5-5:45 p.m. Practical Application of a Web-based Personal Response System

*Poster – Joseph C. Fritchman,* The Ohio State University, 191 W. Woodruff Ave., Columbus, OH 43210-1168; joseph.fritch@gmail.com*

*Zhao Fu, Jing Han, Lei Bao, The Ohio State University*

Students increasingly attend classes with Internet-connected devices (cell phones, tablets, laptops) which allow teachers to readily implement easy to use, web-based personal response systems. This study examines the use of web-based clickers in college physics lectures and comments on the practical application of such systems. An ideal web-based system will be much more cost-effective than requiring students or departments to purchase physical clickers, while requiring minimal setup time for both teachers and students, and achieving similar improvement on students' conceptual learning when compared to traditional clickers. These systems also open the possibility of more question and answer formats with quicker personal and class-wide feedback than previously feasible. Results help to suggest how to implement web-based systems in the classroom.

*Sponsored by Lei Bao

### PST2E08: 5:45-6:30 p.m. The Evolution of VPython

*Poster – Bruce A. Sherwood, North Carolina State University, 515 E. Coronado Road, Santa Fe, NM 87505; bruce_sherwood@ncsu.edu*

*Ruth W. Chabay, North Carolina State University*

VPython, a very accessible 3D programming environment, has been used for the past 16 years by physics students in introductory and advanced courses, by physics instructors, and by physics researchers to construct dynamic 3D computational models of physical systems. Recent developments in the computer world, including the dominant role of browsers and the increasing capabilities of GPUs (Graphics Processing Units), have stimulated further development of VPython. Two new versions of VPython will soon replace the older "Classic" VPython. GlowScript VPython requires no installation, and many introductory physics students now use it to write and run VPython programs in a browser. Jupyter VPython runs in the increasingly popular professional IPython environment and displays 3D animations in a browser-based Jupyter notebook. The full Python ecology is available to Jupyter VPython, which is easily added to either the Anaconda or Canopy Python distributions.

### PST2E09: 5-5:45 p.m. A New App for Physics Simulations

*Poster – Sonia Tye, CK-12 Foundation, 3610 Jetty Point, Carlsbad, CA 92010; sonia.tye@ck12.org*

*Byron Philhour, San Francisco University High School*

*Neeru Khosla, CK-12 Foundation*

In collaboration with physics teachers, animators, and software developers, the nonprofit CK-12 Foundation has generated dozens of new free-to-use tablet and laptop-ready HTML5-based interactive physics simulations. Recently, we have released an app for mobile tablets that allows easy access to the simulations. Our goal for each simulation is to build a bridge between compelling real-world situations and the more abstract and mathematical physics descriptions. These sims are appropriate for middle school, high school, and introductory college level physics. Topical coverage is broad, from motion and mechanics to electricity and magnetism, sound and light, and modern physics. Our physics sims are based in engaging, real-world examples, big questions, a playful interactive sandbox, data graphs, and novel modes of instructional feedback. This poster presentation is one part of our efforts to engage in a discussion with the physics education community about how best this work can be used to facilitate both classroom-based and independent instruction, foster interest in science, challenge misconceptions, and support best practices in online learning.

### PST2E10: 5:45-6:30 p.m. Assessing Student Work Beyond the Final Answer, Electronically

*Poster – Thomas Foster, Foster Learning LLC, 900 Timberlake Drive, Edwardsville, IL 62025; tfoster@siue.edu*

*Eddie Ackad, Foster Learning LLC*

PathPlan (tm) is an electronic Android(c) based .app designed to let students solve problems in a quasi guided environment. Feedback can be provided to the teacher about the solution path the students took to solve he problem. This is much more detail than providing only the answer. Please stop by the poster and we can show you the .app and maybe you can help us beta test it.

### PST2E11: 5-5:45 p.m. Between Nature of the Things, Representations and Mathematical Object: The Case of the Scalar and Vector Fields

*Poster – Eduardo Chávez, Lima ESCOM-IPN, Miguel Othon de Mendizabal s/n Mexico, MEX 07738 México; echavezl@ipn.mx*

*Miguel Olvera Aldana, ESCOM-IPN*

*Mario Humberto Ramírez Díaz, CICATA-IPN*

When we consider physics like a general science, and thus isolate the individual sciences, we sometimes forget it interpreting the phenomena by their representations available to the human being. If it's possible, we sometimes give as an explanation of the nature of the "thing," is to develop a mathematical model that gives formalizing but: How is geometric interpretation? How is it described in the regular language? How was the modeling of phenomena made? A fundamental element is how it is learned and linked thee three elements in a regular class, even more if we use the technology like a mediator tool. In this proposal, we made proofs using an App in a mobile device to integrate the three elements to teach and learn scalar and vector fields.

### PST2E12: 5:45-6:30 p.m. Learning of Biot-Savart Law Using the Project-based Learning Methodology and Development of Experimental Prototypes in Mexico

*Poster – Lilia Teresa Carrera de Anda, Instituto Tecnológico de Parral, Avenida Tecnológico 57 Parral, MEX 33850 México; lili.carrerada@gmail.com*

*Mario Humberto Ramírez Díaz, CICATA-IPN*

In this work we present the results of educational research to measure the effectiveness of learning the Biot-Savart law using the Project-based Learning methodology and development of experimental prototypes. The objective of the research is measurement of the learning effectiveness in Electromechanical and Mechatronics Engineering students from Instituto Tecnologico de Parral. The investigation was carried out with Mechatronics Engineering students who served as an experimental group and Electromechanical Engineering students as a control group, both groups of trainees subject of Electromagnetism. 27 items of an instrument that was used in investigations by Guisasola and Almudi were used. In assessing the results, the Hake factor was introduced to determine the gain in both the experimental group and the control. The analysis results show that the Project-based Learning and development of experimental prototypes is a good method of teaching the Biot-Savart law on the subject of Electromagnetism and the "physical make" favors understanding and building concepts.

### PST2E13: 5-5:45 p.m. Use of Facebook to Teach Photovoltaic

*Poster – Mario Humberto, Ramirez Diaz, CICATA IPN Av. Legaria, 694 Mexico, MEX 11500 México; mramirezd@ipn.mx*

*Mario Rodriguez Castillo, CICATA-IPN*

Facebook is the most popular social network among college students. Its significance has transcended beyond its purpose to the point where it is presumed to be able to support a learning environment for teaching physics. The purpose of this research was to investigate if Facebook offers a useful and meaningful educational environment able to support, enhance, or strengthen the learning of physics in college students. The research will conduct an experiment to identify the concept of students about the use of Facebook as a virtual environment that facilitates learning of physics, identify instrumentative elements developed by students during the use of Facebook as a learning environment in the subject of photovoltaic theory, and identify the significant difference in learning of a group of 40 students in their first year of college. All this under the theoretical framework of Instrumental Genesis.

# Wednesday, July 20 Highlights

**Yoga on Sacramento Capitol Lawn**
6:45–7:45 a.m.

**Committee on SI Units and Metric Education**
7–8 a.m
Sheraton - Compagno

**High School Teacher Lounge**
1–4 p.m
Sheraton - Falor

**PLENARY – David Reitze, LIGO Laboratory**
10:30–11:30 a.m.
Sheraton - Magnolia/Camellia

**PERTG Town Hall**
12–1 p.m.
Sheraton - Magnolia/Camellia

**PERC Bridging Session**
2–3 p.m.
Sheraton - Magnolia/Camellia

**PER Conference and Poster Reception**
3:30 p.m.
Sheraton – Magnolia/Camellia

## Session FA: PER: Exploring Problem Solving Approaches and Skills - A

**Location:** CC - Room 306
**Sponsor:** AAPT
**Date:** Wednesday, July 20
**Time:** 8:30-10 a.m.

*Presider: Shannon D. Willoughby*

### FA01: 8:30-8:40 a.m. Eye Gaze Patterns While Viewing Visual Cues and Video Solutions*

*Contributed – Tianlong Zu, 1365 W. State St., Apt. 16, West Lafayette, IN 47907-2040; zutianlong@gmail.com*

*Elise Agra, University of Chicago*

*John Hutson, Lester C. Loschky, Kansas State University*

*Nobel S. Rebello, Purdue University*

Transfer of learning is a valued educational goal, but it is usually hard to achieve. Visual cues and video solutions have been shown to facilitate this process. Students from an algebra-based physics class participated in our study. Each participant solved two different sets of tasks. In each set students solved one initial task, completed an intervention depending upon condition, and then solved a near transfer and far transfer task. Students were randomly assigned to one of three conditions. The visual cue condition completed four isomorphic training tasks with visual cues. The video solution condition was shown multimedia solutions of two isomorphic tasks. The third condition completed two isomorphic training tasks with visual cues and were shown one multimedia video solution. We compared the eye movements on the initial, near transfer and far transfer tasks in the three conditions.

*Supported in part by NSF grant 1348857.

### FA02: 8:40-8:50 a.m. How Do Multimodal Hints Affect Conceptual Physics Task Solving?*

*Contributed – Xian Wu, 116 Cardwell Hall, Manhattan, KS 66506; xian@phys.ksu.edu*

*John Hutson, Lester C. Loschky, Brett DePaola, Kansas State University*

*N. Sanjay Rebello, Purdue University*

Students' visual attention on conceptual physics tasks with diagrams can provide us insight into how multimodality hints affect students' task performance on conceptual physics tasks. We conducted a 2 (visual hint or not) × 2 (text hint or not) × 2 (audio hint or not) full factorial experiment design. One hundred sixty-two subjects from a conceptual physics class were recruited to participate in individual clinical interviews with randomly assigned multimodal hints according to the condition. All of the interviews were video and audio recorded. An eye tracker was used to record the subjects' eye movements. The data were analyzed to compare how the experimental conditions affected performance on conceptual physics tasks and their visual attention in relevant areas on the task diagram.

*This research is supported in part by the U.S. National Science Foundation under Grants 1348857 and 1138697. Opinions expressed are those of the authors and not necessarily those of the Foundation.

### FA03: 8:50-9 a.m. Using Phenomenography to Better Understand Student Development with Computational Physics

*Contributed – Michael J. Obsniuk, Michigan State University, Biomedical Physical Sciences East, Lansing, MI 48824-2320; obsniukm@msu.edu*

Paul W. Irving, Marcos D. Caballero, Michigan State University

In Projects and Practices in Physics—a highly interactive and technologically modern introductory physics classroom with a strong pedagogical foundation—students are exposed to fundamental physics phenomena with the aid of computation. Within the context of this classroom, we have conducted a phenomenographic investigation of a small cohort of students. This cohort was exposed in-class to a "suite" of three scaffolded computational physics problems focusing on the fundamental physics phenomenon of force and motion. Over the three week duration of this "suite," we invited the cohort to repeated semi-structured interviews, one for each problem, in order to observe their development in approach to computational problems. From an analysis of the students' perceived variation in the computational features discerned to be critical, we have observed several qualitatively different categories of student development with modeling motion computationally.

### FA04: 9-9:10 a.m. Using the C3PO Interface to Develop and Modify Computing Coaches

*Contributed – Susan M. Kasahara, Normandale Community College, Bloomington,, MN 55437; susan.kasahara@gmail.com*

Improving students' problem-solving skills is a basic goal of many college-level introductory physics courses. At the University of Minnesota, investigators have developed computer programs designed to provide students with coaching to help them become better at solving problems in an introductory college physics course. As a physics instructor at Normandale Community College, I am participating in a study to test the feasibility of using this computer coach interface to modify existing coaches and create new coaches suitable for students enrolled in the introductory physics classes at Normandale and to assess their usability and educational impact with Normandale students. In this talk I will report on my initial experience with using C3PO: Customizable Computer Coaches for Physics Online to create and modify physics computing coaches.

### FA05: 9:10-9:20 a.m. Probing Students' Mathematical Difficulties in Introductory Physics*

*Contributed – David E. Meltzer, Arizona State University, 7271 E. Sonoran Arroyo Mall, Mesa, AZ 85212; david.meltzer@asu.edu*

*Matthew I. Jones, Arizona State University*

Instructors often report apparent difficulties among introductory university physics students with mathematical skills and concepts normally taught in high school or earlier. As part of a systematic effort to identify and address such difficulties, we have begun to investigate skill levels with trigonometry, basic algebra, symbolic manipulation, and vector concepts, among students in algebra- and calculus-based introductory physics. We will present a summary of our initial results, and outline a strategy for addressing these difficulties within the context of physics classes themselves.

*Supported in part by NSF DUE #1504986.

### FA06: 9:20-9:30 a.m. Reading Between the Lines: Lab Reports Help Develop Scientific Abilities

*Contributed – Danielle Bugge, Rutgers University, 8 Perrine Path, West, Windsor, NJ 08550; danielle.bugge@gse.rutgers.edu*

*Eugenia Etkina, Rutgers University*

Science practices are an integral part of learning science. Over the course of the 2015-2016 school year, high school physics students, initially unfamiliar with an inquiry-based environment, engaged in ISLE labs that focus on the development of student scientific abilities. Based on the last year's investigations, we know that factors such as time, ability type, student grouping, and instructor influence student development of scientific abilities. This year, we are continuing to examine student lab reports in order to better understand the process students go through when they write these reports. The revision history feature of the Google Documents provides insight into development of discourse as well as collaboration amongst students. We also continue to investigate differences in individual and group reports and students' self-assessments and reflections of their progress in development of these different abilities.

### FA07: 9:30-9:40 a.m. Elective Recitation Sections in Freshman E&M Courses

*Contributed – Steve McCauley, Dept. of Physics & Astronomy, Cal Poly Pomona, 3801 West Temple Ave., Pomona, CA 91768; swmccauley@cpp.edu*

*Nina Abramzon, Alex Rudolph, Homeyra Sadaghiani, Alex Small, Dept. of Physics & Astronomy, Cal Poly Pomona*

Students from 23 departments on the Cal Poly Pomona campus are required to take freshman physics service courses. Many of them struggle to succeed. Introductory physics courses at Cal Poly Pomona do not normally include any recitation sections focused on concepts and problem solving skills. We present data that we used to assess the effectiveness of elective recitation sections designed to accompany our freshman E&M course.

### FA08: 9:40-9:50 a.m. Investigating Students' Understanding of ac Biasing Networks*

*Contributed – Kevin L. Van De Bogart, University of Maine, 120 Bennett Hall, Orono, ME 04469; kevin.vandebogart@maine.edu*

*MacKenzie R. Stetzer, University of Maine*

As part of an ongoing effort to investigate the learning and teaching of bipolar junction transistor circuits (e.g., the common-emitter amplifier) in physics and engineering courses, we have begun to examine student understanding of ac biasing networks. These biasing networks are critical for signal processing via transistor circuits, yet the coverage of such networks in both courses and texts is typically sparse and frequently secondary to coverage of the amplifier circuits themselves. In this cross-disciplinary project, we have been examining the extent to which students are able to correctly predict the behavior of the biasing network under both dc and ac conditions. In this presentation, we will use specific examples to highlight the most prevalent conceptual and reasoning difficulties identified. Implications for instruction emerging from this investigation will also be discussed.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1323426 and DUE-0962805.

### FA09: 9:50-10 a.m. Thinking Quantum Mechanically: Introducing Students to Reasoning in Modern Physics*

*Contributed – Jessica Hoy, University of Colorado, Boulder, 390 UCB Suite F-1011, Boulder, CO 80309; jessica.hoy@colorado.edu*

*Noah D. Finkelstein, University of Colorado Boulder*

Learning quantum mechanics requires students to develop new conceptual understanding and mathematical skills, and to reason differently about the nature of systems (i.e. an electron is no longer a point-like particle). We present a broad view of our research in a Modern Physics course at CU Boulder where second-year physics and engineering students learn the foundations of quantum mechanics. In this work, we focus on classically unfamiliar or unusual cases, such as tunneling and delayed choice experiments, and look at the nature of student reasoning in these situations. We present both qualitative (recorded focus group discussions) and quantitative (conceptual and epistemological survey) data and demonstrate that students are capable of engaging in sophisticated reasoning about quantum phenomena. By explicitly attending to applications and interpretation within instruction, we foster an environment in which students negotiate and grapple with quantum concepts.

*Work supported by NSF

## Session FB: PER: Examining Content Understanding and Reasoning - A

**Location:** CC - Room 307
**Sponsor:** Committee on Research in Physics Education
**Date:** Wednesday, July 20
**Time:** 8:30-10:20 a.m.

*Presider: Natasha Holmes*

### FB01: 8:30-8:40 a.m. Classical Physics Learning from Analysis of Modern Physics Data II

*Contributed – Kenneth W. Cecire, University of Notre Dame, Department of Physics, 225 Nieuwland Science Hall, Notre Dame, IN 46556; kcecire@nd.edu*

*Deborah Roudebush, Oakton High School*

Whether students are studying classical physics or cutting edge physics, many of the same principles apply. For example, the conservation of momentum is a time-honored classical topic that is absolutely necessary to understand the products of particle collisions in the Large Hadron Collider. The authors have created a pre- and post-study instrument to try to determine if students are more motivated to learn about classical principles from activities which employ authentic data from current, cutting-edge experiments and if such activities might enhance learning of such classical topics.

### FB02: 8:40-8:50 a.m. Concept Inventories and the Next Generation of Assessment

*Contributed – James T. Laverty, Michigan State University, 620 Farm Lane, Erickson Hall, Room 115, East Lansing, MI 48824-1046; laverty1@msu.edu*

*Marcos D. Caballero. Michigan State University*

In 2012, the National Research Council released A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. This report synthesized the literature on how students learn science into three dimensions that should be blended together in instruction, curriculum, and assessment. This “three-dimensional learning” is the basis for the Next Generation Science Standards and researchers have recently made calls to bring it to higher education as well. We have developed the Three-Dimensional Learning Assessment Protocol (3D-LAP), which can characterize assessments in introductory science courses as aligning (or not) with scientific practices, crosscutting concepts, and core ideas. In this talk, I apply the 3D-LAP to some commonly used concept inventories in physics to characterize their alignment with the three dimensions from the Framework. I will explore the potential utility of these concept inventories in the era of the Next Generation Science Standards.

### FB03: 8:50-9 a.m. Investigating Student Ability to Reason in Different Directions*

*Contributed – MacKenzie R. Stetzer, University of Maine, 5709 Bennett Hall, Room 120, Orono, ME 04469-5709; mackenzie.stetzer@maine.edu*

*J. Caleb Speirs, William N. Ferm Jr., University of Maine*

As part of a larger, multi-institutional effort to investigate and assess the development of student reasoning skills in the context of scaffolded physics instruction, we have designed and administered new tasks in order to examine student ability to reason in different directions in introductory calculus-based physics courses. In these reasoning reversal tasks, two different versions of a physics problem are randomly administered to students in the course. In one version, students are asked to predict how a modification to an experimental setup will change the outcome of the experiment; in the other version, students are asked to infer the modification to the experimental setup that led to a specified change in the outcome of the experiment. In this talk, we will present preliminary results from these reasoning reversal tasks.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432765, DUE-1432052, and DUE-0962805.

### FB04: 9-9:10 a.m. Investigating Student Understanding of Radioactivity With the Radiation Conceptual Evaluation*

*Contributed – Brant E. Hinrichs, Drury University, 729 N. Drury Lane, Springfield, MO 65802p; bhinrichs@drury.edu*

*Andy Johnson, CAMSE, Black Hills State University*

*Christos Deligkaris, Drury University*

As part of developing a comprehensive package of classroom materials for radiation literacy, the Inquiry into Radioactivity (IiR) project has drafted a Radiation Conceptual Evaluation (Rad CE). This instrument detects major problematic categories of student thinking such as the “substance-like view” of radiation, and ionizing radiation as waves. Students with the substance-like view think of radiation as “bad stuff” that is emitted from radioactive objects and contaminates other objects when it gets on them, making them radioactive in turn. Students with this view typically do not distinguish radiation from the condition of being radioactive. Pre and post-testing using the Rad CE at two different universities indicate that nearly all nonscience majors begin the IiR course with the substance-like view, but gradually transition to a “particles-in-motion” view over time. We compare data from both universities and draw implications for teaching radioactivity.

*This project was supported by NSF DUE grant 0942699.

### FB05: 9:10-9:20 a.m. Overview of 50+ Research-based Assessments in Physics and Beyond

*Contributed – Adrian M. Madsen, American Association of Physics Teachers, 1100 Chokecherry Lane, Longmont, CO 80503; amadsen@aapt.org*

*Sarah McKagan, American Association of Physics Teachers*

*Jaime Richards, John Thompson, Leanor C. Sayre, Kansas State University*

The PER community has produced 50+ research-based assessments (RBAs) which evaluate the effectiveness of different teaching methods, covering diverse physics topics (both introductory and upper-level) as well as beliefs about the nature of physics, problem solving, lab skills etc. Results on these tests show that PER-based teaching methods lead to dramatic improvements in students learning, so assessment can act as a gateway drug to better teaching. However, physics faculty often struggle with knowing which assessments are available and which to use in their course. We have written a resource letter in which we discuss the details of each research-based assessment, including the course-level, content, purpose, level of research validation and implementation details. We also compare relevant assessments and give recommendations on when to use each assessment. In our talk, we will give an overview of the categories of assessments, paying particular attention to those that are less well known.

### FB06: 9:20-9:30 a.m. Targeted Student Feedback Using Transition Matrices

*Contributed – Paul J. Walter, St. Edward’s University, 3001 S. Congress Ave., CM, 1043 Austin, TX 78704; pauljw@stedwards.edu*

*Gary A. Morris, St. Edward’s University*

*Spencer Skees, Valparaiso University*

*Samantha Swartz, Plymouth High School*

We introduce a new tool for adoption by high school and college-level physics teachers who use a common assessment such as the Force Concept Inventory (FCI). The tool uses a spreadsheet application to create a simple matrix that identifies the percentage of students that who select each possible pre-/post-test answer combination on each question of the diagnostic exam. From this, it determines changes in students' understanding of concepts and common misconceptions. For those students who selected the wrong answer to a question on both of the pre-/post-tests, we also determine whether they are moving toward a "better" wrong answer. Feedback from the tool allows instructors to close the loop on assessment and tailor instruction in an informed way.

### FB07: 9:30-9:40 a.m. Novice Index Representation of Conceptual Transformation During Physics Instruction

*Contributed – Michi Ishimoto, Kochi University of Technology, Tosayama-da-cho Kochi, Japan 782-8502 Japan; ishimoto.michi@kochi-tech.ac.jp*

The Newtonian score representation of students' understanding of force and motion concepts has been a standard index in quantitative studies on conceptual transformation. Whereas students' proficiency before physics instruction is associated with learning gain, the robustness of novice views is attributed to learning inefficiency among low proficiency students. This study attempts to relate the inefficiency and the robustness of the primary commonsense conceptions by devising a noviceness index using a large number of students' pre-test and post-test results on the Force and Motion Conceptual Evaluation. The results show that the proportion of change from novice responses to correct responses increased with an exponential regression curve, with R2 close to 1. The exponential rate of the transformation of a novice view could bring forth empirical data on other aspects of this transformation, such as what is involved in the rewiring of a neural network to build a new network.

### FB08: 9:40-9:50 a.m. Investigating Student Understanding of Vector Calculus in E&M

*Contributed – Ryan L. C. Hazelton, University of Washington, 200 NE 65th St., Seattle, WA 98115; rlhazelton@gmail.com*

*Bert C. Xue, Peter S. Shaffer, University of Washington*

Over the past several years the Physics Education Group at the University of Washington has been working to probe the difficulties students encounter in junior-level electrodynamics courses. A large proportion of these difficulties involve interpreting mathematical statements about physical systems. A major subset of these difficulties involve student understanding of the divergence and curl operators. This talk will discuss several examples of these difficulties in the context of Maxwell's equations.

### FB09: 9:50-10 a.m. Improving Student Understanding of Vector Fields in E&M

*Contributed – Bert C. Xue, University of Washington, 11540 Pinehurst Way NE, apt, 406, Seattle, WA 98125; bertxue@gmail.com*

*Ryan L.C. Hazelton, Peter S. Shaffer, University of Washington*

The Physics Education Group at the University of Washington has been developing tutorials for the junior-level electrodynamics courses. We have observed that most students enter these courses with a working knowledge of static electric and magnetic fields in simple systems. However, these students have significant difficulties in transferring this knowledge to other vector fields or to more complex systems. This talk will present results from our attempts at improving student understanding of vector fields and the physical interpretation of vector derivatives.

### FB10: 10-10:10 a.m. Improving Student Understanding of Degenerate Perturbation Theory in Quantum Mechanics

*Contributed – Christof Keebaugh, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu*

*Emily Marshman, Chandralekha Singh, University of Pittsburgh*

We investigate student difficulties with degenerate perturbation theory in quantum mechanics by administering free-response and multiple-choice questions and conducting individual interviews with advanced students. We find that students display many common difficulties related to this topic. To improve student understanding, we use these difficulties as resources and develop a Quantum Interactive Learning Tutorial (QuILT) along with a pre-test and a post-test using an iterative approach. We will discuss the development and evaluation of the QuILT. We thank the National Science Foundation for support.

