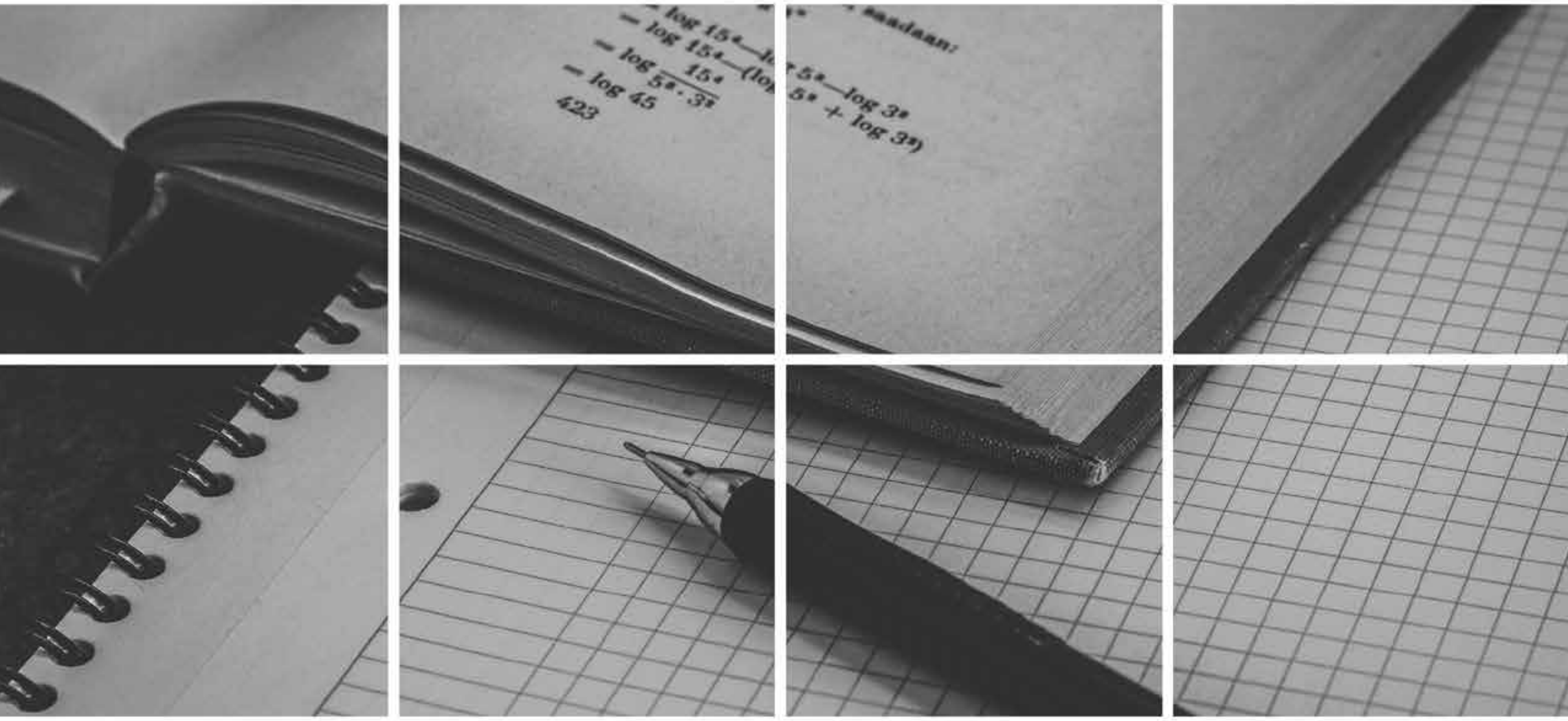
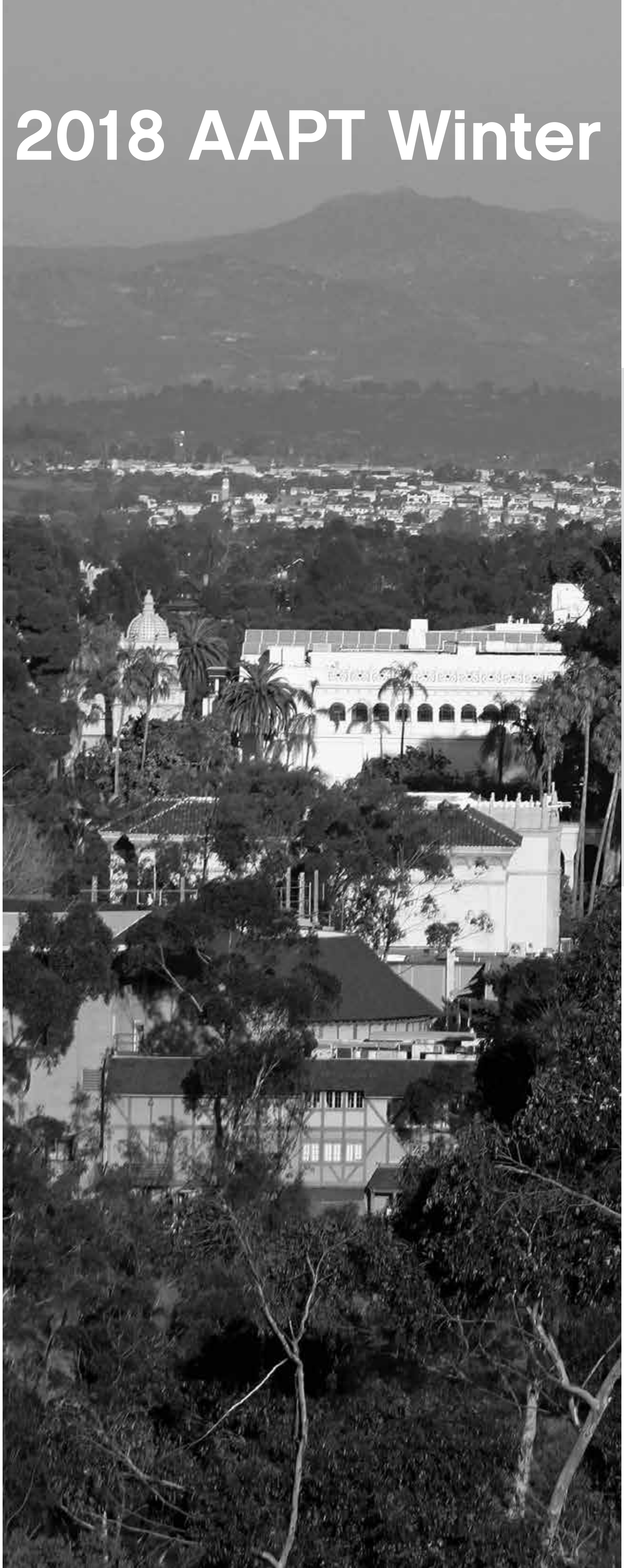
AAPT
PHYSICS EDUCATION

2018 AAPT Winter Meeting

National Society of Hispanic Physicists



2018 AAPT Winter Meeting



San Diego, CA
January 6-9

National Society of Hispanic Physicists

AAPT
PHYSICS EDUCATION

American Association of Physics Teachers

One Physics Ellipse
College Park, MD 2040
www.aapt.org
301-209-3311

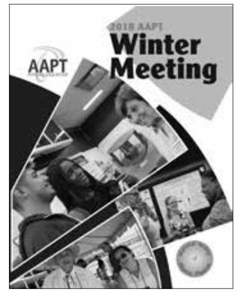
Special Thanks

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

Greg Severn, University of San Diego for organizing the workshops.

Paper sorters:

- Beverly (Trina) Cannon
- Charlene Rydgren
- Jackie Doyle
- Katie Ansell
- Frank Lock
- Bahar Modir
- Brad Conrad
- Ryan Hazelton
- Andy Rundquist
- Rob Salgado
- Ernie Behringer
- Dan Jackson
- Jeremiah D. Williams
- Frank Lock



Attention!

This is the last printed copy of the AAPT National Meetings Program Book. AAPT has decided to move forward with a green initiative that will allow us to protect the environment and save money.

The national meetings program will be available in the following formats, starting at the 2018 Summer Meeting.

1) AAPT National Meetings Program APP
2) Online PDF of Program
3) Meeting at a Glance

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 **#aaptwm18**. 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 the Cincinnati area. We look forward to connecting with you!