### FB11: 10:10-10:20 a.m. Exploring Student Sensemaking through Layers of Epistemic Games

*Contributed – Michael Vignal, Oregon State University, 301 Weniger Hall, Corvallis, OR 97331-8507; vignalm@oregonstate.edu*

*Elizabeth Gire, Oregon State University*

Several studies have demonstrated the utility of epistemic games in understanding problem-solving behavior in physics. Many researchers acknowledge the issue of grain-size as a challenge when identifying epistemic games in data, but few papers discuss games with various grain sizes. In analyzing a problem-solving episode with upper-division physics undergraduate students, we explore grain-size in an effort to understand student sensemaking. We identify distinct layers of epistemic games in the episode and look for relations between these layers.

## Session FC: Evaluating Instructional Strategies - A

**Location:** CC - Room 308
**Sponsor:** AAPT
**Date:** Wednesday, July 20
**Time:** 8:30-10 a.m.

*Presider: Shannon D. Willoughby*

### FC01: 8:30-8:40 a.m. An Activity-based Model for Training Physics Teaching and Learning Assistants

*Contributed – Monica K. Cook, Georgia State University, 25 Park Place, Suite 600, Atlanta, GA 30302-3999; monica@physics.gsu.edu*

*Joshua S. Von Korff, Georgia State University*

Preparing graduate teaching assistants (TAs) and undergraduate learning assistants (LAs) in Introductory Physics to facilitate discovery learning in labs and tutorials is a topic of intense interest in Physics Education Research. Our model for training TAs and LAs includes an overview of pedagogical theory, roleplays targeted at specific issues in active learning, and direct feedback from multiple teaching observations throughout the semester. The content of the roleplays and other activities emphasizes the importance of discourse, questioning, and eliciting student ideas by requiring the TAs and LAs to model those practices. We examine survey data from TAs and LAs and their students, and video data and field notes from training activities and teaching observations to consider the viability of our model as a method for preparing TAs and LAs to teach physics effectively. We also reflect on our training model for its potential to train future physics faculty members in student-centered learning.

### FC02: 8:40-8:50 a.m. National Assessment of the Impact of Learning Assistants on Physics Students' Learning

*Contributed – Ben Van Dusen, California State University Chico, 2354 Farmington Ave., Chico, CA 95928; bvandusen@csuchico.edu*

This study investigates the effects of various uses of Learning Assistants (LAs) on student outcomes across over 20 LA Alliance member institutions. Over 5000 physics students and 29 instructors participated in the study using the LA Supported Student Outcomes (LASSO) online student evaluation system. The Force and Motion Concept Evaluation (FMCE), Force Concept Inventory (FCI), Brief Electricity and Magnetism Assessment (BEMA), and Conceptual Survey of Electricity and Magnetism (CSEM) were used by over 40 different classes across the U.S. Our analysis links course-level information (e.g. how LAs are utilized) and average LA-student interaction time to course learning gains. We will report results from various institutional settings and discuss contextual effects on student outcomes.

### FC03: 8:50-9 a.m. Physics Teachers' Questioning Patterns and the Reasoning Behind Them

*Contributed – Brianna Santangelo, The College of New Jersey, 16 Maryland Ave., West, Long Branch, NJ 07764; santanb1@apps.tcnj.edu*

*AJ Richards, The College of New Jersey*

One of teachers' greatest tools in the classroom is questioning. It has long been theorized that higher level questioning leads to students developing a better understanding of the material but no one has examined the types of questions asked in physics classrooms in great detail. We used Bloom's revised taxonomy to classify the questions asked by high school physics instructors and surveyed them on what they believe their questioning patterns to be. By analyzing the distribution of question types and the teachers' self-perceived questioning patterns we take a first step to better understanding the use of questioning in physics classrooms.

### FC04: 9-9:10 a.m. Principles for Research-based Physics Activities

*Contributed – Joshua S. Von Korff, Georgia State University, 25 Park Place, #605, Atlanta, GA 30303; jvonkorff@gsu.edu*

*Amin Bayat Barooni, Georgia State University*

Physics instructors obtain their educational activities from a variety of sources. They may invent the activities themselves, use activities that have been designed for them by other faculty in their department, or use published materials that can be purchased or downloaded. Over the last few decades, many published materials have been tested and shown to benefit students' conceptual understanding. We have analyzed some of these published physics activities and interviewed their designers in order to better understand the principles behind them. These principles are valuable for understanding the impact that physics activities have on students and for understanding non-published activities developed by individual instructors.

### FC05: 9:10-9:20 a.m. Comparing Factor Analysis and Network Methods to Cluster Test Questions

*Contributed – Mark Eichenlaub,* University of Maryland, College Park, 1117 John S. Toll Building #82, College Park, MD; 20742-2421 mark.d.eichenlaub@gmail.com*

When creating concept inventories, we usually write questions in clusters, each cluster corresponding to a particular concept. Do these clusters appear in the data generated when students take the concept inventories, and what does this tell us about student thinking? The physics education research community has often tackled this problem using factor analysis. Other recent work has modeled test result data as a bipartite network and applied community detection algorithms to identify clusters of questions. To better understand the differences between these methods, we hypothesize a model of how students answer questions inspired by the resource framework, use the model to simulate test results with known cluster structure, and compare the two methods' ability to recover the known cluster structure. Finally, we discuss implications of these results on how we should understand the way that students generate answers to test questions.

*Sponsored by Edward Redish

### FC06: 9:20-9:30 a.m. Large-scale Assessment Yields Evidence of Minimal Use of Reasoning Skills

*Contributed – Beth Thacker, Texas Tech University, Physics Department, MS 41051, Lubbock, TX 79409-1051; beth.thacker@ttu.edu*

Large-scale assessment data from Texas Tech University yielded evidence that most students taught traditionally in large lecture classes with online homework and predominantly multiple choice question exams, when asked to answer free-response questions, did not support their answers with logical arguments grounded in physics concepts. Their answers indicated not only their lack of conceptual understanding, but their inability to apply even lower order thinking skills to solve a problem. While correct answers indicated evidence of lower level thinking skills, when coded by a rubric based on Bloom's taxonomy, incorrect and partially correct answers indicated little or no evidence of the use of thinking skills at all. The free-response format, unlike other assessment formats, allowed assessment of both their conceptual understanding and their application of thinking skills, clearly pointing out weaknesses not revealed by other assessment instruments.

### FC07: 9:30-9:40 a.m. Social Network Analysis of Support Groups in Introductory Physics

*Contributed – Christopher A. Oakley, 350 Spelman Lane, Atlanta, GA 30314; coakley@spelman.edu*

Research suggests that students benefit from peer interaction and active engagement. The quality and nature of these interactions is currently being explored. Students have been surveyed at regular intervals during the second semester of trigonometry-based introductory physics to determine the frequency and self-reported quality of interactions. These interactions can be with current or past students, tutors, and instructors. Our current research focuses on the metrics of Social Network Research in an effort to refine deeper research questions regarding success in the introductory sequence and the support system that student create during the two-semester physics sequence. These metrics include centrality of students as well as segmentation of groups.

### FC08: 9:40-9:50 a.m. Examining the Necessity of Problem Diagrams Using MOOC AB Experiments

*Contributed – Zhongzhou Chen, Massachusetts Institute of Technology, 77 Massachusetts Ave., Building 26-321, Cambridge, MA 02139-4307; zchen22@mit.edu*

*Neset Demirci, Balikesir University*

*Youn-jeng Choi, University of Alabama*

*David Pritchard, Massachusetts Institute of Technology*

Creating high-quality problem diagrams consumes significant resources from both instructor and publisher, yet the benefit of problem diagrams has not been confirmed by research. Using the AB experiment functionality of the edX MOOC platform, we selected 12 problems where the diagram adds no critical information for problem solving, and studied the impact of adding/removing a diagram on both student' correctness and problem solving behavior. We found that providing a diagram improved 1st attempt correct rate by merely 3% overall, but reduced the fraction of students drawing their own diagram by ~10% on half of the problems. On the other half, providing a diagram have no detectable impact on either correctness or behavior. Further analysis confirmed that except for the most spatially challenging problems, MOOC students are able to compensate for the loss of a diagram by drawing their own.

### FC09: 9:50-10 a.m. Inquiry vs. Traditional: Student Perceptions and Learning Gains

*Contributed – Adam B. Francis, University of Colorado, Boulder, 7734 Durham Cir., Boulder, CO 80301; francis_adam@svvsd.org*

*Nicholas Hooker, University of Colorado, Boulder*

This PER study investigates the order in which conceptual topics and laboratory exercises are presented in a high school physics classroom. By varying the order of presentation of conceptual material and labs, the researchers aimed to identify if student scores and growth on conceptual measures differed in the two contexts. We hypothesized that students learning with the guided inquiry model, in which laboratory exercises preceded conceptual lessons, would demonstrate higher scores and greater growth on objective measures of learning. We further hypothesized that these students would indicate a preference for learning via the guided inquiry model. We will discuss significant differences in group means in the two learning contexts. Results of student preference surveys will also be reported in order to evaluate student perceptions of the two instructional paradigms.

## Session FD: Computer Modeling and Simulation in the IPLS Course

**Location:** CC - Room 315
**Sponsor:** Committee on Physics in Undergraduate Education
**Date:** Wednesday, July 20
**Time:** 8:30-10:20 a.m.

*Presider: Juan Burciaga*

### FD01: 8:30-9 a.m. Learning Physical Biology via Modeling/ Simulation: New Course and Textbook*

*Invited – Philip Nelson, University of Pennsylvania, Physics DRL, Philadelphia, PA 19104; nelson@physics.upenn.edu*

Undergraduate life-science curricula remain largely rooted in descriptive approaches, even though much current research involves quantitative modeling. Not only does our pedagogy not reflect current reality; it also reinforces the silos that prevent students from connecting disciplines. I'll describe a course that has attracted undergraduates in several science and engineering majors. Students acquire research skills that are often not addressed in traditional undergraduate courses, using a general-purpose platform like MATLAB or Python. The combination of experimental data, modeling, and physical reasoning used in this course represents an entirely new mode of "how to learn" for most of the students. These basic skills are presented in the context of case studies from cell biology. Documented outcomes include student reports of improved ability to gain research positions as undergraduates, and greater effectiveness in such positions, as well as students enrolling in more challenging later courses than they would otherwise have chosen.

*Work supported by NSF under grants EF–0928048 and DMR–0832802.

### FD02: 9-9:30 a.m. Stochastic Simulations and Finite-difference Models for the Life Sciences

*Invited – Peter H. Nelson, Benedictine University, 6601 Fernwood Drive, Lisle, IL 60532; pete@circle4.com*

Life-science students are introduced to modeling and simulation using a simple kinetic Monte Carlo (kMC) simulation of diffusion. The model is first introduced as a physical "marble game" and then implemented as a kMC simulation. Students work through a self-study guide introduction to Excel and write their own simulation from scratch in a blank spreadsheet. In a guided-inquiry exercise students discover that Fick's law of diffusion is a consequence of Brownian motion. Subsequent activities introduce students to: algorithms and computational thinking; exponential decay in drug elimination and radioactive decay; half-life and semi-log plots; finite difference methods (and calculus); the principles of scientific modeling; model validation and residual analysis; and osmosis. Analysis of published clinical data and Nobel Prize winning osmosis research is featured in an active learning environment. Because the materials are self-contained, they can be used in a flipped-classroom approach. Sample chapters are available for free at http://circle4.com/biophysics/chapters/

### FD03: 9:30-9:40 a.m. Introducing Coarse-Graining Part 1: From Molecular Dynamics to Random Walks

*Contributed – Edit Menuha Yerushalmi, Weizmann Institute of Science, 10 Haim Haviv St., Jerusalem, 96788 Israel; edit.yerushalmi@weizmann.ac.il*

*Haim Edri, Bat-Sheva Eylon, Samuel Safran, Nava Schulmann, Weizmann Institute of Science*

Applying physics to understand structure formation in chemical and biological systems often requires coarse-graining which averages over the short time and length scales of the system. This allows one to focus on a more limited number of degrees of freedom. We present an instructional sequence intended to introduce this concept to introductory level students. The sequence involves comparison between several computational models for diffusion differing in their length and time scales. At the shortest scales one can treat all the interacting particles in the many-body system using deterministic mechanical laws (Molecular Dynamics). While this provides complete information, coarse-grained models are needed to reduce complexity and to obtain physical intuition: In the Langevin model, where the mechanical laws are applied only to the colloidal particles while the solvent is accounted for by friction and stochastic forces. At even larger scales, random walk on a lattice model, involving only the colloidal particles.

### FD04: 9:40-9:50 a.m. Introducing Coarse-Graining Part 2: Structuring and Problematizing

*Contributed – Haim Edri, Weizmann Institute of Science, 234 Herzl St., Rehovot, 7610001 Israel; haim.edri@weizmann.ac.il*

*Bat-Sheva Eylon, Samuel Safran, Edit Yerushalmi, Weizmann Institute of Science*

Applying physics to understand structure formation in chemical and biological systems often requires coarse-graining which averages over the short time and length scales of the system. This allows one to focus on a more limited number of degrees of freedom that govern the properties on long spatial and time scales. The concept was introduced in an instructional sequence involving several computational models of diffusion (of a molecule in a gas or liquid or a colloidal particle in a solvent), that apply to different time and spatial scales. At increasingly larger scales, one can represent the system using effective laws such as molecular dynamics, Langevin dynamics and random walks. We present activities structured to enable introductory level students to construct the various models, as well as activities intended to problematize students' work when examining the transition between these models.

### FD05: 9:50-10 a.m. Modeling of Brownian Motion Using VPython in an IPLS Course

*Contributed – Betsy M. Chesnutt, Itawamba Community College, 602 W Hill St., Fulton, MS 38843; bcchesnutt@iccms.edu*

Random motion at a microscopic level is extremely important in the life sciences, but this topic is rarely encountered in a traditional physics course. At the microscopic level, particles suspended in a gas or liquid move in a random manner known as Brownian motion. As a result, cells and other biological materials must move through fluids in a way that is very different from the way that larger objects move through the world. It is essential to understand and characterize this volatile behavior if we hope to make sense of the biological world. To help introductory physics students understand Brownian motion and how it effects the motion of cells in liquid environments, a series of activities have been developed, which include modeling random motion using VPython. The computational model is then used to visualize directed motion of a cell-like object as it collides with particles undergoing Brownian motion.

### FD06: 10-10:10 a.m. Modeling the Heart's Dipole Moment in the Introductory Physics Laboratory

*Contributed – Mary Ann H. Klassen, Swarthmore College, 500 College Ave., Swarthmore, PA 19081; mklasse1@swarthmore.edu*

*John W. Hirshfeld, University of Pennsylvania Medical Center*

*Catherine H. Crouch, Swarthmore College*

We present an introductory laboratory in which students measure their own simplified electrocardiogram (ECG), a set of potential differences measured on the surface of the body, and learn to interpret it in terms of the moving electric dipole moment of the heart during a single pumping cycle. Using Vernier software EKG sensors, students acquire data for the two basic "leads" (electrode configurations) that are the starting point for clinical measurements (which involve additional electrode pairings). Students are guided through analyzing the raw voltage-time data to compute the magnitude and direction of the heart's dipole moment through one contraction cycle. A simple Mathematica script is used to visualize and animate the data.

### FD07: 10:10-10:20 a.m. Attitudes of Life Science Majors Towards Computational Modeling in Introductory Physics

*Contributed – Brandon R. Lunk, Texas State University, Roy F. Mitte Building, 749 N. Comanche St., San Marcos, TX 78666; brlunk@ncsu.edu*

*Anna Lewis, Elon University*

*Robert Beichner, North Carolina State University*

Biological and health-care majors comprise one of the largest populations of students enrolled in physics courses each year. Because of this, there is a growing interest within the physics and biology communities to restructure the introductory physics courses for life science majors to better support the needs of these students. In this context, computational modeling could prove to be an accessible and compelling tool for exploring biologically and medically relevant phenomena within in the physics course. As a first step leading to implementation, we conducted an exploratory study to help us learn about life-science majors' attitudes towards programming. Our observations suggest that these students had an apprehension towards programming but at the same time held a positive attitude towards the use of spreadsheets, which could be used to scaffold more rigorous computational modeling tasks in the classroom.

## Session FE: PER: Diverse Investigations - A

**Location:** CC - Room 314
**Sponsor:** AAPT
**Date:** Wednesday, July 20
**Time:** 8:30-10:10 a.m.

*Presider: Trevor Smith*

### FE01: 8:30-8:40 a.m. Who Let the Cold Out?

*Contributed – Carolina Alvarado, University of Maine, 5727 Estabrooke Hall, Orono, ME 04469; carolina.alvarado@maine.edu*

*Michael C. Wittmann, Adam Z. Rogers, Laura Millay, University of Maine*

In the MainePSP*, we have observed students improve the way they analyze thermal energy after instruction, but that many of them continue to use the idea that "coldness" transfers. Past researchers have identified that cold is commonly perceived as a separate heat energy. Nevertheless, we have not found specific activities to address this idea. We present the analysis of a collaborative session among K-12 teachers who were trying to analyze how to address coldness in the classroom. During the sessions, teachers got to model the energy in two different scenarios which include an object in room temperature interacting with snow. Then, teachers interacted with two simulations that address thermal energy to consider their utility as an instructional tool. Engaging teachers in these activities led to additional insights and questions about how to convincingly address students' observable experience, that coldness transfers, using a thermal energy model.

*NSF MSP 0962805

### FE02: 8:40-8:50 a.m. "Who Can Be an Engineer?" Investigating Attitudes and Self-Identification

*Contributed – Jacqueline Doyle, Florida International University, 11200 SW 8th St., CP 204, Miami, FL 33199; doylejackd@gmail.com*

*Geoff Potvin, Florida International University*

Robust physics and engineering identities are strong predictors of students' choice to pursue a degree in physics or engineering; students who go into either of these fields are often drawn from the same pool of potentially interested high schoolers, who must decide between majoring in the two fields. Many studies of engineering students have treated them as a homogenous population or focus only on one sub-discipline, rather than distinguishing engineers between disciplines more carefully. Recently, we surveyed students on several attitudinal constructs, such as Grit, the "Big 5" Personality Traits, and Performance-Approach mindset, which have been correlated with the development of identity and academic success in these fields. Using data from the 2,966 introductory engineering students surveyed, we investigate the associations between student attitudes and both physics and engineering identity and disaggregate by major to uncover differences and similarities which will help broaden a conversation about who "can" be an engineer.

### FE03: 8:50-9 a.m. Applying Business Literature to Product Development in STEM Education*

*Contributed – Raina M. Khatri, Western Michigan University, 1903 W. Michigan Ave., Kalamazoo, MI 49008; raina.m.khatri@gmail.com*

*Charles Henderson, Western Michigan University*

Over the past few decades many innovations to improve undergraduate STEM education have been developed, only to fizzle out as they struggle to find an audience. Funding agencies have noticed this problem and are putting increased attention on development projects that build in aspects of sustainability after the project funding has ended. In recent years there has been research done within physics and STEM education on developing and disseminating education research projects. But, there is a much longer history and body of literature with common goals in the business literature related to product development and innovation. In this talk I discuss product development and launching the product from a business perspective, and how what is known about this process can be directly applied to developing and propagating an education innovation. *Supported by the National Science Foundation under Grant No. 1122446.

*Supported by the National Science Foundation under Grant No. 1122446

### FE04: 9-9:10 a.m. Embedded Experts: A Productive Approach to Transforming Undergraduate STEM Education*

*Contributed – Stephanie Viola Chasteen, University of Colorado Boulder, 247 Regal St., Louisville, CO 80027; United States chasteen@colorado.edu*

In order to achieve broader educational change in STEM discipline, research suggests that we need to engage faculty within a discipline, with opportunities to reflect on their teaching over long periods of time. One strategy that achieves this is the "embedded expert" model, where postdocs and other educational experts are partnered with faculty within a department to support course transformation. This model has been successfully used in the Science Education Initiative (http://colorado.edu/sei) at two institutions, using postdoctoral fellows as embedded experts. This model is being adapted and studied at seven institutions, using various embedded experts, in a new NSF-funded project (TRESTLE; http://www.colorado.edu/csl/trestle) in order to test how this intervention can be implemented in different institutional contexts to propagate widespread STEM education reform. I will discuss the embedded expert model, past results, the variations used in TRESTLE, and how we plan to test them.

*This material is based upon work supported by the National Science Foundation under Grant No. 1525331

### FE05: 9:10-9:20 a.m. Algebra-based Students and Vectors: Assessing Physical Understanding in Arrow vs ijk

*Contributed – John B. Buncher, North Dakota State University, Department of Physics, PO Box 6050, Fargo, ND 58102; john.buncher@ndsu.edu*

A recent study of students in a calculus-based introductory physics course found that students performed significantly better on vector addition and subtraction tasks when the questions were given using the ijk representation instead of an "arrows-on-a-grid" representation, and also presented evidence that working knowledge of the ijk format was necessary to correctly perform vector operations in the arrow format. A follow-up study found that students in an algebra-based physics course also performed significantly higher in the ijk representation than the arrow representation in both one- and two-dimensional problems, even though no explicit ijk instruction was given in the course. In a subsequent investigation we asked students in the algebra-based course to physically interpret their answers, in order to assess if the higher performance on ijk questions indicates physical understanding or is the result of algorithmic "plug-and-chug" thinking. Our findings will be discussed along with instructional implications.

### FE06: 9:20-9:30 a.m. Classroom Instruction Promotes Posterior Medial Cortex Brain Activity During Problem-Solving

*Contributed – Jessica E. Bartley, Florida International University, 7221 SW 127th St., Miami, FL 33156; jbart047@fiu.edu*

*Shannon Pruden, Eric Brewe, Matthew T. Sutherland, Angela R. Laird, Florida International University*

Understanding of physics-related concepts is often quantified through physics problem-solving (PPS) assessments. However, no study has characterized neurobiological processes underlying PPS or skill development via classroom instruction. We used functional magnetic resonance imaging (fMRI) to delineate PPS brain networks and probe differences resulting from classroom instruction. 15 students underwent pre- and identical post-instruction PPS fMRI sessions. We assessed brain activity and identified regions more engaged post- relative to pre-instruction ($P<0.05$). Data revealed consistent fronto-parietal networks contributing to PPS. Moreover, significantly increased post-instruction fMRI activity in posterior medial cortex (PMC), accompanied by improved PPS scores, implicated this region's critical role in skill development. As PMC supports spatial memory and attentional focus [1,2], these novel neurobiological observations provide insight into how education experience may augment brain activity which, in turn, contributes to enhanced PPS skills.

1. Leech et al. 2014 Brain 137; 2. Vann et al. 2009 Nat Rev Neurosci 10

### FE07: 9:30-9:40 a.m. Examining Time Use in Introductory Calculus-based Physics Students

*Contributed – Seth T. DeVore, West Virginia University, 135 Willey St., Morgantown, WV 26506-0002; stdevore@mail.wvu.edu*

*John Stewart, West Virginia University*

Student time use is a major element of success in any course, especially in physics courses in which expertise is earned largely through exposure to the problem-solving process. Surveys were developed which probed the distribution of student time use across various typical tasks associated with the introductory, calculus-based physics sequence. These surveys were implemented at four points in each the fall 2015 and spring 2016 semesters. Two of these surveys explored time use during weeks in which students were preparing for the first two exams of the semester, while the other two were implemented during typical non-test weeks. Measurements of incoming student SAT/ACT score, student grade expectations and student test grades were taken. An analysis of this data, including how students at large and potential sub-categories of students regulate their time use in response to exam scores and grade expectations, will be discussed.

### FE08: 9:40-9:50 a.m. Identifying Different Student Groups Using Cluster Analysis

*Contributed – John C. Stewart, West Virginia University, 235 White Hall, Morgantown, WV 26501; jcstewart1@mail.wvu.edu*

*Rachel Stoiko, West Virginia University*

This paper presents an analysis of the effect of pre-preparation and effort on the performance in a physics class using data collected over 21 semesters ($N=1747$). An overall significant negative correlation with total time out-of-class time invested was found ($p<0.0001$). Cluster analysis was used to identify distinct subgroups of students with different levels of incoming preparation for the class and distinctly different out-of-class study behaviors. The highest performing subgroup invested the lowest out-of-class time but began the class with superior preparation in the material covered. Representation of students of different gender was not uniform across the set of clusters ($p<0.0001$). Female students were underrepresented in the cluster of students with high pre-preparation and overrepresented in the cluster whose primary mode of exam preparation was reading. Male students were overrepresented in the cluster identified by the failure to submit required assignments.