Facebook: facebook.com/AAPTHQ

Twitter: twitter.com/AAPTHQ

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AAPT Associate Executive Officer

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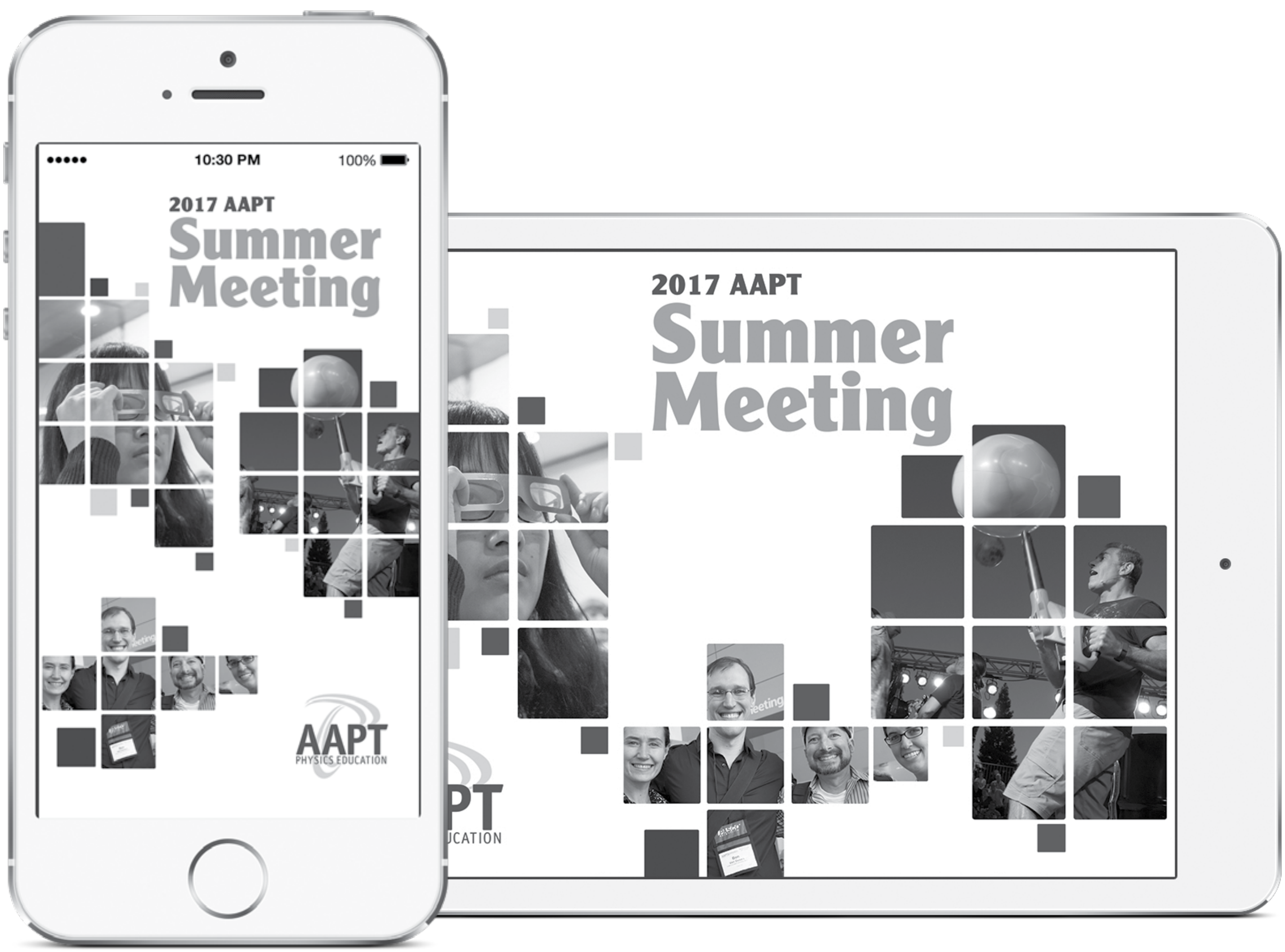


Barbara L. Whitten

The Value of Diversity in Physics

Tuesday, January 9

12–1 p.m.

Golden Ballroom

2018 Oersted Medal Awarded to Barbara L. Whitten

Barbara L. Whitten is Professor Emerita of Physics, at Colorado College in Colorado Springs, CO. She earned her BA in Physics at Carleton College and her MA and PhD at the University of Rochester, Rochester, NY. She is an excellent physicist, teacher, mentor who is strongly committed to education and the wider physics community. Prior to joining the faculty of Colorado College, she taught in the Western College Program of Miami University and worked as a research scientist at Lawrence Livermore National Laboratory.