### FE09: 9:50-10 a.m. What Happens After Paired Teaching? Continued Use of Research-based Instructional Strategies

*Contributed – Jared Stang, University of British Columbia, 334 - 6224 Agricultural Rd., Vancouver, BC V6T 1Z1 Canada; jared@phas.ubc.ca*

*Linda Strubbe, University of British Columbia*

Paired (or co-) teaching is an arrangement in which two faculty are collaboratively responsible for all aspects of teaching a course. By pairing an instructor experienced in research-based instructional strategies (RBIS) with an instructor with little or no experience in RBIS, paired teaching can be used to promote the adoption of RBIS. We report on several examples of instructors who were the relative novices in such pairs. Using data from in-class observations, the Teaching Practices Inventory, and interviews with the instructors, we characterize the extent to which they have continued using RBIS in the courses they have taught after pair-teaching. Preliminary results indicate both a continued use of RBIS when teaching in the same course that they pair-taught in and some transfer of RBIS to new contexts.

### FE10: 10-10:10 a.m. When Buy-in Is Not Enough: GTAs' RIOT Profile in Mini Studios*

*Contributed – Matthew Wilcox, University of Central Florida, 4111 Libra Drive, Physical Sciences Bldg. 430, Orlando, FL 32816; mwilcox1@knights.ucf.edu*

*Yuehai Yang, Jacquelyn J. Chini, University of Central Florida*

Using the Real-time Instructor Observing Tool (RIOT), we observed six Graduate Teaching Assistants (GTAs) and coded for the amount of time they spent on various teaching actions to create an "action profile." The GTAs were teaching in a student-centered combined recitation and laboratory "mini-studio." At the end of the semester, we asked all GTAs to use the RIOT protocol to describe action profiles from several perspectives: 1) what the course designers want; 2) what the GTA thinks is most helpful; 3) what the students think is most helpful; and 4) what the GTA thinks his/her actual profile resembles. In this talk we compare the responses of an exemplary GTA to find a high amount of buy-in to the mini-studio method but an actual profile that more closely resembled what she believed her students wanted. These findings are supported by the GTA's other responses about her teaching experiences.

*This work is supported in part by the U.S. National Science Foundation under grant DUE-1246024.

## Session FF: Lab Guidelines Focus Area 3: Modeling

**Location:** CC - Room 304/305
**Sponsor:** Committee on Laboratories
**Date:** Wednesday, July 20
**Time:** 8:30-9:30 a.m.

*Presider: Joe Kozminski*

### FF01: 8:30-9 a.m. Model-based Reasoning in Upper-Division Lab Courses

*Invited – Heather Lewandowski, University of Colorado, CB 440 Boulder, CO 80309; lewandoh@colorado.edu*

Modeling, which includes developing, testing, and refining models, is a central activity in physics. Modeling is most fully represented in the laboratory where measurements of real phenomena intersect with theoretical models, leading to refinement of models and experimental apparatus. However, experimental physicists use models in complex ways and the process is often not made explicit in physics laboratory courses. We have developed a framework to describe the modeling process in physics laboratory activities. The framework attempts to abstract and simplify the complex modeling process undertaken by expert experimentalists. The framework can be applied to understand typical processes such the modeling of the measurement tools, modeling "black boxes," and signal processing. We demonstrate that the framework captures several important features of model-based reasoning in a way that can reveal common student difficulties in the lab and guide the development of curricula that emphasize modeling in the laboratory.

### FF02: 9-9:30 a.m. Modeling the Physical World with Real-Time Physics

*Invited – David R. Sokoloff, Department of Physics 1274, University of Oregon, Eugene, OR 97403-1274; sokoloff@uoregon.edu*

One of the six focus areas included in the AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum[1] is Modeling: ". . . developing an abstract representation of a real system being studied in the laboratory." In the experiments that make up the four Modules of RealTime Physics: Active Learning Laboratories (RTP)[2,3] students construct models from real observations of the physical world. These observations are often aided by computer-based tools like sensors and video analysis. The results are usually presented as graphs of the observed physical quantities, and students use analytical tools included in the software to construct descriptive and/or mathematical models of the phenomena. This paper will illustrate RTP modeling with examples from a diverse collection of introductory physics laboratory activities like projectile motion, Coulomb's law of the electrostatic force and Malus' law for intensity of light transmitted through a linear polarizer.

1. Available from AAPT at http://aapt.org/Resources/upload/LabGuidlines-Document_EBendorsed_nov10.pdf 2. David R. Sokoloff, Ronald K. Thornton and Priscilla W. Laws, "RealTime Physics: Active Learning Labs Transforming the Introductory Laboratory," Eur. J. of Phys.: 28 (2007), S83-S94. 3. David R. Sokoloff, Ronald K. Thornton and Priscilla W. Laws, RealTime Physics: Active Learning Laboratories, 3rd Edition, Module 1: Mechanics, Module 2: Heat and Thermodynamics, Module 3: Electricity and Magnetism and Module 4: Light and Optics (Hoboken, NJ, John Wiley and Sons, 2011).

## Session FG: High School

**Location:** CC - Room 310
**Sponsor:** AAPT
**Date:** Wednesday, July 20
**Time:** 8:30-9:30 a.m.

*Presider: Jay Nadeau*

### FG01: 8:30-8:40 a.m. Teaching AP Physics 1 to the World, a Second Time

*Contributed – Andrew G. Duffy, Boston University, Department of Physics, 590 Commonwealth Ave., Boston, MA 02215; aduffy@bu.edu*

This year, for the second time, Boston University taught an AP Physics 1 course online on edX, with a goal of helping students prepare for the AP Physics 1 exam in May. In this talk, we will discuss improvements we made to the course between the first and second runs, and also compare the outcomes from the first run (Jan. – May 2015) and the second (Sept. 2015 – May 2016). After the first run, students who took the AP Physics 1 exam told us that our course needed to be even more conceptual than it was, and we will discuss, in particular, how we responded to that feedback.

### FG02: 8:40-8:50 a.m. Closing the STEM Learning Gap for Underserved Populations

*Contributed – Mark D. Greenman, Boston University, 868 Humphrey St., Swampscott, MA 01907; greenman@bu.edu*

Many students from low-income urban communities are denied access to rigorous college-level Advanced Placement science courses. A team at Boston University is testing a blended MOOC that incorporates the best of the formal supportive structures from the student's home school, a private online tool specifically adapted to support underserved students and weekly tutoring and laboratory experience at a local university to test a scalable and replicable model for effectively delivering AP physics to underrepresented high school students. This is the first year of a pilot program impacting 25 students from seven different Boston area high schools that do not offer AP Physics as part of the school's program of study. Seventy percent of participating students are students of color and/or ethnic Latino. Twenty weeks into the program, attendance at tutoring sessions remains high at 90% and the dropout rate remains low at 8%.

### FG03: 8:50-9 a.m. Summarizing Discussion Interventions and Student Content Learning Gains

*Contributed – Jared W. Sommervold, University of Colorado, 1040 Sunset St., Longmont, CO 80501; sommervold_jared@svvsd.org*

This physics education research study focuses on how student-led summarizing discussions help solidify physics content understanding following inquiry-based lab activities among high school students. This study was conducted in eight sections of physics taught by three teachers. We investigated different formats for running summarizing discussions, and compared them to learning outcome data. Discussion formats that were studied included whole class student led discussions, consensus board discussions with grade impact, gallery walk with anonymous feedback, and teacher led discussions which resembled traditional lecture formats. Findings suggest that different formats range in their effectiveness, and discussions do not always lead to assessment growth gains. Results will be shared, and limitations and benefits of each format will be discussed.

### FG04: 9-9:10 a.m. The Effect of Discussion and Student-Generated Data on Written Scientific Explanations

*Contributed – Alisa P. Grimes, University of Colorado Boulder/Academy High School, P.O. Box 256, Kittredge, CO 80457; alisapaulinegrimes@yahoo.com*

*Valerie Otero, University of Colorado Boulder*

Students need help learning how to use evidence and reasoning to support their claims when developing written explanations. Constructing and critiquing evidence-based explanations engages students in an authentic scientific practice and helps them develop problem-solving and reasoning skills. In this study we examine ways to help secondary students build written scientific explanations. We employed 4 treatments: (1) students were provided data but no time was given to discuss with their peers before they wrote their scientific explanation; (2) students physically collected quantitative or qualitative data and used this data to write their scientific explanation; (3) students were provided class time to participate in a whole class or small group discussion regarding their data before they wrote their scientific explanation; and (4) students physically collected data and were provided time to discuss this data in a whole group or small group discussion before they wrote their scientific explanation.

### FG05: 9:10-9:20 a.m. AP Chemistry Content Knowledge and Guided Inquiry Lab Instructional Strategies

*Contributed – Emily A. Knapp, University of Colorado Boulder/Longmont High School, 1040 Sunset St., Longmont, CO 80504; knapp_emily@svvsd.org*

With the extensive content requirements for Advanced Placement Science courses, teachers may find it challenging to teach adequate content without compromising time for laboratory data analysis during lessons. The College Board published a series of guided inquiry experiments for AP Chemistry with the goal that students have the opportunity to engage in science practices while learning the necessary content. This study examines how instructional strategies, such as small group presentations and whole-class consensus discussions about these guided inquiry labs, may influence student assessment performance on nationally normed AP Chemistry released questions.

### FG06: 9:20-9:30 a.m. A Customizable Private Online Resource for Flipping Your AP Physics Classroom

*Contributed – David E. Pritchard, MIT, Room 26-241, Cambridge, MA 02139-4307; dpritch@mit.edu*

*ZhongZhou Chen, Chris Chudzicki, Sunbok Lee, MIT*

The RELATE.MIT.edu group at MIT is offering our audited College Board AP C level physics MOOC, 8.MechCx Introductory Mechanics, as a free Custom Course on edX.org (CCX) for high school or college instructors. "Custom Course" is a new feature of the edX platform that allows individual instructors to assign resources (problems, videos, texts) chosen from our MOOC to their own students according to their own schedule. This course features over 1000 high quality problems at different levels of difficulty, over 370 pages of e-text written and edited by MIT faculty based on PER research, as well as interactive online simulations, labs based on Direct Measurement Videos created by Peter Bohacek and simple "build it yourself" laboratories. In this talk we will describe the course and the research-based pedagogy; then demonstrate the CCX course, show how to enroll your own students, assign resources, set due dates and view student progress.

## Session FH: PhysTEC Teacher Preparation in California

**Location:** CC - Room 309
**Sponsor:** Committee on Teacher Preparation
**Date:** Wednesday, July 20
**Time:** 8:30-9:50 a.m.

*Presider: Monica Plisch*

### FH01: 8:30-8:50 a.m. Cal Poly Pomona PhysTEC Program

*Invited – Homeyra Sadaghiani, Cal Poly Pomona, 3801 W Temple Ave., Pomona, CA 91768-2557; hrsadaghiani@cpp.edu*

*Steve McCauley*

The Cal Poly Pomona PhysTEC program utilizes the Learning Assistant (LA) program as a mechanism to recruit and prepare physics majors for careers in teaching. Learning Assistant program provides potential future teachers with low-stress early teaching experiences that can encourage them to pursue teaching certification. However, the particular features of each institution present distinct challenges in establishing and maintaining the program. We will report on our challenges and achievements as well as strategies to sustain various elements of the program.

### FH02: 8:50-9:10 a.m. Building a Pathway for Physics Majors to Teachers

*Invited – Chuhee Kwon, California State University Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840-0119; chuhee.kwon@csulb.edu*

*Galen Pickett, Laura Henriques, California State University Long Beach*

The Department of Physics and Astronomy at California State University, Long Beach actively contributes to the physics teacher preparation through building a robust number of majors, exposing and supporting students to a teaching career, and maintaining outreach programs to local teachers. Physics majors are encouraged to consider teaching as a career early on (PHYS 390). In addition, students can get involved in various teaching opportunities such as providing academic support to peers (the Learning Assistant Program), interacting with pre- and in-service physics teachers (the PhysTEC events), and doing research with the Science Education Department faculty. In AY 2014/15, the department awarded 34 bachelors and nine masters degrees (15 URMs) in physics. In recent years, more CSULB physics majors are entering and receiving a teaching credential. We will discuss how the PhysTEC grant became the catalyst to transform the department.

### FH03: 9:10-9:30 a.m. PhysTEC at Cal Poly: Ten-Years Later – What Worked?

*Invited – Chance Hoellwarth, Cal Poly, 1 Grand Ave., San Luis Obispo, CA 93407; choellwa@calpoly.edu*

Cal Poly was a comprehensive PhysTEC site from 2003-2006 and the changes instituted during this time impacted the number of students earning a physics credential. Prior to 2003, Cal Poly awarded an average of one physics credential every two years. After our PhysTEC participation, our numbers increased to an average of two credentials per year in 2008 and have since increased to four to in 2015. Many of the changes implemented from 2003 to 2006 are still in place: teacher-in-residence program, reformed classes, recruitment efforts, and working closely with the School of Education. In addition, we have also added the Summer Teacher and Researcher Program and a Noyce scholarship program. We attribute our success to all of these changes. This talk will highlight our most effective changes, discuss the impact of PhysTEC, and address how some of the changes have been sustained.

### FH04: 9:30-9:50 a.m. PhysTEC Teacher Preparation in California: Themes, Challenges, and Opportunities

*Invited – Stamatis Vokos, 3307 Third Ave. W, STE 307, Seattle, WA 98119-1957; vokos@spu.edu*

As the discussant in this session, I will draw out some general themes that emerge from the previous talks. I will pay special attention to identifying opportunities for future closer collaboration among PER faculty at current or legacy PhysTEC sites.

## Session FI: Supporting Hispanic Women Students in Physics

**Location:** CC - Room 311
**Sponsor:** Committee on Women in Physics
**Co-Sponsor:** Committee on International Physics Education
**Date:** Wednesday, July 20
**Time:** 8:30-10 a.m.

*Presider: Daryl McPadden*

*The Hispanic population is the largest minority group in the United States, making up 17% of the total population, and is projected to increase to 31% by 2060. However, Hispanic students are disproportionately underrepresented in physics, especially in the intersection of Hispanic women. This panel will focus on the experiences of, research with, and strategies for supporting Hispanic women students in physics.*

### FI01: 8:30-9 a.m. One Among Many: Experiences of a Hispanic Woman in Physics

*Invited – Ana V. Aceves, 518 Beacon St., Boston, MA 02215; ana.aceves1291@gmail.com*

Like many, my parents emigrated from Mexico to the United States seeking a better lifestyle – and that included giving us the opportunity of a higher education. Eighteen years later, and I was packing my bags and moving 120 miles away from home to get a degree in astrophysics. I was the first in my family to graduate from college. It wasn't easy, and it wasn't because my classes were hard. Looking around my physics classes, I noticed no one else looked like me. There were women and Hispanic men, but no Hispanic women. I decided I wanted to make a difference, so I'm a Spanish-language science communicator. In this session, I will speak about my experiences as a Hispanic woman in physics and give suggestions on how to make classrooms more inviting for other Hispanic women.

### FI02: 9-9:30 a.m. Examining the Identity Development of Female Physics Majors

*Invited – Sissi L. Li, California State University Fullerton, 800 N. State College Blvd., Fullerton, CA 92831-3547; sissili314@gmail.com*

*Michael E. Loverude, California State University Fullerton*

The challenges of becoming an expert in and a member of a field are both content-based and sociocultural. In pursuing a degree in physics, social interactions with faculty and peers can help shape students' understanding of what it means to be a physicist. Cultural expectations are learned through social interactions and show how student identities fit into the community. Because physics is perceived as one of the most difficult in STEM, and it is one of the least diverse fields [81% of US physics BS recipients are white, and 79% male (AIP, 2010)], women and other underrepresented groups must overcome cultural differences and barriers while learning physics content. We will present the experiences of women who have successfully achieved a bachelor's degree in physics. Through interviews with these women, we will shed light on prominent features of their experience that helped shape their identity as physicists in their undergraduate endeavors.

### FI03: 9:30-10 a.m. Using Social Psychology to Support Underrepresented Students in Physics

*Invited – Gregg A. Muragishi,* Stanford University, 450 Serra Mall, Jordan Hall, Stanford, CA 94305-2130; muragishi@stanford.edu*

*Lauren Aguilar, Gregory M. Walton, Stanford University*

Two important tasks for teachers are to decide what material to cover and how to present it. Recent research in social psychology, however, shows that fostering student learning requires more than just presenting the material in an engaging manner – it also requires teachers to understand how students experience the classroom environment. Students from groups that are negatively stereotyped or underrepresented in physics are more likely to question whether they belong in school and look for evidence to confirm or allay these doubts. From this perspective, behaviors that seem positive to a teacher, like offering extra help, can make a student wonder if the teacher doubts their ability. How, then, can physics teachers create positive classroom environments for all students? This talk will review organizational mindsets, feedback, and affirmation strategies and describe how teachers can harness the power of social psychological research to help support the needs of all students.

*Sponsored by Daryl McPadden

## Session FJ: Ardiuno, Teensy, FPGA's et al

**Location:** CC - Room 312
**Sponsor:** Committee on Educational Technologies
**Co-Sponsor:** Committee on Apparatus
**Date:** Wednesday, July 20
**Time:** 8:30-10:10 a.m.

*Presider: Eric Ayars*

### FJ01: 8:30-9 a.m. Teensy Microcontrollers in the Undergraduate Lab

*Invited – Jonathan Newport, American University, 4400 Massachusetts Ave. NW, Washington, DC 20016-8003; newport@american.edu*

The Teensy microcontroller is a powerful upgrade to the standard Arduino microcontroller family. With onboard high-resolution analog to digital and digital to analog converters, a touch sensitive controller, and Digital Signal Processing instructions, the Teensy expands the scientific capabilities of low-cost data acquisition systems for use in undergraduate laboratories and capstone projects. Some of the many past and ongoing projects performed by students and faculty at American University will be presented. These projects include audio spectrum analyzers, phased microphone/speaker arrays, discriminators, PID controllers, and perceptual experiments.

### FJ02: 9-9:30 a.m. Physical Computing with the Arduino Family of Microcontrollers

*Invited – Herbert Jaeger, Miami University, Department of Physics, Oxford, OH 45056; jaegerh@MiamiOH.edu*

Among a wide selection of microcontrollers, the Arduino is one of the more popular ones. Unlike many competitors, Arduino's hardware and software are open-source, and the user has the support of a huge community of hobbyists and engineers at the tips of her fingers. Arduino comprises a family of models, most of which are based on Atmel's 8-bit AVR-RISC processor. Some models use 5V logic levels, others are 3.3V-based for low power consumption. In this talk I will go over basic applications of Arduino as a low-cost data logger, including interfacing sensors and external circuits with SPI and I2C protocols. Hardware interrupts can be used when timing is essential. We will discus how the Arduino can transmit data to an LCD display, to an SD memory card, or directly into spreadsheet files. Moreover, Arduinos can be connected to the internet and so may be employed in sensing and controlling remotely.

### FJ03: 9:30-9:40 a.m. Arduino-based Upper Level Electronics Class and Student Projects

*Contributed – Jolene L. Johnson, St. Catherine University, 2004 Randolph Ave., St. Paul, MN 55105; jljohnsonarmstrong@stkate.edu*

In spring semester 2016, St. Catherine University added a new electronics course that focuses on Arduino applications in addition to the traditional topics taught in an upper-level physics electronics course. This course is an important component of the applied physics major that we are developing, and is 100% lab and project based. In this talk I will discuss the structure and content of this course, concentrating on the Arduino units. For five to seven weeks of the semester, the students worked exclusively on Arduino projects. Project ideas came from other STEM faculty members who shared ideas on new equipment or enhancements to current equipment that would help them with their research. Students in the course worked with these faculty to find solutions to their electronic circuit needs. I will share the results of these projects and lessons learned along the way.

### FJ04: 9:40-9:50 a.m. Arduinos and Research and Design Cohorts at Linn-Benton Community College

*Contributed – Gregory Mulder, Linn-Benton Community College, 6500 SW Pacific Blvd., Albany, OR 97321; mulderg@linnbenton.edu*

Five years ago, thanks to an AAPT workshop on Arduino Microcontrollers, Linn-Benton Community College created a 1-credit Arduino class to support the campus' Remotely Operated Vehicle (ROV) team. Since then, Arduinos have been adopted by a variety of departments at our college. In 2015, LBCC received a five-year NSF S-STEM grant* that has helped us create Arduino-based Research and Design Cohorts (RDCs) as well as provide $100,000 per year in student scholarships. RDCs provide students authentic research experiences starting their first day on campus. Our current RDCs include the original ROV team, as well as a space exploration team, a high-altitude balloon team and a micro-gravity team. I will discuss how Arduinos changed the student and instructor experience on our campus.

*NSF DUE 1458839 "Promoting Retention and Completion with STEM Research and Design Cohorts at Linn-Benton Community College"

### FJ05: 9:50-10 a.m. Arduinos as a Vehicle to Teach Circuits

*Contributed – Chuck Winrich, Babson College, Kriebel 203, Babson Park, MA 02457-0310; cwinrich@babson.edu*

*Jeffrey Wetter, Shawn Reeves, Babson College*

We use Arduinos as part of the Electronics course at Babson College to get across basic concepts in circuits. Electronics is an option for non-majors to fill a lab science requirement. Instead of a traditional lab sequence, the students work in the lab periods throughout the semester to build a smart device based on the Arduino platform, using a variety of sensors we have available. Through characterizing an analog sensor (specifically a light-dependent resistor) the students learn how the input voltage is interpreted in the Arduino. Students go on to characterize their own sensors as part of their project work. This presentation will include examples of introductory exercises to introduce students to the Arduino project. We will also discuss the students' troubleshooting activities, and present examples of some student projects from recent semesters.

### FJ06: 10-10:10 a.m. Adding Arduinos to a Traditional Analog Electronics Course

*Contributed – Steve Lindaas, Minnesota State University Moorhead, 1104 7th Ave. South, Moorhead, MN 56563; lindaas@mnstate.edu*

Students are not usually exposed to microcontrollers like Ardunios in a traditional analog electronics course. However many students either are using them already or want to use them. For students who do not know about these devices, they need to know about them. We have recently added Arduinos to our electronics course. This addition has been useful and actually strengthened the understanding and appreciation of basic components like transistors and sensors. Adding Arduinos also allows a wider spectrum of student projects. Arduinos are a good choice for a gateway device since they are fairly simple, relatively cheap and there is a large user group supporting and contributing to the community of knowledge. In this talk we will share the challenges and opportunities of using Arduinos.

## Session FK: AP Physics 2 Labs with Java Applets

**Location:** CC - Room 301
**Sponsor:** Committee on Physics in High Schools
**Date:** Wednesday, July 20
**Time:** 8:30-10:30 a.m.

*Presider: Oather Strawderman*

*Learn how to use web-based Java Applets to perform high-quality physics labs that match up with common AP Physics 2 topics. While performing the activities, participants will examine how these labs still require rigorous data analysis and result in a deep understanding of the topic. Participants will assess how matching the applets with common AP Physics 2 Learning Objectives greatly increase students' learning and their performance on the AP Physics exam. They will also learn how to assess their students' performance on the labs using rubrics. Lab descriptions and handouts will be provided. The session will be broken down into four different sections corresponding to four different web based labs and their accompanying example Free Response questions. The four labs will focus on Buoyancy, Electrostatics, Optics and the Photo-electric Effect. The participants will work together through the labs in order to know how the interface works so when they get back to their classrooms they can easily implement the labs. They will also perform the data analysis to see how the activities are very rigorous.*

# Plenary Session (Sponsored by the APS Forum on Education)

**Location:** Sheraton - Magnolia/Camellia
**Date:** Wednesday, July 20
**Time:** 10:30–11:30 a.m.

*Presider: George Amann*

**David Reitze**

## *Colliding Black Holes & Convulsions in Space-time*

**by David Reitze,** LIGO Laboratory, California Institute of Technology

The First Observation of Gravitational Waves by LIGO: On September 14, 2015, scientists from the LIGO Scientific Collaboration and the Virgo Collaboration observed the collision and fusion of the two black holes by directly measuring the gravitational waves emitted during the collision using the LIGO detectors. This detection comes 100 years after Einstein developed his revolutionary general theory of relativity that predicted their existence, and 50 years after scientists began searching for them. This discovery has truly profound implications. Gravitational waves provide unique information on the most energetic astrophysical events, revealing insights into the nature of gravity, matter, space, and time. We have opened a new window on the cosmos. I will talk about how we made the detection and discuss how gravitational astronomy promises to change our understanding of universe.

## TOP07: Web Resources for Teaching Astronomy

**Location:** CC - Room 319
**Sponsor:** Committee on Space Science and Astronomy
**Co-Sponsor:** Committee on Educational Technologies
**Date:** Wednesday, July 20
**Time:** 11:30 a.m.-1 p.m.

*Presider: Kevin Lee*

*This topical discussion will look at several new astronomy offerings on the internet. Participants (who are encouraged to bring laptops, tablets, and mobile devices) will then brainstorm in groups on how to best make use of these capabilities.*

## TOP08: Work-Life Balance

**Location:** CC - Room 316
**Sponsor:** Committee on Professional Concerns
**Date:** Wednesday, July 20
**Time:** 11:30 a.m.-1 p.m.

*Presider: Kathleen Falconer*

*One significant problem faced by women physicists is balancing work and family obligations. The session will feature a panel of women physicists who have built successful careers in physics while maintaining strong families to provide practical advice.*

## Session GA: Preparing Pre-service Physics Teachers for the Middle School Classroom

**Location:** CC - Room 301
**Sponsor:** Committee on Pre-High School Education
**Co-Sponsor:** Committee on Teacher Preparation
**Date:** Wednesday, July 20
**Time:** 1-2 p.m.

*Presider: Alexis Knaub*

### GA01: 1-1:30 p.m. What Can Help Middle School Science Teachers be Successful?

*Invited – Gordon Aubrecht, The Ohio State University at Marion, 193 North Washington St., Delaware, OH 43015-1609; aubrecht.1@osu.edu*

A successful program for inservice middle school teachers offers suggestions for features that would better help prepare prospective teachers for the "real thing." These include, in addition to content support from staff and / or teachers, content support from peers as part of unit creation, experience of alternative methods of teaching rather than telling (such as, but not limited to, Physics by Inquiry), autonomy in choice of standard-supported units, and training in the use of formative assessments.

### GA02: 1:30-2 p.m. Learning through Doing: Educating Pre-Service Elementary and Middle School Teachers

*Invited – Robert Zisk, Rutgers University, 10 Seminary Pl., New Brunswick, NJ 08901-1281; robert.zisk@gse.rutgers.edu*

Pre-service teachers preparing to enter the middle and elementary school science classroom often face challenges related to content knowledge, confidence and how to adapt more complex science topics for younger learners. The implementation of the Next Generation Science Standards has added to these challenges by emphasizing the development of science practices as a way to learn the science content. In order to overcome these challenges, we have spent the past five years developing a course to increase pre-service teachers' comfort with science, develop content knowledge and help them develop a philosophy that students' learn science best through engagement in science practices. In this talk, I will use artifacts from the course to describe how the students in the course learn to teach science to young students through first participation in lessons as they would be taught in an elementary or middle school classroom and then reflecting on then as teachers.

## Session GB: Particle Physics Investigations by Students

**Location:** CC - Room 312
**Sponsor:** Committee on Physics in High Schools
**Co-Sponsor:** Committee on Physics in Two-Year Colleges
**Date:** Wednesday, July 20
**Time:** 1-3 p.m.

*Presider: Kenneth Cecire*

### GB01: 1-1:30 p.m. Using Cosmic Rays to Introduce Special Relativity in a College Physics Course

*Invited – Martin Shaffer, Cowley College, 125 S 2nd St., Arkansas City, KS 67005; martin.shaffer@cowley.edu*

This talk will discuss the use of a QuarkNet cosmic ray detector in a college physics course at Cowley College in Arkansas City, KS, to measure the speed of cosmic ray muons. Results from student work with real data will be used to examine what happens to particles moving close to the speed of light. This leads to the introduction of Einstein's theory of special relativity to explain the relative abundance of cosmic ray muons on the surface of the Earth.

### GB02: 1:30-2 p.m. High School Students Investigating the World of Particle Physics*

*Invited – Shane Wood, QuarkNet, 3439 Garfield Ave. #104, Minneapolis, MN 55408; swood5@nd.edu*

Physics research today involves many exciting recent discoveries (detection of gravitational waves, discovery of Higgs boson, etc.) and many profound mysteries (search for dark matter, quantum gravity, etc.). Learn how you and your students can tap into this excitement by investigating the world of particle physics. By using e-Labs or participating in a particle physics Masterclass, students can access real particle physics data in order to better understand the world of quarks and leptons, while meeting many standards, including Next Generation Science Standards (NGSS).

*This work is sponsored under the QuarkNet program by the National Science Foundation and the Department of Energy Office of Science.

### GB03: 2-2:10 p.m. Energetic Students – Developing Interest and Skill in Experimentation

*Contributed – Anthony Valsamis, Glenbrook North High School, 2300 Shermer Rd., Northbrook, IL 60062; avalsamis@glenbrook225.org*

More than 25 students at Glenbrook North High School meet once a week to discuss their high energy physics research. Using QuarkNet detectors, these students work in either small groups or individually to develop experiments using collected cosmic ray data. The use of this data ranges from studying natural phenomena, to learning about how the detectors work. One of the many current projects is focusing on the effect of barometric pressure on measured events of particle detection. Students look at weather patterns and altitude differences in various locations around the world. The goal of this group is to both give students hands-on time with real large-scale collaborative experiments as well as help build experimentation skills and analytical abilities.

### GB04: 2:10-2:20 p.m. The Particle Physics Playground: Tutorials and Activities Using Experimental Data*

*Contributed – Matthew Bellis, Siena College, 515 Loudon Rd., Loudonville, NY 12211-1462; mbellis@siena.edu*

*Amanda Depoian, Siena College*

Data from the Large Hadron Collider experiments are available to anyone with the time and inclination to learn the analysis procedures. The CMS experiment, in particular, has made a significant amount of data available in basically the same format the collaboration itself uses, along with software tools and a virtual environment in which to run those tools. These data have been mined for very packaged educational exercises that range from simple to quite advanced. This talk presents an alternative: the Particle Physics Playground website, a project that uses data from CMS and other experiments in tutorials and exercises aimed at the high school and undergraduate student level. The data are stored as text files and users are provided with starter Python/Jupyter-notebook programs and accessor functions which can be modified to perform fairly high-level analyses. The status of the project, success stories, and future plans for the website will be presented.

*http://particle-physics-playground.github.io/

### GB05: 2:20-3 p.m. A HS Science Teacher Workshop Constructing Turnkey Cloud Chambers

*Contributed – Jamie R. Bedard*, Siena College, 515 Loudon Road, Loudonville, NY 12211; jr06beda@siena.edu*

*Alyx S. Gleason, Matthew Bellis, Siena College*

In the summer of 2015, we hosted 10 high school teachers for a three-day "Physics at the Frontier" Workshop. Mornings were spent learning about general nuclear and particle physics concepts and the science of the Large Hadron Collider. Afternoons were spent building turnkey cloud chambers for use in classrooms. The basic design uses Peltier thermoelectric coolers, rather than dry ice. We started with instructions found online but developed our own build that made it easier to use in the classroom and maintain. We also focused on keeping the cost below $200/chamber and created a website with instructions for those who are interested in building their own. This workshop was funded in part by a minigrant for Outreach and Education from the USCMS collaboration. Our experience with the workshop and the lessons learned from the cloud chamber design will be discussed.

*Sponsored by Matthew Bellis (mbellis@siena.edu) http://mattbellis.github.io/turn-key-cloud-chamber/

## Session GC: Teacher Training/ Enhancement

**Location:** CC - Room 310
**Sponsor:** AAPT
**Date:** Wednesday, July 20
**Time:** 1-2:10 p.m.

*Presider: Warren Christensen*

### GC01: 1-1:10 p.m. Framework for Evaluating Teacher Discourse During Professional Development

*Contributed – Alice M. Flarend, Pennsylvania State University, 209 W. 15th Ave., Altoona, PA 16601; amf@blwd.k12.pa.us*

*Scott P. McDonald, Tanya Furman, Pennsylvania State University*

High quality professional development activities tend to involve teachers actively engaged in small group discussions. A question remains about what professional development providers (and classroom teachers) should look for as their "students" work in these groups in order to assess the success of these discussions. Discourse analysis is a promising methodology for gathering evidence of productive conversations. This presentation will provide a framework for classifying the discourse of small group talk into increasing levels of learning potential. Findings about the structure of professional development activities that lead to productive discourse will also be discussed.

### GC02: 1:10-1:20 p.m. A New Online Master's Program in Physics for High School Teachers

*Contributed – William G. Newton, Texas A&M University-Commerce Department of Physics and Astronomy, Commerce, TX 75429-3011; William.Newton@tamuc.edu*

*Robynne Lock, Texas A&M University-Commerce*

In spring 2014 we began to develop a new Master's in Physics with Teaching Emphasis aimed at in-service high school teachers. We have developed six brand new Master's level courses in physics aimed specifically at teachers, and are in the process of transferring them online. The aim is to support physics teachers for whom physics was not their major subject by reinforcing their content knowledge, giving them access to physics education research, teaching them the background necessary to discuss with their students the current hot physics topics that make the popular media, and providing a forum for teachers to share teaching strategies and material. In this talk we discuss the strategies employed in the classes so far, their content, and early outcomes.

### GC03: 1:20-1:30 p.m. Discovering and Eliminating Flaws in Physics Test Questions

*Contributed – Jesse J. Miner, Educational Testing Service, 7508 Nutwood Ct., Derwood, MD 20855; jminer@ets.org*

A physics test should measure a student's content knowledge and problem solving skills. However, a student's performance on a poorly constructed test may actually measure, e.g., reading comprehension, socioeconomic status, or equation matching. In large-scale assessment, standard practice for test development includes several levels of independent reviews that look beyond test content to find possible distractions within test questions that could skew results. I will present sample test questions that, while appearing to be reasonably well-written, have subtle flaws that could potentially disadvantage some students, and describe strategies for eliminating such flaws. I will also discuss basic methods for interpreting statistical performance of test questions, specifically addressing correlation between performance on a specific question to overall test performance to flag potentially flawed questions. This glimpse into the test development process will help teachers create robust tests that accurately measure student understanding.

### GC04: 1:30-1:40 p.m. The OK PhysTEC Collaborative*

*Contributed – Steven J. Maier, Northwestern Oklahoma State University, 709 Oklahoma Blvd., Alva, OK 73717-2799; sjmaier@nwosu.edu*

The OK PhysTEC Collaborative consists of the four PhysTEC member institutions of Oklahoma. The goal of the project is to increase the number of physics education candidates statewide over a three-year span. To do this, high school and undergraduate students are being recruited into physics and science education programs. In addition, support for travel to physics education conferences is offered to high school teachers, undergraduate physics students, and in-service physics teachers. Participating institutions include Northwestern Oklahoma State University (lead institution), East Central University, Oklahoma State University, and Southwestern Oklahoma State University. Recruitment efforts to date will be reported, along with summaries of enrollments, program changes motivated by the project, and challenges that remain.

*The OK PhysTEC project is supported by a PhysTEC Recruitment Grant

### GC05: 1:40-1:50 p.m. Design and Evaluation of Campus-wide Professional Development Program in STEM

*Contributed – Alistair G. McInerny, North Dakota State University, 1005 35th St, N Apt #117, Fargo, ND 58102; Alistair@Mcinerny.org*

*Jared Ladbury, Mila Kryjevskaia, Paul Kelter, North Dakota State University*

A North Dakota State University team of faculty is designing, implementing, and evaluating a sustainable campus-wide professional development program to help faculty maximize instructional effectiveness by building expertise in student-centered practices. As part of the program, we are developing a sequence of workshops that is helping create faculty learning communities and provide support for ongoing collaborations. A variety of instruments are being used to assess the effectiveness of our efforts. Pre-post-retrospective surveys are being used to probe how attitudes, subjective norms, and perceived self-efficacy predict faculty intentions to implement active learning pedagogy. Four repeated-measures ANOVAs are determining differences between each construct across the three time points. In addition, linear regression is being used to determine the ability of attitudes, norms, and self-efficacy to predict intentions. Preliminary results will be presented and implications for the design, implementation, and evaluation of professional development programs will be discussed.

### GC06: 1:50-2 p.m. Hands-on Physics Demos – A New Approach

*Contributed – James Lincoln, PhysicsVideos.com, AAPT Films, PO Box 11032, Newport Beach, CA 92658; LincolnPhysics@gmail.com*

Physics Demos must now be in the hands of students. Current Physics Education Research Demands Interactive Learning! But, how can we change our old demonstrations to make this possible? In this talk, I outline how to do this effectively, and how to get the most out of Physics Demos, which help blur the line between laboratory and activity, making the classic demos more engaging and active in order to reach more students, while at the same time highlighting new demos that you probably don't know about.

### GC07: 2-2:10 p.m. Integrating a Learning Community of Learning Assistants and Teaching Assistants

*Contributed – Manher Jariwala, Boston University, 590 Commonwealth Ave., Boston, MA 02215; manher@bu.edu*

*Kathryn Spilios, Bennett Goldberg, Boston University*

At Boston University, the physics department supports both a robust undergraduate Learning Assistant (LA) program as well as the formal professional and pedagogical development of graduate students through participation in the CIRTL (Center for the Integration of Research, Teaching, and Learning) Network. We describe our recent efforts to integrate the pedagogical training of undergraduate LA's and graduate student TA's and to promote partnership in teaching between LA's and TA's, leveraging best practices from both the LA and CIRTL programs. We also provide examples of individual change agents that have emerged from each group and discuss the common elements and shared values between undergraduate and graduate students efforts.

## Session GD: Introductory Courses

**Location:** CC - Room 311
**Sponsor:** AAPT
**Date:** Wednesday, July 20
**Time:** 1-2:40 p.m.

*Presider: DJ Wagner*

### GD01: 1-1:10 p.m. Satellite Splat! Exploring Sticky Collisions with a Surface Launched Projectile

*Contributed – Philip R. Blanco, Grossmont College, 8800 Grossmont College Drive, El Cajon, CA 92020-1799; philip.blanco@gcccd.edu*

*Carl E. Mungan, United States Naval Academy*

A projectile launched from the surface of a planet collides and sticks to satellite in a circular orbit. What happens next? The resulting motions display a rich variety of outcomes dependent on the projectile's trajectory, the satellite's orbital radius, and the projectile/satellite mass ratio. We show how conservation of mechanical energy, angular momentum, and linear momentum are used to determine whether the combined object will subsequently crash into the surface of the planet, remain in orbit, or escape. One important result is that there is a maximum orbital radius beyond which a satellite cannot be brought down in this manner. This exercise can help students gain insight into the role of angular momentum in orbital motion. We shall present simulations of some of the motions involved, and suggest further investigations for students to explore.

### GD02: 1:10-1:20 p.m. Students' Understanding of "Centripetal Acceleration" as Evidenced by Answers to a Guided Inquiry-based lab

*Contributed – D. G. Sumith P. Doluweera, Georgia State University, 25 Park Place, Atlanta, GA 30303; ddoluweera@gsu.edu*

*Brian D. Thoms, Joshua Von Korff, Carola Butler, Georgia State University*

GSU is a comprehensive PhysTEC site and has undertaken a reform of calculus-based physics labs in introductory physics sequence I and II. Enhancing students' conceptual understanding of basic physics is a major goal of lab reforms. FCI is the standard instrument of measuring conceptual understanding of mechanics and FCI gains recorded after the introduction of reformed labs (Fall 2014 and later) show significant increase in gains. Increased gains suggest that labs have positively impacted on students' learning. To further investigate the effectiveness of the labs one of the guided inquiry based labs developed, "Centripetal Acceleration" is presented as a case study. An analysis of students' answers for the selected lab for understanding related concepts, how well students managed to get good data, understanding and interpreting graphs, and making a conclusion based on available data are discussed.

### GD03: 1:20-1:30 p.m. Student Symbolic Problem Solving Skills in Introductory Calculus-based Physics

*Contributed – Gregory Mulder, Oregon State University, 1500 SW Jefferson St., Corvallis, OR 97331; mulderg@linnbenton.edu*

Symbolic reasoning is a critical skill for being a physics major, particularly in making the transition from introductory to more advanced physics courses. We explore students' performance and views about solving and interpreting problems symbolically. We will present the results of problem solving interviews with students in a third quarter of calculus-based introductory physics course. During these interviews, students solve pairs of problems with numeric and symbolic parameters. We will discuss differences in student performance on these two problem types and consider cognitive affordances of numeric and symbolic parameters.

### GD04: 1:30-1:40 p.m. Power Boxes: A Novel Graphical Representation of Energy in Circuits

*Contributed – Jason E. Dowd, Duke University, 137 Bio Sciences Building, Durham, NC 27708; jason.dowd@duke.edu*

*Daryl McPadden, Florida International University*

*Eric Brewe, Florida International University*

In order to clarify and provide a conceptual understanding of energy use in circuits, we introduce a new representation for analyzing DC circuits – Power Boxes. Although DC circuits are not generally considered to be among the most insidious topics in introductory physics courses, understanding the role of energy in such circuits can be deceptively challenging. Oftentimes, students see circuits as an infinite source of energy, and many mechanical energy analogies only further this idea. Instead, Power Boxes allow us to discuss and illustrate the role of electric potential energy in circuits at a given time, while simultaneously building upon (rather than competing with or writing over) representations of energy established in mechanics. Power Boxes can provide an intermediate, conceptual step between drawing a circuit diagram and writing equations.

### GD05: 1:40-1:50 p.m. Implementing Studio Physics: The Effect on Physics Identity Development

*Contributed – Robynne M. Lock, Dept. of Physics & Astronomy, Texas A&M University-Commerce, PO Box 3011, Commerce, TX 75429; robynne.lock@tamuc.edu*

*William G. Newton, Melanie Schroers, Dept. of Physics & Astronomy,* *Texas A&M University-Commerce*

The number of students earning bachelor's degrees in physics has increased in recent years but remains small. To increase the number of physics majors, modifications to introductory courses are needed. Strategies found to have a positive effect on physics identity, a predictor of physics career choice, include focusing on conceptual understanding and students teaching classmates. Models such as Studio Physics and SCALE-UP are consistent with these strategies. Additionally, these models have previously been found to improve problem-solving ability and to have a neutral effect on attitudes. We report on the implementation of Studio Physics in our two-semester introductory calculus-based physics sequence at Texas A&M University-Commerce. The effect of Studio Physics on students' physics identities was measured using a previously-developed physics identity instrument. Additionally, we interviewed students. We measured the effect on conceptual understanding through pre/post testing with the Force and Motion Conceptual Evaluation and the Brief Electricity and Magnetism Assessment.

### GD06: 1:50-2 p.m. Game Design and Demonstration to Highlight Evidence-based Reasoning

*Contributed – Kathleen A. Harper, Department of Engineering Education, The Ohio State University, 244 Hitchcock Hall, 2070 Neil Ave., Columbus, OH 43210; harper.217@osu.edu*

At Ohio State, an elective engineering course, based on Maloney's work,[1] focuses on puzzles and games as metaphors for human problem solving and scientific reasoning. One activity that is currently unique to Ohio State's offering is a game design and demonstration assignment. This experience not only incorporates engineering principles, but prompts the students to think critically about the role of evidence. Students work in groups to design a new game, with the constraint that they may only use materials from the four games they previously played in class. Once they have developed a full set of rules for the new game, they must create a short series of demonstration games that, when observed by someone unfamiliar with the game, will allow that person to determine the rules. Details of the assignment, along with samples of student work, will be shared.

1. Maloney & Masters, "Learning the Game of Formulating and Testing Hypotheses and Theories," Phys Teach 48, 22-24 (2010).

### GD07: 2-2:10 p.m. Changing the Paradigm of the Jumping Ring Demonstration*

*Contributed – Rondo N. Jeffery, Weber State University, 2508 University Circle, Ogden, UT 84408-2508; rnjeffery@msn.com*

*Farhang Amiri, Weber State University*

The opposing-poles explanation for the force on the jumping ring is challenged by recent experiments using a long-coil design where the ring is allowed to move over the energizing coil and not just the extended iron core. Iron filings show a dipole field pattern, with a reversal of the radial magnetic field at the center of the long coil. Rings jump up or down, depending on if they are placed above or below the point where the radial field changes sign, called the Null Point. With the apparatus in the horizontal configuration, narrow rings will jump left or right of the Null Point. This contradicts the prediction of the opposing-poles theory but is completely consistent with the Lorentz force theory. We hope these new results will open a dialog on the proper explanation to give for this popular physics demonstration.

*www.jumpingring.com

### GD08: 2:10-2:20 p.m. Data-Driven Efforts to Improve General Physics at NIU

*Contributed – Michael Eads, Northern Illinois University, Department of Physics, LaTourette 202, DeKalb, IL 60115; meads@niu.edu*

*Greg Alley, Wataru Hashimoto, Northern Illinois University*

Northern Illinois University is a large, public, research university located 40 miles west of Chicago. About 500 students enroll in algebra- and calculus-based general physics courses each semester. The format of these courses has historically been very traditional, focused on lectures with a weekly lab session. Starting in 2013, standard assessment instruments (such as the Force Concept Inventory) were administered as part of an effort to critically assess the effectiveness of these courses. As of the fall 2015 semester, concept inventories are being administered in all sections and levels. This data is now being used to help judge the effectiveness of several course improvement efforts, including a small Themed Learning Community section, and changes to instructional strategies, including active learning efforts. While state and university budget situations make for a challenging environment for course transformation, other efforts to improve the general physics sequence are ongoing.

### GD09: 2:20-2:30 p.m. Interpretations of Physics Differentials and Derivatives in Introductory Physics

*Contributed – Nathaniel Amos, 4751 Blairfield Dr. Apt. C, Columbus, Ohio 43214; amos.93@osu.edu*

*Andrew Heckler, Ohio State University*

Introductory university physics courses frequently involve calculus concepts in physical contexts. Existing evidence suggests that students in these courses may lack basic conceptual understanding of calculus in physics despite traditional calculus instruction. Because derivatives in physics can be understood as both instantaneous rates of change and quotients of differentials, we conducted group-tutorials to determine if training on either of these interpretations yielded differences in score on a short post-test, which assessed both. The "rate" condition emphasized derivatives as instantaneous rates of change; differentials were explicitly instructed as "not rates." By contrast, the "differential" condition avoided the concept of rate, and instead built derivatives from infinitesimal quantities, or "differentials." In addition, we also assessed the effect of units and dimensional analysis on this training. Our results show significantly higher post-test performance among students trained on the differential quotient interpretation of derivatives; dimensional analysis was not a significant main effect.

### GD10: 2:30-2:40 p.m. Why Active Learning Physics Teachers Should Think about Facework

*Contributed – Jon D. H. Gaffney, Eastern Kentucky University, 521 Lancaster Ave, NSB 3140, Richmond, KY 40475; jon.gaffney@eku.edu*

*Amy L. Housley Gaffney, University of Kentucky*

Interacting with other people requires a certain amount of vulnerability, and one of the ways we protect others and ourselves is through the mechanism of "facework." Face refers to the favorable self-worth that we hope others have of us; whenever we feel that self-worth threatened or attacked, we feel negative emotions such as embarrassment or shame. However, in social interactions, we can help others "save face," which should mitigate those negative feelings. As active-learning physics classes become more ubiquitous, teachers in those classes find themselves with the power (and obligation?) to support their students' face needs during classroom interactions. In this short talk, we discuss how facework correlates with student satisfaction, and we challenge teachers to think about their own classroom interactions in light of this theoretical construct.

## Session GE: Gender

**Location:** CC - Room 304/304
**Sponsor:** AAPT
**Date:** Wednesday, July 20
**Time:** 1-2:10 p.m.

*Presider: Mary Bridget Kustusch*

### GE01: 1-1:10 p.m. Gender Differences in Students' Epistemologies Regarding the Nature of Experimental Physics

*Contributed – Bethany R. Wilcox, University of Colorado at Boulder, 2510 Taft Dr., Unit 213, Boulder, CO 80302; Bethany.Wilcox@colorado.edu*

*Heather J. Lewandowski, University of Colorado at Boulder*

The existence of a gender gap has been repeatedly demonstrated in scores on conceptual and attitudinal assessments. This gap is often present in student's pre-instruction scores and persists in their post-instruction scores. One instrument that has not been examined for the existence of a gender gap is the Colorado Learning Attitudes about Science Survey for Experimental Physics (E-CLASS). Here, we utilized a national data set of responses to the E-CLASS to determine if they demonstrate a significant gender gap. We also investigate how this gap varies along multiple student and course demographic slices, including course level (first-year vs. beyond-first-year), major (physics vs. non-physics), and pedagogy (traditional vs. transformed). We find that a gender gap in pre- and post-instruction scores is observed in nearly all cases; however, when controlling for pre-instruction scores, the gap in post-instruction scores vanishes for several of these sub-populations (e.g., physics majors and beyond-first-year students).

### GE02: 1:10-1:20 p.m. Sense of Belonging in STEM: Intersections of Race and Gender

*Contributed – Katherine D. Rainey, University of Colorado at Boulder, 4998 Moorhead Ave. Apt 210, Boulder, CO 80305-5567; katherine.rainey@colorado.edu*

*Melissa Dancy, University of Colorado at Boulder*

*Elizabeth Stearns, Roslyn A. Mickelson, Stephanie Moller, University of North Carolina at Charlotte*

Sense of academic and social belonging have been shown to affect retention and performance of students in STEM. Though many studies have looked at differences among gender or race in this respect, few studies discuss the intersections of the two. To investigate factors contributing to students' choices to major in STEM, interviews were conducted with over 300 college seniors who majored in STEM, left a STEM major, or avoided majoring in STEM. Interviews were analyzed and coded based on social connection and study habits. In this presentation, we discuss factors regarding women's sense of belonging in STEM, specifically focusing on racial aspects.

### GE03: 1:20-1:30 p.m. Sentiment Analysis of Teaching Evaluations to Explore Gender Bias

*Contributed – Scott V. Franklin, Rochester Institute of Technology, 1 Lomb Memorial Drive, Rochester, NY 14623-5603; svfsps@rit.edu*

*Andamlak Terkik, Emily Prud'hommeaux, Cecilia Ovesdotter Alm, Rochester Institute of Technology*

Sentiment analysis is a computational linguistics tasks that characterizes affective meaning, such as positive-negative tone, expressed in language data. We analyze more than 5,500 student comments spanning over eight years of biology, chemistry, physics, and math courses and explore differences in sentiment pertaining to instructor competence, organization/presentation, personality/helpfulness, and overall satisfaction. Of particular interest are differences in perception conveyed toward male and female faculty, and between faculty of different disciplines. We also compare automatically extracted sentiment scores with quantitative Likert ratings that students enter alongside their comments, and report on the extent to which the quantitative and qualitative evaluations correlate.

### GE04: 1:30-1:40 p.m. Student Discourse About Equity in an Introductory College Physics Course

*Contributed – Abigail R. Daane, Seattle Pacific University, 3307 3rd Ave., West Seattle, WA 98115-3755; abigail.daane@gmail.com*

In a typical introductory college calculus-based physics course, the makeup of the classroom looks much like the physics community, including few women and even fewer underrepresented minorities. This lack of representation is well known, but is rarely an explicit topic of conversation in physics courses. In an introductory physics course at Seattle Pacific University, I facilitated several activities aimed at raising student awareness about the disparity between the demographics of the physics community and the demographics of the general population. Students had the opportunity to discuss and reflect about what it means to do physics, who does it, and why particular groups of people are not equitably represented in the field. In this presentation, I share preliminary findings about the impact of and response to these activities.

### GE05: 1:40-1:50 p.m. The Role of Personality and Gender in Performance in Physics

*Contributed – Rossina B. Miller, West Virginia University, 436 Pennsylvania Ave., Morgantown, WV 26501; rtmiller@mix.wvu.edu*

*John Stewart, Seth Devore, West Virginia University*

The Big Five Inventory (BFI) measuring the 5-factor personality model was given to 804 science and engineering students in introductory physics classes across two semesters at a large Eastern university. Science and engineering students showed similar personality characteristics as would be expected from measurements of the general population, with only women scoring significantly differently on the neuroticism scale. The BFI facets had differential explanatory power for test average and course grade with the conscientiousness facet as the only significant treatment effect for course grade, but it was not significant for test average. Personality facets, when combined with high school GPA, explained substantially different levels of variance in course grade for male and female physics students.

### GE06: 1:50-2 p.m. Learning Assistant Practices in an Active Learning Landscape

*Contributed – Hagit Kornreich-Leshem, Florida International University, 11200 SW 8th, Miami, FL 33199; hkornrei@fiu.edu*

*Rocio Benabentos, Zahra Hazari, Geoff Potvin, Laird Kramer, Idaykis Rodriguez and institute, Florida International University*

With increased efforts to engage women and underrepresented minorities in STEM our project focuses on the impact of Learning Assistants in collaborative STEM College classrooms on student success and intent to pursue a STEM career. Using epidemiological-type methods, this retrospective cohort study examines the extent to which classroom interactions with Learning Assistants influence academic outcomes, affective outcomes and career aspirations. LA practices under examination include frequency of interactions, type of conversations between LAs and students, discussion facilitation, conditions that broaden student participation, and positioning acts. Controlling for experiences outside the classroom with and without LAs, study habits and instructor interactions allows for a construction of predictive models that isolate the effect of in-class student interactions with LAs. We will present findings that bridge practice and research and provide foundation for addressing issues associated with student success and retention in Introductory STEM courses.

### GE07: 2-2:10 p.m. Impacts of Lecture-based Teaching and Faculty Disconnection on STEM Majoring

*Contributed – Melissa Dancy, University of Colorado, Dept. of Physics, Boulder, CO 80309; melissa.dancy@gmail.com*

*Katherine Rainey, University of Colorado*

*Elizabeth Stearns, Roslyn Arlin Mickelson, Stephanie Moller, UNC - Charlotte*

Over 300 university seniors were interviewed about their experiences pursuing a major. The students were either STEM majors, had left a STEM major, or had considered but never pursued a STEM major. The majority of students interviewed were from an underrepresented group, i.e. women and/or racial minority. Students reported a preference for interactive teaching yet experienced high levels of lecturing in college classes. Additionally, they report positive influences of high school teachers but rarely of college faculty in their decisions to pursue or continue a STEM major. Students report particularly negative experiences in physics. Poor college level teaching appears to disproportionately impact underrepresented groups.

## Session GF: Technologies

**Location:** CC - Room 306
**Sponsor:** AAPT
**Date:** Wednesday, July 20
**Time:** 1-2 p.m.

*Presider: Toby Dittrich*

### GF01: 1-1:10 p.m. Arduino in Electronics Course Leads to Arduino and FPGA Student Research Projects

*Contributed – Michele McColgan, Siena College, 515 Loudon Road, School of Science, Loudonville, NY 12211; mmccolgan@siena.edu*

Students are introduced to programming the Arduino with Matlab, Simulink, and the Arduino IDE in a sophomore-level electronics course. Students continue with independent studies and summer research projects using the Arduino and the Xilinx Zedboard FPGA. Examples of student projects will be presented.

### GF02: 1:10-1:20 p.m. Wave Shaping by Guitar Amplifier Tubes

*Contributed – David Keeports, Mills College, 5000 MacArthur Blvd., Oakland, CA 94613; dave@mills.edu*

*Alex Riaboff, Mills College*

It is commonly claimed that overdriven tube guitar amplifiers produce sound superior to transistor amplifiers because tube amplifiers produce prominent second harmonics while transistor amplifiers produce prominent third harmonics. In my previous talk, I provided evidence for the validity of this claim by inputting sine waves and examining overdriven tube and transistor output in the frequency domain. In this talk, I will consider tube output in the time domain. Surprisingly, output wave shapes at speakers for tubes are often considerably more complex than wave shapes predicted from tube function. Output from a very simple tube preamp built by one of my students provides a convincing explanation of this difference.

### GF03: 1:20-1:40 p.m. Ron Edge: String and Sticky Tape

*Contributed – Donald G. Franklin, Penfield College of Mercer University, 39 West Main St., Hampton, GA 30228, donfranklin8@gmail.com*

Ron Edge has contributed many articles for the Economic Way to Teach Physics. String and Sticky Tape allows for any teacher anywhere to show their students how physics is part of their life.

### GF04: 1:40-1:50 p.m. Periodic Roads and Quantized Wheels

*Contributed – Eduardo De Campos Valadares, Physics Department-ICEx, Federal University of Minas Gerais (UFMG), Av. Antonio Carlos, 6627 Belo Horizonte, MG 31270-901 Brazil; ecamposv@fisica.ufmg.br*

A simple approach to determine all possible wheels that can roll smoothly without slipping on a periodic roadbed while keeping their center of mass at a constant level is proposed. The inverse problem of obtaining all quantized wheels by determining the roadbed profile compatible with a specific wheel is also addressed.[1-5] It is highlighted the role of symmetry, which might preclude the center of mass to be at a constant level. Illustrative examples highlight counter-intuitive aspects of the world of non-conventional wheels and potential applications.

1 Eduardo C. Valadares, "Physics on sale – Brazilian style", Physics World 12, p. 64 (1999). 2 Jeffrey R. Regester, "A Long and Bumpy Road", The Physics Teacher 35, 232-233 (1997). 3 Eduardo de Campos Valadares, "Physics, Fun, and Beyond", Prentice Hall, 2006, pp. 45-48. 4 Leon Hall and Stan Wagon, "Roads and Wheels", Mathematics Magazine, Vol. 65, No. 5. (Dec, 1992), pp. 283—301. 5 Nelson H. Klein, "Square Wheel", Am. J. Phys. 61, 893-896 (1993).

### GF05: 1:50-2 p.m. Electronic Lab Notebooks Using Blackboard, Microsoft Word, and Livescribe Pens

*Contributed – Adam C. Lark, Hamilton College 198 College Hill Rd., Clinton, NY 13323-1218; daltonurza@gmail.com*

In this new digital age, students are far more accustomed to typing documents than writing documents by hand. Despite this, laboratories have typically had difficulty moving to electronic documents. Equations and diagrams are simultaneously an essential part of a lab notebook and difficult to generate digitally. I propose a way of using Blackboard, Microsoft Word, and Livescribe pens to implement electronic lab notebooks in a lab setting. Blackboard is used to administer the electronic documents, Microsoft Word to compose the document, and Livescribe pens to easily digitize equations and diagrams. With this system, the introductory physics laboratories at Hamilton College have accomplished electronic lab notebooks successfully through the past year.

## Session GG: Two Years of New AP Physics 1 and 2

**Location:** CC - Room 307
**Sponsor:** Committee on Teacher Preparation
**Co-Sponsor:** Committee on Physics in High Schools
**Date:** Wednesday, July 20
**Time:** 1-2:30 p.m.

*Presider: Rebecca Howell*

*As the second year of the new AP Physics 1 and AP Physics 2 courses closes many instructors and administrators are interested in how the changes have affected high school physics students. A presentation of scores, college credit acceptance, and expanded accessibility will be the focus of this session. Members of the AP Test Development Committee will be present to share their opinions and experiences with the newly designed courses. At the conclusion of the presentation, attendees will be given the opportunity to ask questions of the panelists and engage in professional discussion.*

### Panelists:

*Oather Strawderman, Lawrence Free State H.S.*

*Gay Stewart, University of West Virginia*

*Trinna Johnson, College Board*

## Session GH: Mining Data Generated in the Classroom

**Location:** CC - Room 308
**Sponsor:** Committee on Educational Technologies
**Co-Sponsor:** Committee on Research in Physics Education
**Date:** Wednesday, July 20
**Time:** 1-2:30 p.m.

*Presider: Bruce Mason*

### GH01: 1-1:30 p.m. Big Data and PhysPort

*Invited – Eleanor C. Sayre, Kansas State University, 116 Cardwell Hall, Manhattan, KS 66506; esayre@gmail.com*

*Adrian M. Madsen, American Association of Physics Teachers*

*Sarah B. McKagan, American Association of Physics Teachers*

PhysPort (http://physport.org) is a website that supports physics faculty in implementing research-based teaching practices in their classrooms, by providing expert recommendations about teaching methods, assessment, and results from PER. The PhysPort Data Explorer is an intuitive online tool for physics faculty to analyze their assessment data. Faculty upload their students' responses using our secure interface. The Data Explorer matches their pre/post data, scores it, compares it to national data, and graphs it in an interactive and intuitive manner. We accept data in almost any format for the most popular research-based assessment instrument in physics (FCI, FMCE, BEMA, CSEM, CLASS, MPEX); more assessments will be available soon. We augment Data Explorer data with secondary analyses of all peer-reviewed papers which publish data from U.S. and Canadian colleges and universities to compare the effects of different teaching methods at different kinds of institutions with varying student populations. We investigated student understanding in introductory mechanics & EM and student beliefs and attitudes across the curriculum. In this talk, I'll detail some initial results from the Data Explorer and compare them to published literature.

### GH02: 1:30-2 p.m. Mining FCI Data to More Effectively Diagnose Student Conceptions*

*Invited – Eric Brewe, Florida International University, 11200 SW 8th St., Miami, FL 33199; ebrewe@fiu.edu*

*Jesper Bruun, Ian Bearden, University of Copenhagen*

We describe a project using network analysis of existing FCI data to identify modules of student conceptions. This project, which is an alternative to factor analysis, uses network analysis to find and characterize latent structure within the dataset. The is built on a small data set, however, the scalability and intent of identifying patterns within a dataset are consistent with the move to big data. We describe our approach that involves constructing a bipartite network of students by answers, projecting this to an answer network, using sparsification methods to reduce our data, and community detection to identify modules of student ideas. Our work identified nine modules which we then interpreted. We present several modules along with our interpretation and distinguish these from factors found using factor analysis. Finally, we discuss how network analysis will be used to provide more robust diagnostic analysis of existing assessment tools like the FCI.

*This work supported in part by NSF grant PHY 1344247

### GH03: 2-2:30 p.m. It's All in the Data – But What Is It?

*Invited – Gerd Kortemeyer, Michigan State University, East Lansing, MI 48825; kortemey@msu.edu*

Even without being "massive," online components of blended, flipped, or virtual courses produce vast amounts of data: accesses, submissions, transactions, discussions, navigation -- down to one-second resolution for every student, already transcribed and contextualized. Before "Learning Analytics" became a buzzword for campus administrators and redefined into what more correctly may be characterized as "Academic Analytics," transactions within courses were analyzed as a unique window into student learning. Over the last 15 years, what have we found in the data streams generated within our physics courses with respect to learning effectiveness, student behavior, and success factors?

## Session EL: The Great American Eclipse of 21 August 2017: Preparing for Maximum Impact

**Location:** CC - Room 317/318
**Sponsor:** Committee on Space Science
**Date:** Tuesday, July 19
**Time:** 1:30-3:20 p.m.

*Presider: Richard Gelderman*

### EL01: 1:30–2 p.m. The Citizen CATE Experiment for the Great American Eclipse

*Invited – Matt Penn, National Solar Observatory, 950 N Cherry Ave ,Tucson, AZ 85719; mpenn@nso.edu*

*Richard Gelderman, Western Kentucky University*

*Don Walter, South Carolina State University*

*Mike Pierce ,University of Wyoming*

*Robert Baer, Southern Illinois University Carbondale*

The total solar eclipse of 21 August 2017 will be viewed by 10 million Americans, and will be seen on broadcasts by hundreds of millions. The Citizen Continental-America Telescopic Eclipse (CATE) Experiment is a partnership of five universities, three corporations, three national research labs, and 100 citizen volunteers from middle school to retirement age. CATE uses 60 identical telescopes from Oregon to South Carolina to record the solar corona, revealing 90 minutes of plasma dynamics never before seen. After the eclipse, the project will reinvigorate citizen science by transferring the experiment equipment to the volunteers and providing more citizen science projects. The goals for CATE range from providing an authentic STEM research experience for students and lifelong learners, to making state-of-the-art solar coronal observations of the plasma dynamics of coronal polar plumes, to increasing the U.S. scientific literacy.

### EL02: 2-2:30 p.m. Preparing Teachers and Students for the Eclipse

*Invited – Andrew Fraknoi, Foothill College, 12345 El Monte Rd., Los Altos Hills, CA 94022; fraknoiandrew@fhda.edu*

I will discuss how this "All-American" eclipse (with enormous media and public interest anticipated) presents an opportunity to teach students about eclipses specifically, and about solar science in general. (And to share activities, information sheets, and resources with K-12 teachers, staff in museums and nature centers, and librarians, to help them convey the relevant science with their students and audiences.) Astronomy Educator Dennis Schatz and I have written a book that includes 45 standards-aligned learning experiences (and lots of background information) about the Sun, the Moon, the sky, the calendar, and eclipses. Entitled "Solar Science," it is published by the National Science Teachers' Association. You can find a free booklet all about the eclipse and many other online resources from it by going to: www.nsta.org/solarscience. I'll present specific learning activities and discuss how viewing the eclipse safely is a local and national challenge worthy of our best efforts.

### EL03: 2:30-3 p.m. Solar Eclipses: From Omens of Doom to Einstein and Exoplanets

*Invited – Tyler Nordgren, University of Redlands, 1200 E Colton Ave., Redlands, CA 92373-0999; tyler_nordgren@redlands.edu*

Solar Eclipses are one of the few phenomena that have made the transition from omens of doom to utterly harmless tourist attraction.

Along the way they became the single most useful scientific tool for understanding our universe. Solar (and lunar) eclipses demonstrated a periodic cosmos that was therefore knowable while revealing the size and shape of the heavenly spheres. With the advent of modern astronomy, including advances in our understanding of physics (from atoms, to optics, and gravity) solar eclipses were the celebrated laboratory requiring globe-spanning expeditions that drew international attention. These culminated in the most famous eclipse expedition of all: the 1919 total solar eclipse that verified General Relativity and catapulted Einstein into the public imagination. Today there exists a huge range of simple physical phenomena and experiments accessible by the general public that can all be connected back to that most spectacular, yet rare, celestial phenomenon.

### EL04: 3-3:10 p.m. The Transient Response of Temperature Sensors to Step Temperature Changes

*Contributed – Kaye L. Smith, St. Catherine University, 2004 Randolph Ave., Saint Paul, MN 55105-1789; klsmith2@stkate.edu*

*Brittany Craig, Erick Agrimson, St. Catherine University*

*James Flaten, University of Minnesota, Twin Cities*

Accurate measurements of air temperature from high-altitude weather balloon payloads are complicated by extreme low temperature and low-pressure measurement conditions, sensor-reading transients, and multiple potential heat transfer mechanisms. In this talk, we present results of work measuring the transient response of different temperature sensors to step changes in temperature; an important consideration when designing an air temperature measuring system for use in weather-balloon-lofted missions to the stratosphere. Heat transfer models are used to compare the dynamic response of temperature sensors under different heat exchange mechanisms. The motivation for this work is the need to accurately measure temperature, and temperature changes, during high- altitude ballooning research activities, including experiments we plan to fly during the total solar eclipse that will cross the continental United States on August 21, 2017.

### EL05: 3:10-3:20 p.m. Stratospheric Balloon Studies of the August 21, 2017, Solar Eclipse

*Contributed – Erick Agrimson, St. Catherine University, 2004 Randolph Ave., St. Paul, MN 55105; epagrimson@stkate.edu*

*Gordon McIntosh, University of Minnesota, Morris*

*James Flaten, University of Minnesota, Twin Cities*

*Kaye Smith, St. Catherine University*

*Angela Des Jardins, Montana State University*

Groups that use weather balloons to lift science experiments into the stratosphere are awaiting the total solar eclipse of August 2017 with a wide variety of experiments planned. In particular, colleges and universities involved in the Stratospheric Ballooning Association (SBA) and those in NASA's National Space Grant College and Fellowship Program (Space Grant) have been collaborating to develop and disseminate flight hardware and to train additional faculty and students in this engaging STEM activity. This presentation will describe a variety of stratospheric ballooning experiments discussed in a recent SBA ballooning workshop and conference, with emphasis being given to two experiments our Minnesota team is preparing for flight. These experiments are (a) monitoring changes in the Pfotzer maximum for cosmic radiation during a solar eclipse, led by U of MN, Morris, and (b) studying variation in the thermal wake below ascending balloons during a solar eclipse, led by St. Catherine University.

## Session GJ: Teaching Physics in High Needs High Schools

**Location:** CC - Room 313
**Sponsor:** Committee on Professional Concerns
**Co-sponsor:** Committee on Physics in High Schools
**Date:** Wednesday, July 20
**Time:** 1-3 p.m.

*Presider: Colleen Megowan-Romanowicz*

### GJ01: 1-1:30 p.m. Twenty Plus Years of Physics Teacher Professional Development in Rural Kansas

*Invited – Paul E. Adams, Fort Hays State University, 600 Park St., Hays, KS 67601-4099[ padams@fhsu.edu*

*Earl Legleiter, Legleiter Consulting*

Fort Hays State University (FHSU) has focused on providing professional development for teachers of physics in high need schools —primarily rural schools in Kansas -- for over 20 years. Through numerous grants and formation of partnerships with other universities and service centers, FHSU has provided not only professional development for cross-over, novice, and expert physics teachers utilizing the Modeling Method of physics instruction, but also thousands of dollars of teaching apparatus from sensors to robots, and a support system for physics teachers in high need areas. While our efforts have been successful, it required meeting the challenge of place and time bound teachers, under-funded school districts, shortage of STEM teachers, and leveraging resources of time, talent and treasure. The experiences—both success and failures—at FHSU provide insight for other institutions looking for ideas to provide sustained ongoing professional development to assure high-quality physics teaching for all students.

### GJ02: 1:30-2 p.m. Sometimes the Science Comes Second: Modeling in High Needs Schools

*Invited – Steve Nixon, Marina High School, 1537 Devers Ct., Marina, CA 93933; stnixon@gmail.com*

One of the major challenges faced in a high needs school is the students' social emotional health. Instructional curricula such as Modeling can be an effective technique to boost the social emotional health of students while also increasing academic achievement in physics classes at multiple levels. Specifically, in my experience, Modeling techniques, such as goalless problems and whiteboarding, along with other instructional strategies like Project Based Learning, increase scientific reasoning skills, student confidence, and student engagement. I will present Classroom Test of Scientific Reasoning results and in-class evidence and anecdotes of student gains that span multiple schools.

### GJ03: 2-2:30 p.m. Reflections on Modeling Instruction in Urban Schools

*Invited – Bradley Gearhart, Buffalo Public Schools, 256 South Elmwood Ave., Buffalo, NY 14201; fizz6guy@yahoo.com*

*Dan MacIsaac, Kathleen Falconer, Buffalo State College*

Over the past decade, I have employed Modeling Instruction as the main mechanism by which physics content is delivered in my classroom. During that time, my classroom setting has varied greatly as I transitioned from a private catholic school, to a high-achieving suburban school, and finally to an under-performing urban school district. Despite the diverse demographic and socio-economic shifts that came with each transition, my use of Modeling Instruction and reflection have been important to me as I have seen the benefits in each of these educational environments. During this talk, I will use student work and RTOP to define the quality of instruction, describe how extending Modeling Instruction within the Buffalo Public School District and mentoring my colleagues through the Interdisciplinary Science and Engineering Partnership (ISEP) informs and develops my physics teaching practices.

### GJ04: 2:30-2:40 p.m. Motivating Students with Limited Skills to Learn Physics Concepts Through Challenges

*Contributed – Cliff Gerstman, Middle College High School, 3325 GOndar Ave., Long Beach, CA 90808; cliffg37@verizon.net*

Having taught physics for 10 years in the inner city of South Central Los Angeles, I needed to develop ways to motivate students with low interest and limited math skills to really grab physics concepts. What I came up with was a series of one or two class competitions that made students want to succeed. Each challenge competition would come with a goal, and analysis questions to be answered individually by the students. In this round about method, students answered questions and internalized concepts without ever realizing they were doing so.

### GJ05: 2:40-2:50 p.m. Crossing Cultural Borders

*Contributed – Danny Doucette, International School of Latvia, Meistaru iela 2, Pinki, LV-2107 Latvia; danny.doucette@gmail.com*

Many of the challenges we face as teachers stem from the tremendous cultural divide between students' experiences outside of the classroom and the unique physics culture they find within. The concept of cultural border crossing is a useful way to understand students' experiences and needs. By approaching language learning, gender/racial gaps, and student disengagement as aspects of cultural border crossing, we can engage with the root causes of students' cultural challenges and change our teaching practice appropriately.

## Session GK: Do Try This at Home!

**Location:** CC - Room 314
**Sponsor:** Committee on Apparatus
**Date:** Wednesday, July 20
**Time:** 1-2:50 p.m.

*Presider: Stephen Irons*

### GK01: 1-1:30 p.m. From Online Stunt to Science Literacy*

*Invited – Pati Sievert, Northern Illinois University STEM Outreach, DeKalb, IL 60115; psievert@niu.edu*

Between YouTube and Pinterest, there's plenty of bad science mixed in with some really cool things for our students to try out at home. How do we turn a cool science activity found online into good science that's still fun? I'll dissect a few old standards along with some bad examples you can turn to your advantage. Having pre-collegiate students interact with family members in the execution of their "at home experiment" can increase both the student and family members' understanding of scientific processes, which along with engineering processes are one thread in the three dimensional NGSS.

*www.niu.edu/stem

### GK02: 1:30-2 p.m. Get Your Science On with the Little Shop of Physics

*Invited – Brian Jones, Colorado State University, Physics Department, 1875, Fort Collins, CO 80523; brian.jones@colostate.edu*

The Little Shop of Physics team has shared our hands-on science experiments with half a million K-12 students. Our emphasis is on accessibility—we want the barrier to experimentation to be low. We have a podcast series that tells students how they can reproduce anything we've built at home, and we make sure that the necessary skills and equipment are quite basic. In this talk I'll share some of our favorite experiments, and show where you find information about many more.

### GK03: 2-2:30 p.m. Physics Beyond the Formulas: Creating and Sharing Demonstrations

*Invited – Dianna L. Cowern, Physics Girl, PO Box 9281, San Diego, CA 92169; dianna.leilani@gmail.com*

In classroom learning, the question is often asked, "what does this have to do with real life?" Some of the most effective learning comes from student-driven questions, curiosity and from when students can tie learning concepts to their daily lives. The aim of the PBS YouTube series Physics Girl has been to connect physics to the real world in a conceptual way through curiosity-inspired questions. There are two parts to this talk. One will focus on the characteristics of effective physics demonstrations as guided by the success of certain experiment-based physics videos in an online world full of non-educational noise. What demos work in videos and why? The second part will focus on how sharing can enhance the learning experience. What makes viewers care about these demonstrations? This part will address the collaboration and feedback gained by sharing physics during the learning process.

### GK04: 2:30-2:40 p.m. Improving Student Involvement Outside of Class with Family Fizx Fun & Everyday Physics Calculations

*Contributed – Stephanie C. Hawkins, Barrington High School, 201 Lakewood Dr., Oakwood Hills, IL 60013; shawkins@barrington220.org*

Getting regular and low-level physics students to do schoolwork beyond the school day can be a major challenge. By asking students to do non-traditional homework has greatly improved my low level students' involvement beyond the school day. One important way to motivate the students is to incorporate parent support in at-home assignment. Family Fizx is a fun low expectation assignment that gets parents interested in helping their student success in my class. There are endless demos which students can take home to their families. Another at-home activity is real world data calculations, an example includes having students analyze the motion of a MapMyRun workout. Taking the excitement of physics home has allowed me to provide students with more learning experiences, increased parent involvement, and increased out-of-school participation for low-level students.

### GK05: 2:40-2:50 p.m. Try This Experiment Right Now!

*Contributed – Anna Spitz,* PhysicsVideos.com AAPT Films, PO Box 11032, Newport Beach, CA 92658; AnnaSpitzPhysics@gmail.com*

*James Lincoln, SCAAPT*

Physics experiments you can do with no additional equipment! Just the cell phone in your pocket or the computer in front of you. Created for the AAPT Films Video Project, this series continues and helps teachers and students who have little access to equipment or just want to learn something new!

*Sponsored by James Lincoln

## PERC Bridging Session

**Location:** Sheraton - Magnolia
**Sponsor:** AAPT / PER
**Date:** Wednesday, July 20
**Time:** 2-3 p.m.

*Presider: Rebecca Lindell*

### PER01: 2-2:30 p.m. Appropriate Use of Assessments Through Applications of Validity Theoretical Framework

*Invited – Kerrie A. Douglas, Purdue University, 516 Northwestern Ave., West Lafayette, IN 47906; douglask@purdue.edu*

When developers of assessment instruments, such as concept inventories or attitudinal surveys, share an instrument for others to use, they routinely provide some type of evidence of validity when they publish. In turn, the publication provides instructors, researchers, and evaluators with more tools to use for assessment and evaluation. However, there is no single methodology that can be used to generate a perfectly valid assessment instrument. In the end, all assessment instruments have strengths and limitations. The highest quality assessment instruments have been developed and studied for very specific purposes. Yet, others may want to use the instrument for different purposes. Therefore, there is a need to discuss what evidence is needed before using a published instrument. The purpose of this presentation will be to discuss in practical terms how to determine whether an assessment instrument is appropriate for a given use.

### PER02: 2:30-3 p.m. Network Analysis as a Research Methodology in PER

*Invited– Jesper Bruun, University of Copenhagen, Department of Science Education, Øster Voldgade 3, Copenhagen, DK 1350 Denmark; jbruun@ind.ku.dk*

In recent years a number of researchers within our PER community have started using Network Analysis as a new methodology to extend our understanding of teaching and learning physics by viewing these as complex systems. I will discuss how the work of our research group has identified relevant networks analyzing these networks. In so doing I will show how a network can be methodologically described as a set of relations between a set of entities, and how a network can be characterized and analyzed as a mathematical object. Then, as an illustrative example, I will discuss our current work that is using networks to create insightful maps of learning discussions. To conclude, I will show how the adoption of a complex system methodology can lead to rich interplays between qualitative and quantitative analysis to generate a powerful "mixed methods" methodological framing.

## Session HA: Post-deadline Papers I

**Location:** CC - Room 301
**Sponsor:** AAPT
**Date:** Wednesday, July 20
**Time:** 3-4:30 p.m.

*Presider: Kathleen Falconer*

### HA01: 3-3:10 p.m. Exploring Problem-based Cooperative Learning (PBCL) in Undergraduate Physics Labs

*Contributed – Shane Bergin, Trinity College Dublin School of Physics, Dublin, Dublin NA1 Ireland; berginsd@tcd.ie*

This study addresses the potential of problem-based cooperative learning (PBCL) as a teaching approach in expanding students' understanding of the scientific process and perceptions of their own learning, and in engaging students in higher order, problem-solving skills. Contrasting a traditional, manual-based approach to labs with a PBCL approach, this study provides further insight into issues surrounding lack of student engagement in their undergraduate learning. Participant-led methodology was utilized in constructing the research instrument and this analytic focus on engaging small groups of students as co-researchers enables another contribution of this research. Findings suggest that students in the PBCL group engaged in more higher-order, problem-solving skills and had a deeper understanding of the scientific process as a result of this approach to learning. Furthermore, students in the PBCL group were more positively engaged with their learning than their counterparts in the traditional, manual-based group.

### HA02: 3:10-3:20 p.m. Quantum Levitation for Teaching Modern and Classical Physics in Classroom

*Contributed – Boaz Almog, Quantum Experience ltd., Moskovich 13/35, Rehovot, 7647413; boazal@post.tau.ac.il*

*Itai Ben-Mordechai, Quantum Experience ltd.*

Quantum Levitation is one of the only quantum effects that are easily demonstrated in the classroom. By allowing students to engage in Quantum Levitation, construct their own levitation experiments, and explore different aspects of Quantum Locking (flux pinning) we learn about new and exciting physics while teaching students tools of data analysis and analytic conduct. We present specific Quantum Levitation experiments that my be used in two levels - as tools to explore classical physics (energy & momentum conservation, harmonic oscillator, etc.) and experiments in modern physics. We will show and review actual research work done by high-school students. The Quantum Levitation/Locking kits are developed by Quantum Experience ltd., a startup that came out of the High-Temperature Superconductivity research lab in Tel-Aviv University, Israel.

### HA03: 3:20-3:30 p.m. Practical Physics Illustrated by Steam Locomotives

*Contributed – Lewis C. Epstein, 614 Vermont St., San Francisco, CA 94107-2636; thinking@prodigy.net*

Here is Sacramento is a temple to the most wonderful machine, at once beautiful and useful , the Steam Railroad Engine and to its entourage of rolling stock, civil structures, and tools. The California State Railroad Museum draws more visitors than any other state museum or park because the art it exhibits, even in its silent stationary state, grips the attention of the eyes and the emotions of almost all who come into its presence. And behold, this sleeping steel thin is pure physics, inside and out. Not physics buried within some deep cryogenic magnetic confinement or supposedly coded into long lines of algebraic gibberish barbed with mysterious symbols and decorated by super and sub scripts unresolvable to 55-year old eyes. This thing was a free public circus of acts in mechanics, heat, optics…even economics. This is a gold mine of take home and remember stories about practical physics. Let me show you some…..

### HA04: 3:30-3:40 p.m. How to Make a Stone Skip More

*Contributed – Xing Guo Chien-Shiung, Wu College, Southeast University, Jiulonghu campus, NanJing, 211111 China; higuoxing@outlook.com*

*Zhiang Li Chien-Shiung, Zhihao Niu Chien-Shiung, Wu College, Southeast University*

It is generally known that the stone with a correct incidence angle and an accurate velocity could bounce many times on water. Previous works mainly focus on how to make a flat stone skip more times on water. In this paper, we investigate a new type of stone with a curved bottom that can bounce more times and can be more robust during its collision. Analytical model for the motion of the stone is presented. Experiments are conducted at the same time by using an effective stone skipping facility. The minimum skipping velocity indicating the efficiency of a stone is measured by this experiment setup. With the help of this experiment setup, the best stone for skipping on water can be found.

### HA05: 3:40-3:50 p.m. Pre-class Interactive Videos Using Powerpoint Mix

*Contributed – Shiladitya Raj Chaudhury, Auburn University, 353 Foy Hall, Auburn, AL 36849; schaudhury@auburn.edu*

*Ameya Kolarkar, Stuart Loch, Auburn University*

In an attempt to engage students with learning materials prior to their attendance in class, the investigators have been utilizing various methodologies for preparing pre-class interactive videos. Initial efforts included narrated, annotated videos that were accessible to students via YouTube. Data analytics provided insight into a rapid drop off in student viewing. In addition, fine grained viewing data was not readily available. We report here on our use of Microsoft Powerpoint Mix, a plugin available for the Office suite and readily utilized through use of the Microsoft Surface tablet. Mix allows embedding of interactive elements (such as quizzes and simulations) into the pre-class videos and provides detailed analytics on students' use of individual slides in the presentation. Preliminary results from student performance in calculus-based introductory physics courses at our institution will be presented.

### HA06: 3:50-4 p.m. Mechanical Response of Figure-Eight Knots as Physical Parameters Changes

*Contributed – Shazhiyuan Li Chien-Shiung, Wu College, Southeast University, No.2 Dongnandaxue Road,Jiangning Development Zone, Nanjing 211111, P.R.China; 915560950@qq.com*

*Junhong Chen Chien-Shiung, Qi Gu Chien-Shiung, Wu College, Southeast University*

Previous works indicate that the equilibrium shape of the knot is governed by interaction of topology, friction and bending. We propose a new experiment to study the mechanics of figure-eight knots. Our experiments discover the regularity of the pulling force in response to the increase of crossing numbers and our results do not coincide with former theory of crossing numbers. Our results show universality of many kinds of materials. Different from overhand knots, the figure-eight knots have a new type of mechanical response as the physical and topological parameters changes.

### HA07: 4-4:10 p.m. A New Approach in Calculating Occupation Numbers in Microcanonical Ensemble

*Contributed – Jixuan Hou, Physics Department, Southeast University, Jiulonghu campus, Nanjing, 211111 China; jixuanhou@hotmail.com*

*Cuiying SHEN, Southeast University*

Thermodynamic quantities, occupation numbers and the fluctuations of a one-dimensional bose gas confined by a harmonic potential are studied using different ensemble approaches. Combining number theory methods, a new approach is presented to calculate the occupation numbers of different energy levels in microcanonical ensemble. The visible difference of the ground state occupation number in the ground canonical ensemble and microcanonical ensemble is found to decrease by power law as the number of particles increases.

### HA08: 4:10-4:20 p.m. Analysis of Students' Understanding About Vectors and Forces

*Contributed – Judyanto Sirait, Tanjungpura University, Jl. Paris 2, Komp Green Hill A 19, Pontianak, Kalimantan Barat 78124; judyantosirait@gmail.com*

*Hamdani, Tanjungpura University*

*Erwina Oktavianty, Tanjungpura University*

The aim of this study is to analyze the ability of students to understand vectors as well as force concept. We involved 212 physics education students of Tanjungpura University who have taken a basic physics course. Students were asked to solve test of vector and test of force adapted from physics education research group. Test of vector (TUV) consists of 13 items and covers addition, subtraction, and component. Moreover, test of force (TOF) that has nine items covers three different contexts—horizontal surface, inclined plane, and pulling the rope. Before the tests were used, both tests have been validated by experts. We will report (i) students' performance in solving both tests; (ii) students' difficulties while solving the test, and (iii) the correlation between students' ability of vector and students' ability of force.

### HA09: 4:20-4:30 p.m. Comparing Multiple Standardized Assessment Tools in Large-Lecture Introductory Physics

*Contributed – Tor Odden, University of Wisconsin-Madison, 225 North Mills St., Office 215b, Madison, WI 53706-1380; todden@wisc.edu*

*Peter Timbie, University of Wisconsin-Madison*

The University of Wisconsin-Madison Department of Physics is in the process of revising several of its introductory physics courses to incorporate reform-based teaching methods. In order to evaluate the effects of these changes, the department has been trying out and comparing multiple standardized assessment tools, both conceptual and problem-solving based, to see which is the best fit for the program. These assessments include the Force Concept Inventory, the Mechanics Baseline Test, the Conceptual Survey of Electricity and Magnetism, and the physics Survey Instrument. This presentation will report on the results of these comparisons, including correlations between assessments and course grades, correlations between different assessments, and the reliability of the assessments.

## Session HB: Post-deadline Papers II

**Location:** CC - Room 307
**Sponsor:** AAPT
**Date:** Wednesday, July 20
**Time:** 3-4:30 p.m.

*Presider: Larry Brandon*

### HB01: 3-3:10 p.m. Simeon Pease Meads: Science Educator and Unsuccessful Politician

*Contributed – William Pitt Palmer, 1/57 Male St., Brighton, V 3186 AUSTRALIA; bill_palmer15@hotmail.com*

A number of scientists have attempted to become politicians, though they have not always been successful. Simeon Pease Meads was born on 11th January, 1849 in South Limington, Maine. He taught at Oakland High School and became vice-principal in 1891. He invented and patented an electric alarm clock for ringing bells simultaneously throughout the school. In 1884 Meads wrote, Chemical Primer: An Elementary Work for use in High Schools, Academies, and Medical Colleges In 1894, he wrote an elementary physics text entitled Elements of physics for use in secondary schools. He later republished his Chemical Primer as Elements of Chemistry in 1891. Eventually he became Principal of Cole Grammar School in West Oakland from 1908–1916. Meads firmly believed in temperance, and was the Prohibition Party nominee for California Vice-Governor in 1902 and for Governor in 1910, though he was unsuccessful in both attempts.

### HB02: 3:10-3:20 p.m. Mechanical Analysis of the Falling Chimney

*Contributed – Zhiang Li, No.2, Dongnandaxue Road, Jiangning Development Zone, Nanjing, Jiangsu 211189 China; Chee-Uh_Lee@outlook.com*

*Xing Guo Chien-Shiung, Zhihao Niu Chien-Shiung, Wu College, Southeast University*

It is generally known that chimneys might break at a certain place before they hit the ground during a demolition blasting. However, previous models have assumed that the mass distribution of the chimney is uniform. The chimney model analyzed in this paper is a more realistic one with non-uniform mass distribution. Furthermore, clay miniatures are used to reproduce the falling process of a chimney. The experiment result is in good agreement with our outlined theory.

## HB03: 3:20-3:30 p.m. Fulbright Scholar Program: Teaching Experiences in Italy and Brazil

*Contributed – Stephen R. McNeil, Brigham Young University-Idaho, 525 South Center St., Rexburg, ID 83460-0520; mcneils@byui.edu*

The Fulbright Scholar Program is an excellent way to share PER experiences with our international colleagues. This presentation will focus on two types of Fulbright Grants (Specialist and Core), what it takes to get them, and some of my experiences in Italy and Brazil.

## HB04: 3:30-3:40 p.m. In-Lab Conceptual Effectiveness Through Validity and Reliability of Testing Tools

*Contributed – Jesus Valdez, UTEP 500 W. University, El Paso, TX 79968; javaldez5@miners.utep.edu*

*Sergio Flores, Karla Carmona, Roy J. Montalvo, Maria D. Gonzalez, UTEP*

Science labs aim to have students understand basic concepts through experimentation. A test is a useful tool to determine whether the lab exercises are effectively teaching the basic concepts to students. To give an accurate assessment, the testing tool must be both valid and reliable. Physics students at the University of Texas at El Paso (UTEP) are first introduced to Simple Harmonic Motion (SHM) in the lab weeks before the topic is covered in lecture and are tested on the concept of the following lab session. As a result, the student's knowledge of SHM comes solely from lab work. This study focuses on establishing the reliability of the testing tool for SHM utilized in the Physics labs at UTEP from the fall of 2014 to the spring of 2016 through the use of statistical methods. The study will also provide further direction based on the data obtained. If the test is deemed reliable, the reliability of each individual question relative to the rest will be used to find where improvements can be made. If the test is deemed nonreliable, the reliability of each question will be used to ascertain whether the test should be discarded or modified.

## HB05: 3:40-3:50 p.m. Teaching Physics Through Experience, Observation, and Analysis

*Contributed – Evan Pruitt, The Bishop's School, 7607 La Jolla Blvd., La Jolla, CA 92037; evan0390@gmail.com*

*Marcus Milling, The Bishop's School*

In both current and past physics education, there has been a desire and motivation to move from a didactic/rote mathematical approach to a more conceptual and inductive/inquiry-based approach. In this paper, we look to overcome the difficulties of creating a more student-centered approach that still allows for the rigor and organized concept building found in a didactic approach. This paper is specifically targeted for physics classrooms consisting of novice to intermediate learners. The proposed method for overcoming these difficulties is to ground the concepts in experiences gained in laboratory settings that accurately reflect how science is actually performed.

## HB06: 3:50-4 p.m. Students' Conceptual Understanding with Vector Operations

*Contributed – Carlos Cuellar, UTEP, 500 W. University, El Paso, TX 79968; crcuellarrodriguez@miners.utep*

*Sergio Flores, Maria D. Gonzalez, Roy J. Montalvo, Karla Carmona UTEP*

A functional understanding of this concept requires that students be able to reason about vectors in different contexts. We present data collected from more than 160 students and related to traditional instruction at The University of Texas at El Paso. This data describes students' conceptual difficulties with vector addition/subtraction. These students were organized in small groups led by student Teaching Assistants (TAs). TAs help students understand vector operations during a hands-on 50 minute session. Analysis of the data suggests that, after traditional instruction, some students were unable to reason qualitatively about the vector operations. We describe some specific procedural and reasoning difficulties we have observed (e.g. 1. Closing the loop, 2. Tip-to-tip, 3. Use of Pythagorean Theorem, 4. Adding as scalars, and 5. Reflection). We also describe initial measures of the effectiveness of the modified instruction approach.

## HB07: 4-4:10 p.m. Using Theories of Embodied Cognition to Investigate Center of Gravity*

*Contributed – Elise Agra, University of Chicago, 5848 S. University Ave., Green Hall 317, Chicago, IL 6063;7 eagra@uchicago.edu*

*Jason Sattizahn, Sian L. Beilock, University of Chicago*

*Megan Mikota, Susan M. Fischer, DePaul University*

Research on the topic of embodied cognition suggests that when sensorimotor brain areas are involved in thinking and reasoning, our conceptual understanding of action-related tasks can improve. In this study, we applied learning methods that involve the sensorimotor system to the concept of center of gravity. To create a sensorimotor (or embodied) experience, we developed a set of balancing activities using a meter stick and a set of disks. Participants in the embodied group balanced different systems of objects directly on their hands. Participants in the hands-on group used a fulcrum to balance the systems of objects but did not directly experience the feeling of balancing a system of objects. We will discuss the effect of training on post-test accuracy.

*This material is based upon work supported by the National Science Foundation under Grant No. 1348614.

## HB08: 4:10-4:20 p.m. Using the Mouse Trap Car Project to Reinforce Concepts Learned in AP Physics 1 Course

*Contributed – Ravi Lall, International Christian School, Hongkong 599 Sai Sha Road, Tower 5 Flat 5/H, Lake Silver Ma On Shan, NT 000 Hongkong; ravilall@outlook.com*

Using the mousetrap car project as the end of the year project to reinforce the concepts learned in the AP Physics 1 course. The students are assigned a task to design a mousetrap car with compact disks and commonly available materials. The fun part of this project is that it involves variety of concepts like Kinematics, Dynamics, work energy, momentum and also rotation. The students take measurements of speed, velocity, and acceleration using motion sensors and analyze the graphs produced. They also are given the task to find the force constant of the spring used in this mousetrap. To make things more complex I involve the rotary motion aspect also. They could even analyze the moment of inertia of the carts plus the wheels and relate this to the motion which they observe. In the end they write a report with all their investigations with graphs, pictures and video analysis of the motion.

## HB09: 4:20-4:30 p.m. Focusing on Concepts by Covering Them Simultaneously?

*Contributed – Peter V. Schwartz,* Cal Poly, Physics Department, 1 Grand Ave., San Luis Obispo, CA 93407; pschwart@calpoly.edu*

I made these changes after 15 years of lecturing introductory mechanics in conventional style: (1) flip the classroom, providing ~ 100 online videos; (2) use a free online text; (3) use "parallel pedagogy" where I introduce momentum, energy, dynamics, and kinematics on the first day of class and build in complexity throughout the quarter; and (4) transparently and collaboratively open our learning model to the students. Class time is dedicated to working problems in groups and building a supportive social network. Student acceptance, performance, and evaluations improves as I market our learning model with physics education literature and consult the students in curriculum development. Consistent with this learning model, before my presentation please (but come anyway if you don't): 1) See the video of our model for learning physics: www.playposit.com/public/32670/93718/different-mechanics-class 2) Look over the class: http://sharedcurriculum.wikispaces.com/Introductory+Mechanics+Spring+2016

*Sponsored by John Keller

## Session HD: Post-deadline Papers IV

Location: CC - Room 319
Sponsor: AAPT
Date: Wednesday, July 20
Time: 3-4:20 p.m.

*Presider:* Karen Cummings

### HD01: 3-3:10 p.m. Are End-Of-Chapter Problems Really "Localized"?

*Contributed – Bin Xiao, North Carolina State University, 3109A Kings Ct., Raleigh, NC 27606; bxiao@ncsu.edu*

*Robert Beichner, North Carolina State University*

End-Of-Chapter problems in physics textbooks are normally considered to be "localized" when they only practice the concepts within the chapter. We used an introductory-level physics textbook and analyzed the equations needed to solve each of the problems in the Electricity and Magnetism chapters to show how focused those problems are and how they related to other chapters. We also compared the current edition of the textbook to its first edition written 30 years ago. We noted an improvement on the connections between chapters.

### HD02: 3:10-3:20 p.m. Experiment-based Resources for Teaching Modern Physics

*Contributed – Gabriel C. Spalding, Illinois Wesleyan University, 201 E. Beecher St., Bloomington, IL 61702; gspaldin@iwu.edu*

Might you be interested in a very brief prequel to teaching Special Relativity, which illustrates—without the need for introducing any postulates—how time reversals can arise in very simple kinds of measurements? We're excited about our manuscript on "Observation of image pair creation and annihilation from superluminal scattering sources," published in Science Advances (2016). Using the same technologies, we have produced videos intended for classroom discussions regarding the basics of quantum mechanics, as described in our manuscript, "Video recording true single-photon double-slit interference," accepted for publication in American Journal of Physics (2016). Related materials are online at: http://sun.iwu.edu/~gspaldin/SinglePhotonVideos.html

### HD03: 3:20-3:30 p.m. Phield Based Physics

*Contributed – Michelle L. Arnold, Weber State University, 2508 University Circle, Ogden, UT 84408; marnold@weber.edu*

The Weber State Physics Department has developed several new introductory physics labs as part of a "Phield Based Physics" program. These labs are designed for students to see physics concepts in our everyday world, as well as to encourage them to be an active participant in the experimental process by making decisions about the details of the experiment they are doing. Some of these labs use IPads and various apps to directly measure everyday phenomena, such as videoing a falling object to determine the acceleration due to gravity. All of the labs encourage students to think about the experiment; for example the simple pendulum lab asks the students to consider what variables they could change to change the period of their pendulum and then they test whether these variables actually effect the pendulum's period or not. In addition, all the labs have been developed using everyday materials such as paper and pennies, which allow students to see that physics does not require specialized lab equipment but is in our everyday lives. In addition this allows for the option of labs to be conducted outside of the lab room if needed. These labs have been developed around the idea that students can directly experience and understand the physics in their world, and for them to feel a part of the experimental process when conducting their labs rather than just following recipe type directions. Some of the labs developed and feedback from students will be presented.

### HD04: 3:30-3:40 p.m. Reworking an Introductory Physics Lab Course for the Life Science Majors

*Contributed – Clark R. Snelgrove, Brigham Young University, 1158 S. 220 W. Orem, UT 84058; crsnel@byu.edu*

The curricula for the two-semester laboratory course for life science majors at BYU had not had a major revision in over 20 years. The lab equipment that was used was worn out and unreliable. Some lab activities didn't really "work" and the student culture had simply learned how to fake some activities to get a score. A major effort has been undertaken to redevelop the two course using information obtained from education research on learning. Also an effort has been made to make the activities more "authentic" to the life science students that take the course. I will report on the research that went into preparing write the curricula, the actual writing of the first of the two course, and the implementation of the curricula for the first of the two course during the last two semesters.

### HD05: 3:40-3:50 p.m. Design and Implementation of an Electromagneticc Concept Inventory

*Contributed – Francisco Ayala, UTEP 500 W. University, El Paso, TX 79968; fayalarodriguez96@outlook.com*

*Sergio Flores, Roy J. Montalvo, Karla Carmona, Maria D. Gonzalez, UTEP*

For the past three decades the force concept inventory (FCI) has been a reliable tool to measure the student "gain" from instruction in Newton's laws and kinematics. There is no such standard tool for introductory topics in electromagnetism. The physics education group at The University of Texas at El Paso is currently in the process of developing and validating a concept inventory to assess the effectiveness of instruction in introductory electromagnetism courses. Our goal is to create a tool that effectively assesses a wide range of understanding of these topics. Here we present our first set of data from the application of the concept inventory to over 300 students in electromagnetic courses, ranging from physics majors to engineers and live science majors.

### HD06: 3:50-4 p.m. Extending the Flipped Physics Classroom to Recitation

*Contributed – Erica K. Snipes,* Auburn University, 206 Allison Labs, Auburn, AL 36832; eks0009@auburn.edu*

*Ameya S. Kolarkar, Auburn University*

Recitation (or discussion) sessions in physics have been largely untouched by active-learning other than student group-work in the presence of helpers – typically a Graduate Teaching Assistant and possibly a Learning Assistant. We present a model of a "flipped recitation" wherein students are aware of the problems to be solved ahead of time and use the recitation time to create new problems and solve them in small groups at the board. Active and team based learning techniques are used to encourage students to discuss amongst themselves, with the helpers providing occasional guidance to individual groups, rather than to the class as a whole.

*Sponsored by Ameya S. Kolarkar

### HD07: 4-4:10 p.m. Student Sourced Creative Exam Problems

*Contributed – Ameya S. Kolarkar, Auburn University, 206 Allison Lab, Auburn, AL 36849-5606; kolarkar@auburn.edu*

Training undergraduate non-major students to create their own problems results in a significant positive impact on their understanding and exam performance. "Creating" students scored, on average, at least 20% higher than those who did not participate in the creating process. We shall present the implementation of the idea, assessment of student understanding and challenges faced in the process.

## Post-deadline Poster Session 3

**Location:** CC - East Lobby
**Sponsor:** AAPT
**Date:** Wednesday, July 20
**Time:** 3-4:30 p.m.

*Presenters should post their posters at 8 a.m. and they will be viewable until 4:30 p.m. Those persons with odd numbered posters will present their posters from 3 to 3:45 p.m. and presenters with even numbered posters will present from 3:45 p.m. to 4:30 p.m.*

### PST3A01: 3-3:45 p.m. Radioactive Nuts and Fertilizers – Quantitation of Specific Dose Levels

*Poster – Amogh Anakru, Newark Academy, 91 South Orange Ave., Livingston, NJ 07054; aanakru17@newarka.edu*

*Alexander Chang, Tarun Maddali, Newark Academy*

*Daniela Buna, Ramapo College of New Jersey*

The current study investigates a method for the absolute quantitation of Potassium-40 (K-40) in a variety of foods and fertilizers by comparing the energy efficiency method for a NaI scintillation detector with the KF-calibration method that eliminates the dependence on the geometry of the setup. Data show that the ratio of the specific activities of chemicals with known quantities of K-40 have reasonably low error (<5%) while individual absolute activities have errors less than 15%. The study also shows that common foods such as Brazilian nuts, raw almonds, and pecans have measurable levels of K-40, and based on their specific activities, one can calculate their dose to human tissue. While the dose is extremely low (negligible as compared to the sum of all natural sources), this method tested reliable procedures to be used for other measurements of radioactivity in the environment, such as common fertilizers and leakage from nuclear reactors.

### PST3A02: 3:45-4:30 p.m. Bringing the Hour of Code (TM) to the Physics Classroom

*Poster – Chris Orban, The Ohio State University, 191 W Woodruff Ave., Columbus, OH 43210; orban@physics.osu.edu*

*Christopher Porter, Kathleen Harper, The Ohio State University*

*Richelle Teeling-Smith, Marion Technical College*

*Mandeep S Gill, Stanford University -- Kavli Institute for Particle Astrophysics and Cosmology*

As websites like code.org reach wider and younger audiences, the possibilities expand for incorporating programming into introductory STEM courses at the university level. We discuss the processing.org framework which is designed to give first-time programmers a powerful interface for creating interactive graphics and games. The processing.org framework was used to develop eight different programming exercises that were integrated into two introductory physics classes at OSU Marion campus that do not normally include programming content. We discuss the learning objectives of these exercises, including broader goals in STEM education, and present student outcomes from working through the required programming assignments. Possibilities for incorporating programming exercises into courses in other disciplines is also briefly discussed.

### PST3A03: 3-3:45 p.m. Study of Students' Mental Models about Electrostatics in Introductory Physics

*Poster – Jing Zhang,* School of Physics and Optoelectronic Engineering, Yangtze University, 2991 Stadium Drive, Columbus, OH 43210-1168; zhangjingjz@126.com*

*Lin Ding, Department of Teaching & Learning, The Ohio State University*

We investigated students' mental models of matter and interaction in electrostatics. A total of 137 Chinese students from an introductory physics class participated in the study. They completed 22 multiple choice items and eight open-ended questions covering the topics of electronic structure of physical matter, electronic field, and electrostatic interaction. Over 80% of the students consider charge as the essential attribute of physical matter, but it cannot move in a dielectric. Around 61% of the students think that electronic field is not a matter as it is invisible, intangible, and devoid of molecules. However, those who view electronic field as matter cannot clearly describe its property. For the question on electrostatic interaction, 88% of the students use "action at distance model" although they know that the charges' interaction is caused by the effect of electric field. Implications of our findings for teaching will be discussed.

*Sponsored by Lin Ding

### PST3A04: 3:45-4:30 p.m. Development and Application of Course for Pre-service Teacher Training Based on LA Program

*Poster – Hu Jun Jiang, Department of Physics Education, Korea National University of Education, Cheongwon Chungbuk, CB 363 791 Korea; jbkim@knue.ac.kr*

*Jung Bog Kim, Jiwon Lee, Yelin Moon, Korea National University of Education*

In order to solve the problem of curriculum for teacher preparation, we develop a practical course using learning assistant (LA) program and apply to pre-service teachers. The summative evaluation scores of students with learning assistants (LAs) are higher than scores of students without learning assistants. These results show that learning assistants play a role to improve students' understanding of scientific concepts. We also investigate the level of students' satisfaction in learning assistant activity by questionnaire survey including five categories: understanding of learners, questioning strategy, learning guide for scientific concepts, guide in discussion, and assessment for learners. Almost all of the students said that they are very satisfied with learning assistants' activities.

### PST3A05: 3-3:45 p.m. Development of a Discharge-Free Leaf Electroscope

*Poster – Jung-Bog Kim, Dept. of Physics Education, Korea National University of Education, Cheongwon Chungbuk, 363 791; jbkim@knue.ac.kr*

*Soyeon Lee lee, Yeonse Elementary School, Sejong*

A leaf electroscope is used for demonstrating effectively electrostatic forces in middle, high schools, and introductory college physics laboratories. The leaf electroscope should be charged with the same polarity as a charged object when the charged object is touched, and then metal leaves should be spread apart by repulsion. However, in some cases, errors charged with the opposite sign occur. This problem is solved by replacing the leaf of aluminum foil by other material that has larger capacitance and is light and flexible. Flyer of Fun-fly-stick (Unitech Toys company) is very suitable for these requirements. In addition, sharp edges where the electric field is strong can be removed by making the leave's ends round.

### PST3A06: 3:45-4:30 p.m. Effects of Learning Assistant on Changes of Students' Mental Model

*Poster – Jinwoo Mo, Korea National University of Education, Dept. of Physics Education, Cheongwon Chungbuk, 363 791 Korea; jbkim@knue.ac.kr*

*Jung-Bog Kim, Jiwon Lee, Yelin Moon, Hu Jun Jiang, Korea National University of Education*

This study is to identify understandings of concept when Learning Assistant(LA) help students. Peer Instruction were used for teaching sound contents to three group (9 students) with LA and comparative three group (9 students) without LA in class. They are all undergraduate students in KNUE and taking this course as liberal arts. So their majors are so mixed. LAs have played a role of inducing to involve actively students in peer discussions by questioning properly and helped the progress of the discussion. Peer Instruction on a concept test in class were recorded for collect data. Collected data were analyzed and students' mental models of sound were classified as "Entity progress obstruction model", "Entity transmission model", and "Wave model". According to the results of the research, students with LA could develop scientific mental model (Wave model) easier than students without LA.

## PST3A07: 3-3:45 p.m. Improving Students' Study Skills in Conceptual Physics Course

*Poster – Polin Yadak, 655 John Muir Dr. E423, San Francisco, CA 94132; polin_y@yahoo.com*

Conceptual physics courses are being offered as a general science course in most schools and is very popular among freshman students who do not want to deal with deep math in their general courses. Therefore, most students who enroll in conceptual physics have a poor mathematics foundation, and poor study skills. In order to improve students' study skills, the author provided multiple-choice sample questions for each chapter in addition to the homework assignments. Students were encouraged to find the correct answers to the questions in their textbook. The students were required to meet with the instructor or GTA's assigned to the course to check their answers for correctness. This method was implemented in a class of 159 students and after the first midterm in which students received a letter grade C. For second midterm sample questions were provided to the students at the end of each chapter. The students received a letter grade B for their second midterm. The above result is for conceptual physics offered in fall 2015 and the author is implementing the same method in her class in current semester. During the current semester the author is interviewing students to have more information regarding their study method and will have further information at the end of spring 2016.

## PST3A08: 3:45-4:30 p.m. Optics and Photonics Training for Inquisitive eXperimentalists (OPTIX): Facilitating the Transition from Teaching to Research Labs

*Poster – Michaela Kleinert, Willamette University, 900 State St., Salem, OR 97301; Mkleiner@willamette.edu*

*David Altman, Willamette University*

Willamette University's physics department is developing an innovative, hands-on laboratory experience for sophomores and juniors. Capitalizing on the optics expertise of the department's faculty, the program is called the Optics and Photonics Training for Inquisitive eXperimentalists (OPTIX) and has been supported by an NSF IAP grant (#1505919). The goal of OPTIX is to facilitate the transition from introductory lab experiences using teaching-grade equipment to more open-ended exploration in our faculty research labs. Through OPTIX, we provide students with a dedicated space (an "optics playground") with research-grade optics equipment. We are in the process of developing modules that are designed to foster deep, inquiry-based learning. These modules will be implemented in our sophomore and junior level lab-based courses Modern Physics and Advanced Topics in Experimental Physics (ATEP). In this poster we present the first modules that we are currently testing in ATEP, and discuss pre- and post-assessment of students performing these modules. We also compare students' success in these newly designed modules to their performance in our previously used junior-level lab exercises.

## PST3A09: 3-3:45 p.m. Using Modeling Physics to Teach Electricity and Magnetism

*Poster – John L. Roeder, The Calhoun School, 433 West End Ave., New York, NY 10024; jlroeder@aol.com*

The electricity and magnetism portion of the physics elective for juniors and seniors at The Calhoun School in New York City has been taught the past three years with the four-unit curriculum taught at the STEMTeachersNYC Modeling Physics Workshop in Electricity and Magnetism in 2013. The four units in this course are 1) Electric Forces and Fields, 2) Electric Potential, 3) Electric Circuits, and 4) Magnetism. Key ideas are developed from the basis of evidence in all four units.

## PST3A10: 3:45-4:30 p.m. Using Sage Math Cloud for Collaborative Modern Physics Labs

*Poster – Michael Huster, Duquesne University, 511 Atlantic Ave., Monaca, PA 15061; mhuster55@gmail.com*

SageMath.org recently (2013) launched SageMathCloud, a web-based, open source, cloud computing and course management system. It includes filehosting in a Ubuntu environment in which users can collaborate on Jupyter (IPython) notebooks, LaTeX documents, Linux terminal and more running on private virtual machines. The students each have their own accounts and they can work collaboratively with other users. I used this for the first time in the spring semester. The course management system allowed me to easily push folders with pdfs of articles, assignments, skeleton analysis notebooks, sample data files, etc. to specific pairs of students, then interact with them, comment on their work, debug programs, and collect final documents. I have found that students with any programming background can easily adapt to this environment. It is a very effective way of introducing second-year students to authentic scientific collaboration. Examples will be shown of student work.

## PST3A11: 3-3:45 p.m. Using Engineering Notebooks to Evaluate Student Understanding of Physics Concepts

*Poster – Jennifer Rushing, Central Coast New Tech High, 545 N Thompson Ave., Building 900, Nipomo, CA 93444; jrushing@ccnth.org*

*Pamalee A. Brady, California Polytechnic State University*

This study focuses on the application of engineering notebooks to support student learning of engineering practices and physics concepts. A case study approach was used to analyze student teams in four high school physics classes tasked with designing Rube Goldberg Machines following a unit on forces, motion, and energy. Teams were required to document their design and construction processes in an electronic engineering notebook. The notebooks were examined for evidence of student understanding and communication of the engineering design process, reflective learning, and kinematic principles. Research has documented that science teacher efforts focus more on engineering practices such as teamwork and communication rather than the application of the science concepts that are important to engineering problem solving. The objective of this study was to identify tools and practices that would aid K-12 teachers in effectively integrating engineering into curricula.

## PST3A12: 3:45-4:30 p.m. The Construction of Novice Scientist's Activity System and Networks: A Case Study of Participants in Undergraduate Research Program

*Poster – Jiwon Lee, Korea National University of Education, 427 Science Building, 250 Taesung Tapyeonro, KNUE Cheongju, Chungbuk, KS 363791 SOUTH KOREA; ljiwony@naver.com*

This study analyzes how novice researcher makes his research activity system and networks and how research process goes on when he enters the science field. The subject of this study is referred to as Student A who participates in Undergraduate Research Program (URP). The data about the process of performing Student A's first research, including structuring his activity system and making relations to other activity systems, etc., were collected using ethnographic research methods. The collected data were analyzed based on the framework of cultural-historical activity theory.

## PST3A13: 3-3:45 p.m. A Comparison of Graphical Representations of E&M Plane Waves

*Poster – Michael B. Wilson, NC State University, Riddick Hall 247, Raleigh, NC 27695; mbwilson@ncsu.edu*

*Robert Beichner, NC State University*

It is well known that plane waves in electricity and magnetism (E&M) are misunderstood. Particularly, the traditional graphical representation of these plane waves is misleading and students find it confusing. A possible improvement has been designed using an animated vector field. Upper undergraduate and graduate physics students were presented each graphical representation of E&M plane waves. The students were asked to describe what each picture represents in detail. Students' reactions to those two representations is compared, and insight into the content delivered in each graphical representation is interpreted as well as insight into the direction of future research on this topic.

### PST3A14: 3:45-4:30 p.m. A Decade of HI-STAR: Authentic Research Experience for Secondary Students

*Poster – Michael A. Nassir, Univ. of Hawaii at Manoa, Dept. of Physics & Astronomy, 2505 Correa Rd., Honolulu, HI 96822; nassir@hawaii.edu*

*James D. Armstrong, Univ. of Hawaii Institute for Astronomy*

*Geoffrey S. Mathews, Univ. of Hawaii at Manoa*

*Mary Ann Kadooka, Univ. of Hawaii Institute for Astronomy (retired)*

Our annual Hawaii Student/Teacher Astronomy Research (HI STAR) Program seeks to further the STEM interest and skills of motivated 8th-to-11th-grade students through a combination of intensive astronomy education and authentic research experience. Every summer, 20 students attend a week-long residential "camp" on the Univ. of Hawaii campus. Daily lessons, activities, and guest speakers rapidly survey essential astronomical concepts. After an introduction to basic data-reduction tools, students complete week-long team projects under the supervision of professional astronomy mentors. During the six months that follow, students carry out long-term astronomy research projects for submission to their local science fairs. In the past four years, 80% of students completed their long-term projects, and several have advanced to the International Science and Engineering Fair.

### PST3A15: 3-3:45 p.m. A "Green" Spinning Coil for Measuring the Earth's Magnetic Field

*Poster – Xueli Zou, California State University, Chico, Department of Physics, Chico, CA 95929-0202; xzou@csuchico.edu*

*Eric Dietz, Jaydie Lee, Christopher Ard, California State University, Chico*

*Steven Sun, UC Berkeley*

A key laboratory exercise in our introductory electricity and magnetism course demonstrates an application of Faraday's law of electromagnetic induction. In the laboratory, students are to measure the magnetic field of the Earth by rotating a coil of wire and measuring the resulting induced voltage. For this experiment a customized apparatus has been designed and tested, the resulting data from which is compared against accepted experimental data. This poster will present a live demonstration of this new spinning coil lab and address its unique advantages both in physical operations and in student learning, compared to the traditional lab using a motor-powered spinning coil.

### PST3A16: 3:45-4:30 p.m. CU-Prime: Empowering Students to Build Inclusive Physics Communities

*Poster – Benjamin Pollard, University of Colorado Boulder, 2000 Colorado Ave., Boulder, CO 80303; United States pollard@cuprime.org*

CU-Prime is a student-run organization whose goal is to increase inclusion in the Physics Department at the University of Colorado Boulder, especially for women, people of color, first-generation students, and others from underrepresented groups in STEM. Founded in 2013, CU-Prime has grown into a vibrant organization offering four interconnected programs: a talk series, a one-credit class, a mentorship program, and internal diversity workshops. Fueled by the dedication of undergraduate and graduate student organizers, CU-Prime has become an established entity in the department, on campus, and beyond. CU-Prime is also one of the founding organizations of the Access Network, a collaboration between similar programs across the nation. While CU-Prime is still new and constantly improving, several lessons are emerging that could benefit similar programs and efforts working towards goals of equity, inclusion, and making a lasting positive impact on the culture of physics.

### PST3A17: 3-3:45 p.m. Smart Classroom: The Impacts Brought to Traditional Physics Learning

*Poster – Xiaoming Zhai, Department of Physics, Beijing Normal University; College of Education, University of Washington (Seattle), Xinjiekouwai St.19#, Department of Physics Haidian, Beijing 100875 China; xiaomingzh@mail.bnu.edu.cn*

*Meilan Zhang, Department of Teacher Education, University of Texas*

*Yuying Guo, Department of Physics, Beijing Normal University*

Smart-classroom is a teaching and learning management system within 1:1 multi-touch mobile devices. We selected 454 samples from a high school with smart-classroom system, and conducted a followed-up study for a year. We surveyed the use of Smart-classroom, the extent to which it changed the traditional physics instruction practice, etc., and examined the in-class and after-school impacts of using frequency and duration on physics interest and physics achievement for students with different learning ability levels and of different genders, based on panel data, by fixed effect model. Results indicate that the overall using time and frequency are high, but with fluctuant in specific use, and the student-driven and complexity use are relatively rare; the types of use are simplex, and mainly focuses on real-time interactive and accessing use; only augment traditional physics learning without transformation; however, has significant impacts on students' interest and achievements, though varies across levels and gender.

# Index of Participants

Zwolak, Justyna P., CB03

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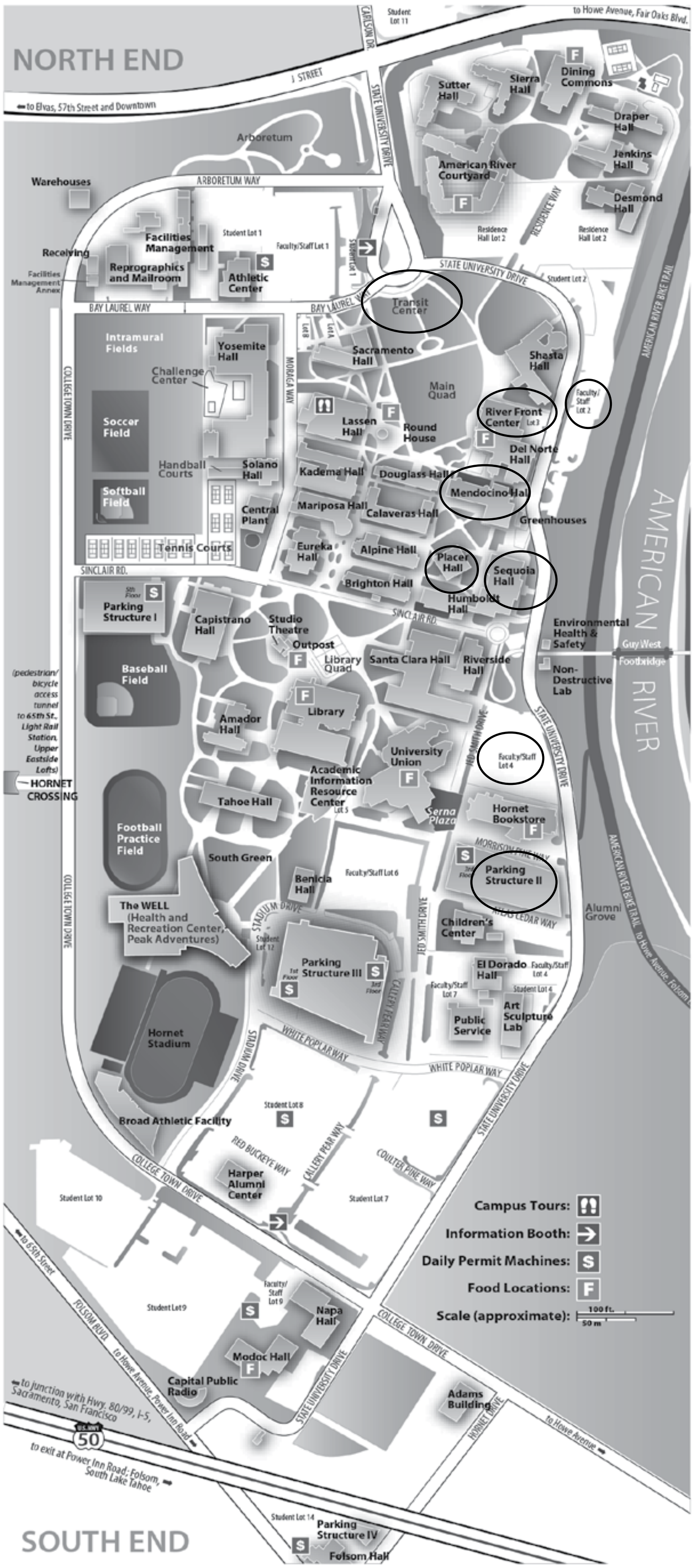


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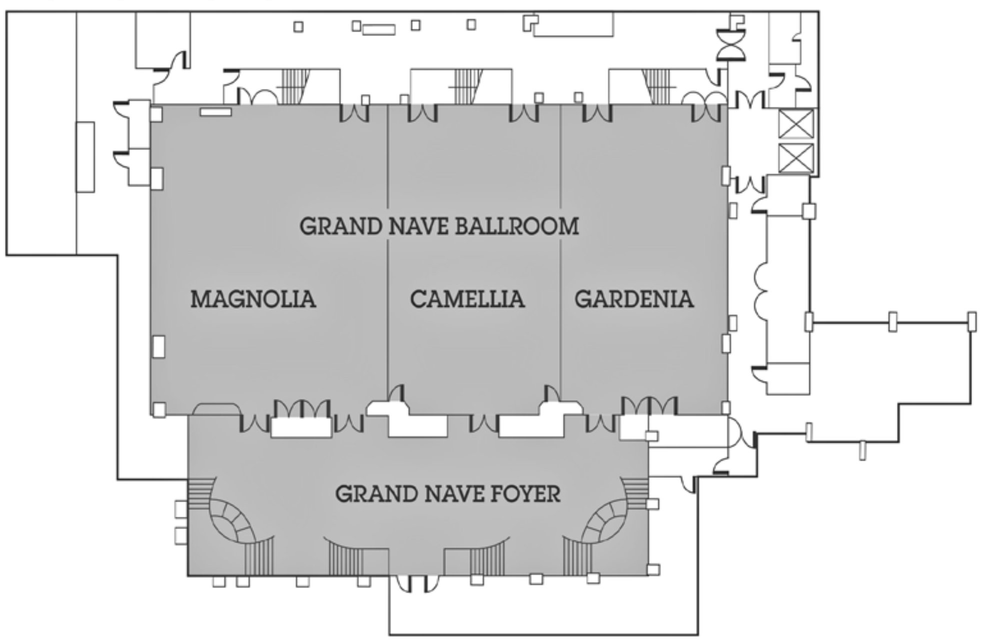


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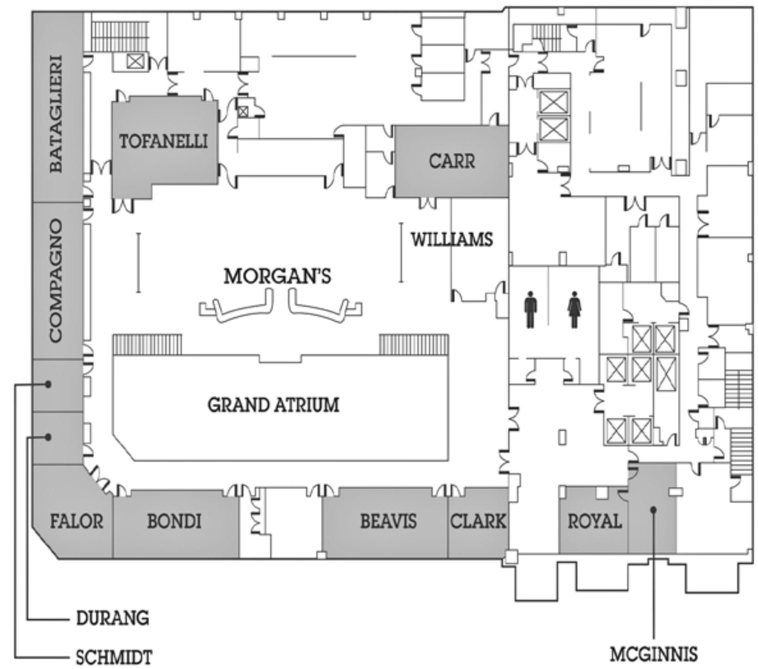


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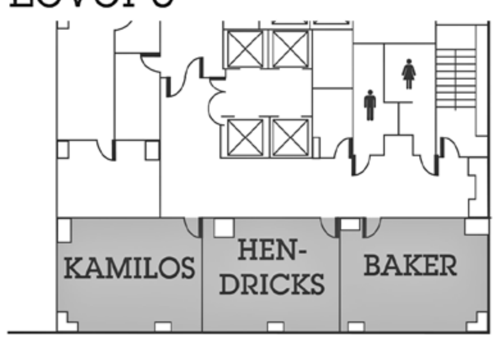
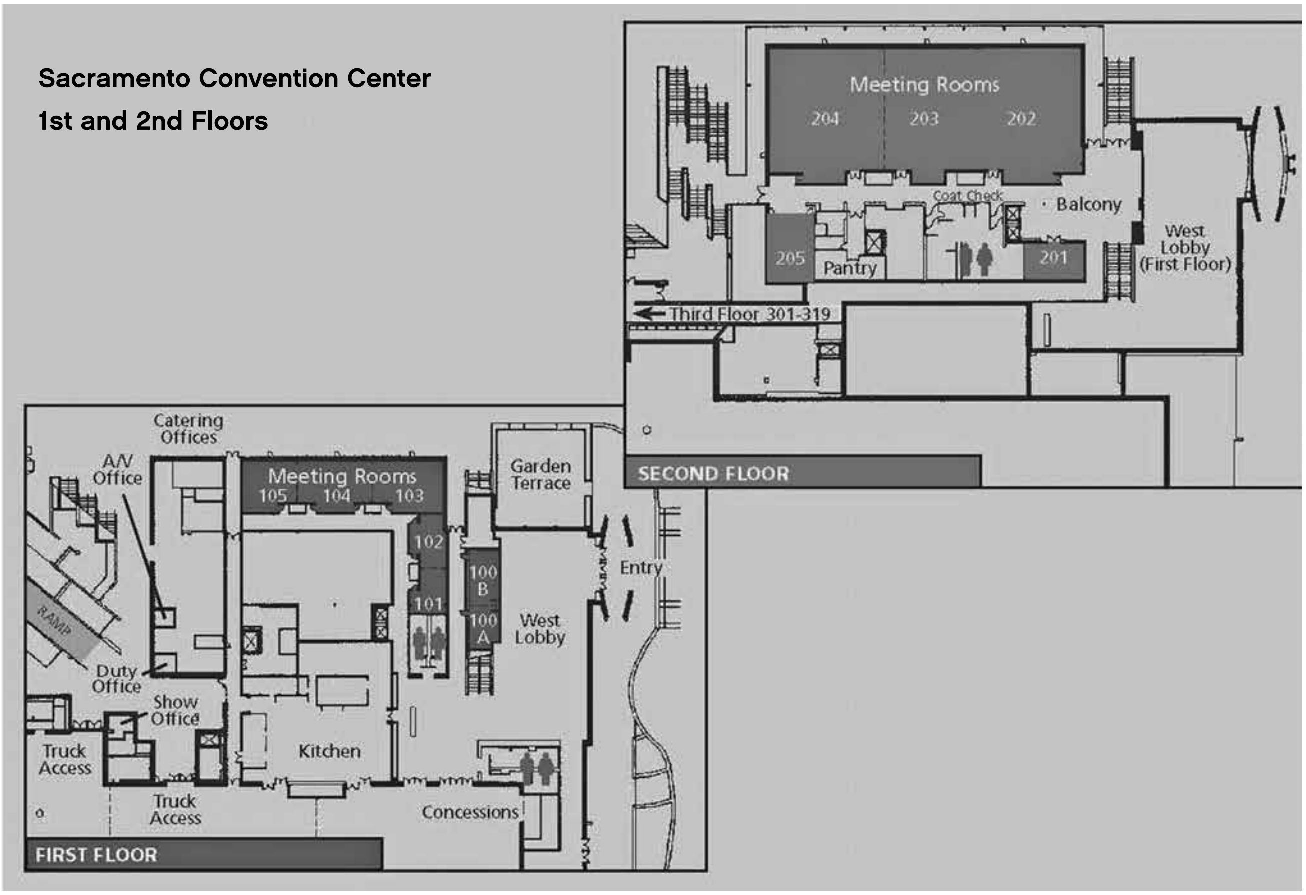
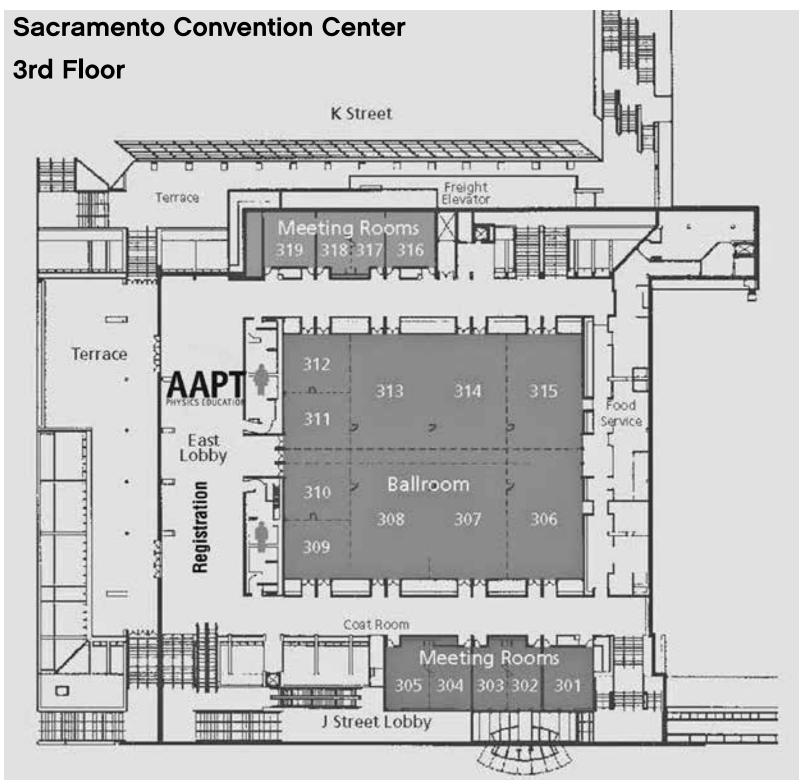



## Lobby Level
Public Market Bar
Glide's Event Space

## Level 4
Sheraton Fitness
Swimming Pool
Executive & Sales-Catering Office

# Sacramento Convention Center



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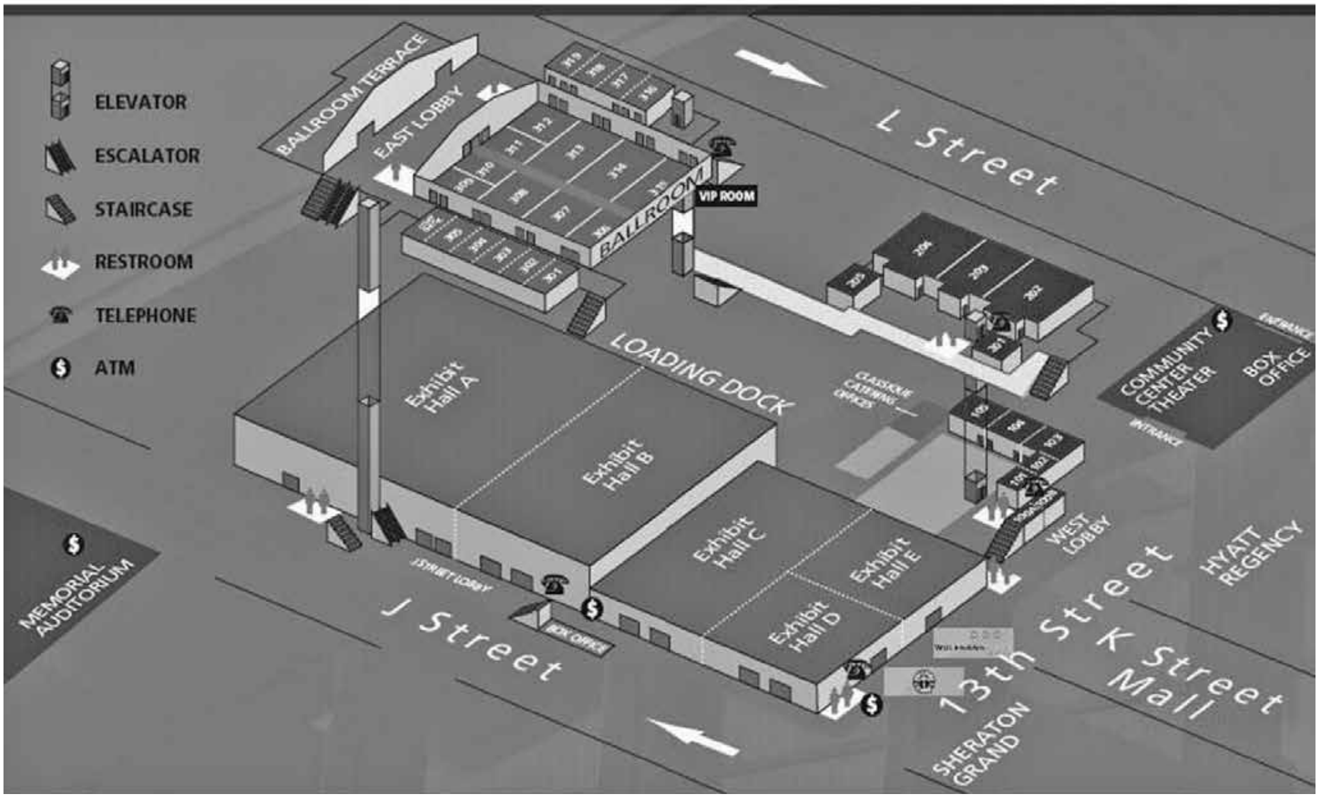
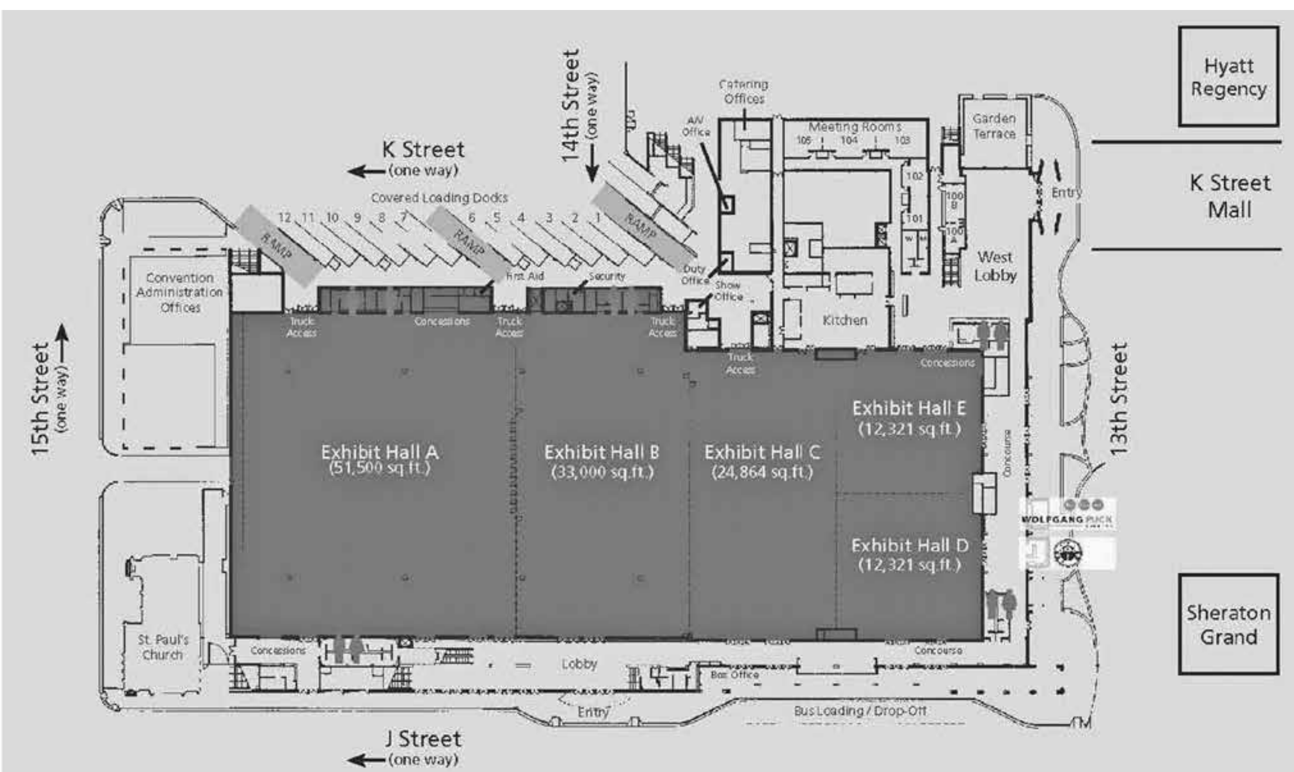
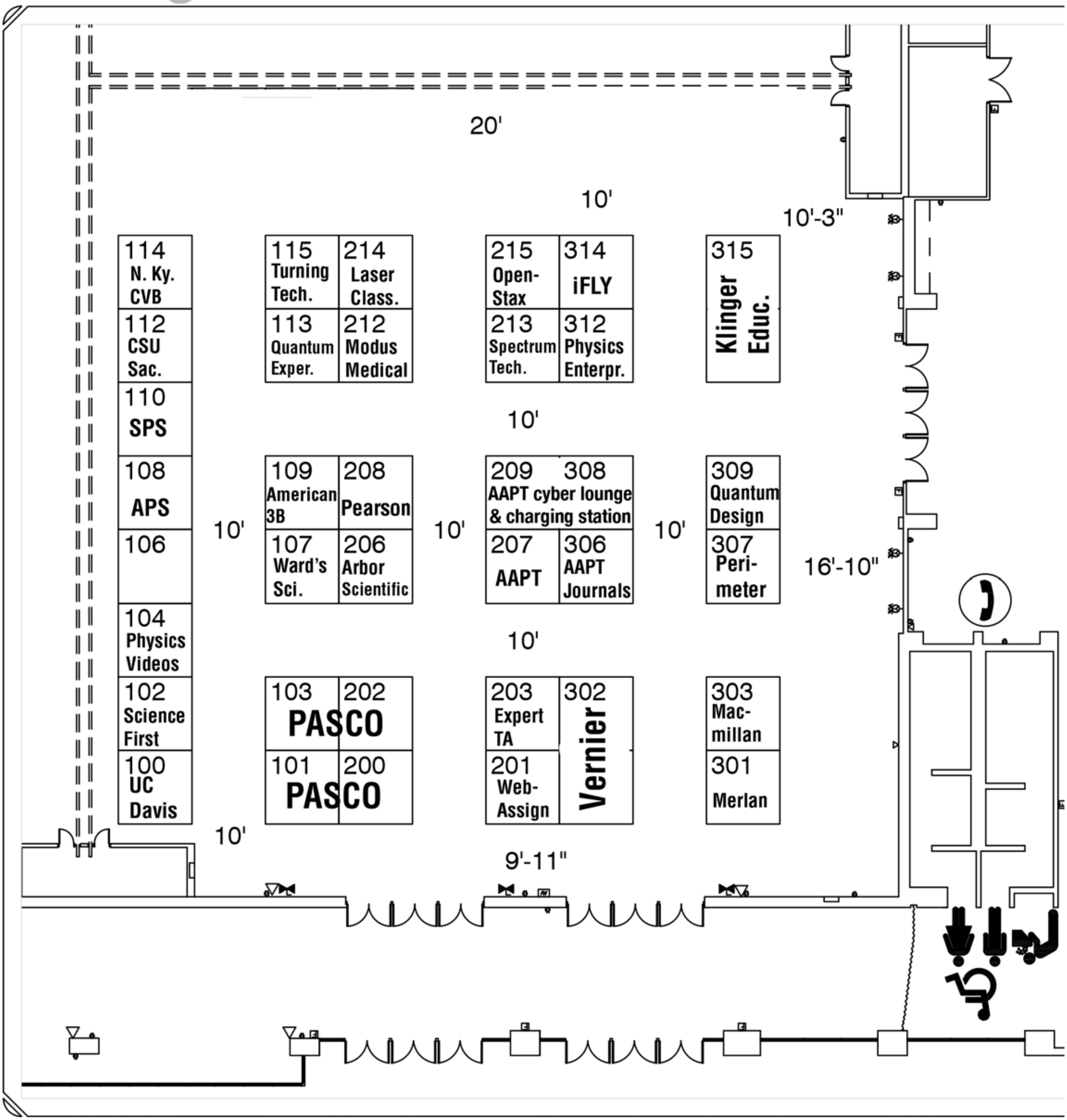


# Exhibit Hall D



# Download Your Mobile App Now!


## Download Steps:

1. Download the app by going to https://crowd.cc/s/c8d6, or search the “Apple” or “Google Play” stores for AAPT, American Association of Physics Teachers, SM16, 2016 AAPT Summer Meeting.

2. Open the app and tap on 2016 AAPT Summer Meeting (SM16).

## Session Sponsors List

### AAPT Committees

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**Undergraduate Education:** W28, W36, W42, W44, FD, W11, AA, AL, BC, BD, BH, CH, CK, DH

**Women in Physics:** W37, EK, FI, BG, BJ, CD, DI

# Call for Nominations

**The AAPT Awards Committee is seeking nominations for the following awards. All AAPT members are urged to review the descriptions of these awards on the AAPT website and then, following instructions available at a link on that website, to nominate individuals deemed worthy of consideration for any of these awards. The Nomination Form is at http://www.aapt.org/Programs/awards/.**


**Robert A. Millikan Medal**

**Oersted Medal**

**Melba Newell Phillips Medal**

**Paul E. Klopsteg Memorial Lecture Award**

**Richtmyer Memorial Lecture Award**

**John David Jackson Excellence in Graduate Education Award**

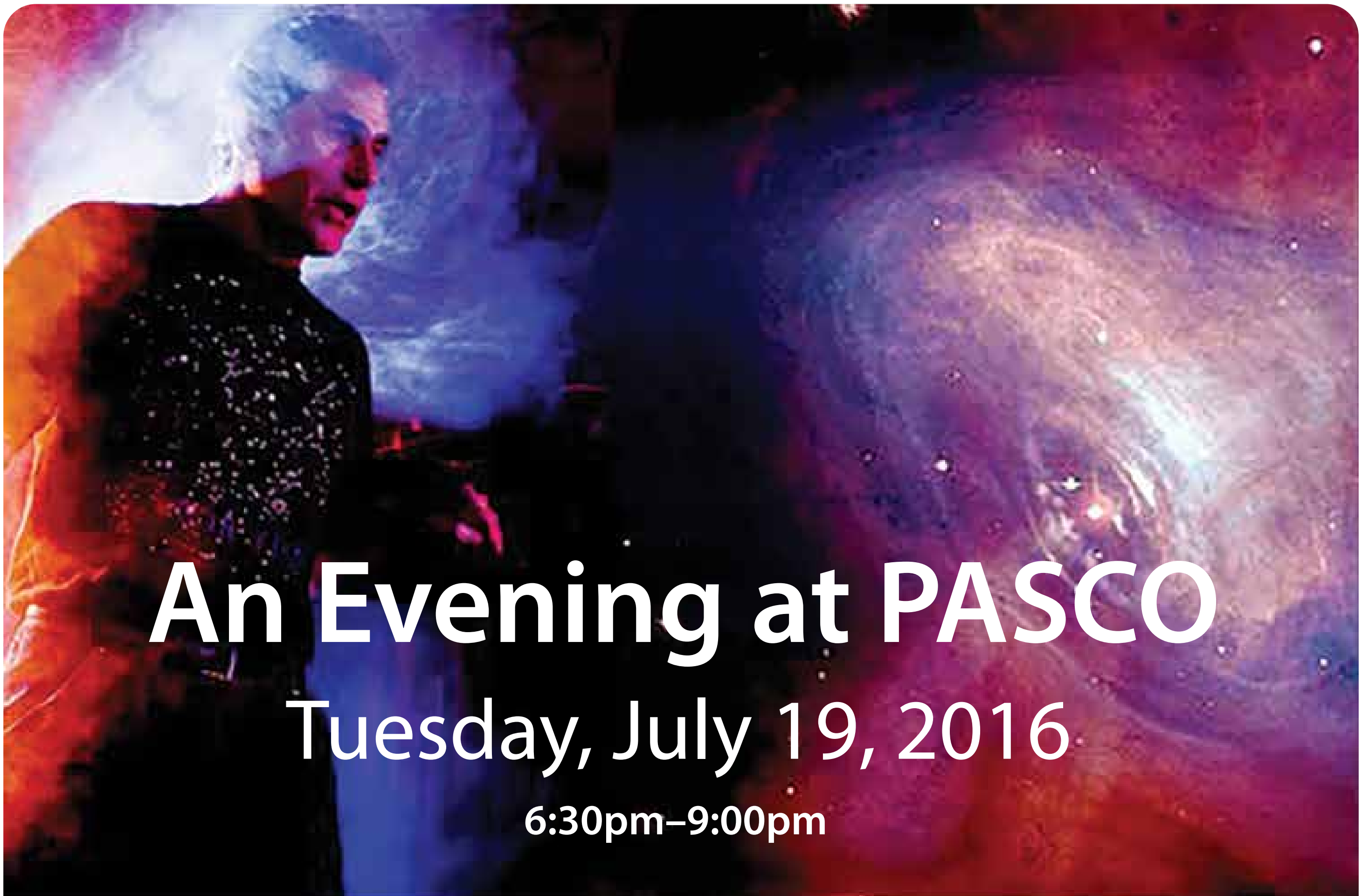
**David Halliday and Robert Resnick Excellence in Undergraduate Physics Teaching Award**

**Paul W. Zitzewitz Excellence in K-12 Physics Teaching Award**

**AAPT Homer L. Dodge Distinguished Service Citations**


We'll see you in
Atlanta,GA
2017 AAPT Winter Meeting
February 18-21


We'll see you in
Cincinnati,OH
2017 AAPT Summer Meeting
July 22-26



# An Evening at PASCO

## Tuesday, July 19, 2016

**6:30pm–9:00pm**

### An evening with PASCO & AAPT

Attending the AAPT Summer Meeting this July? Then enjoy a great summer evening at PASCO Scientific including a picnic dinner, a tour of PASCO, and a physics show.

Featuring many of the demonstrations used in the off-Broadway hit, "That Physics Show"

**Reserve your spot**: You may register for this event at: **aapt.org/Conferences/sm2016**

**Enjoy a picnic dinner**: Your choice of sliced sirloin, teriyaki chicken, or veggie skewers.

**Tour the factory:** See how your PASCO products are designed, engineered, and manufactured.

**Be entertained:** Watch a fantastic physics demo show, brought to you by **PIRA and David Maiullo.**

Transportation from the Sheraton Hotel to PASCO will be provided.

AAPT PHYSICS EDUCATION

**aapt.org/Conferences/sm2016**

PASCO® scientific