Whitten has a variety of interests in physics: both in terms of technical physics and service to the profession. She has maintained an active technical physics program that has most recently focused on computational environmental physics. Over her years at Colorado College, she involved students in her research, taught all levels of the undergraduate curriculum, developed novel courses and served as a founding member of the Feminist and Gender Studies program at Colorado. This meant that from its inception, the Gender Studies program has had a natural scientist as part of its interdisciplinary faculty governing committee. It was her interest in feminist science that led to her primary impact on the physics teaching community.

Many years ago, when thinking about ways to increase the numbers of women and other under-represented groups in undergraduate physics programs, instead of guessing what might be the correct approach, she decided to ask. Specifically, she decided to ask why some physics departments seemed to be more successful in graduating women and underrepresented minorities than others. Working through the APS's Committee on the Status of Women in Physics, she developed and led a site visit program where a team of faculty and students visited several institutions: interviewing faculty, staff, and undergraduate students. By the end of the project, she had conducted 15 site visits and received funding through the National Science Foundation. After visiting each institution, the site visit team would create a summary of their findings. The site visit findings culminated in "What Works for Women in Undergraduate Physics?" featured in Physics Today in 2003. One of the main findings was that the things that improved the departmental climate for women also helped the men in the department. What was good for women in physics helped all undergraduates thrive. The findings from these site visits have continued to influence the ways in which physics departments look at themselves. This project has successfully opened physics departments to women and underrepresented minorities. **(http://www.aapt.org/aboutaapt/Barbara-Whitten-to-Receive-AAPT-2018-Oersted-Medal.cfm)**

Named for Hans Christian Oersted, the Oersted Medal recognizes those who have had an outstanding, widespread, and lasting impact on the teaching of physics. The recipient delivers an address at an AAPT Winter Meeting and receives a monetary award, the Oersted Medal, an Award Certificate, and travel expenses to the meeting. The award was established in 1936.

Mehran Kardar

Force from Non-equilibrium Fluctuations in QED and Active Matter

Sunday, January 7

7:30–8:30 p.m.

Golden Ballroom

2018 John David Jackson Excellence in Graduate Physics Education Awarded to Mehran Kardar

Mehran Kardar was selected to receive the Jackson Award in recognition of his work as a teacher of graduate statistical mechanics. He has written two graduate textbooks in statistical mechanics that are used in many graduate programs. He receives among the very best teaching evaluations of any professor in the MIT Physics Department and his courses draw large crowds. He has received every MIT award for graduate teaching and his students have gone on to become leaders in statistical physics and related fields.

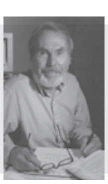
Kardar received his BA in Natural Sciences, his MA from the University of Cambridge and his PhD from the MIT. From 1983 to 86 he was a Junior Fellow of the Harvard Society of Fellows, and a Visiting Summer Research Collaborator at Brookhaven National Laboratories. In 1986 he joined the MIT Department of Physics as an Assistant Professor. In 1990, he was promoted to Associate Professor of Physics, receiving tenure in 1992 and a full professorship in 1996.

Honors and awards include an Alfred P. Sloan Fellowship (1987–91), a Presidential Young Investigator Award (1989), Guggenheim Fellowship (2001), the MIT Class of 1948 Career Development Chair (1990–92), the MIT Edgerton Award for Junior Faculty Achievements (1991), the Buechner Teaching Prize of the MIT Department of Physics (1992), and the MIT School of Science Prize in Graduate Teaching (1993). He is a fellow of the American Physical Society, as well as the American Academy of Arts and Sciences. In both 1993 and 2008 he was recognized with the MIT-wide award for graduate teaching in which the nomination and selection processes are conducted entirely by students.

Starting early in his career, Kardar developed notes for his graduate Statistical Mechanics classes and made them available on line. By 2007 they became two text books published by Cambridge University Press, "Statistical Physics of Particles" and "Statistical Physics of Fields." These popular books are widely used, for example in graduate classes at MIT, Caltech, Cornell, Rutgers and the University of Illinois.

Kardar is an outstanding researcher. His famous paper with Parisi and Zhang on the growth of interfaces has over 3500 citations. His excellence in research has always been inseparable from his mentoring of the graduate students whom he has advised, and it has infused his teaching of more than one thousand graduate students who have been inspired by his classes, and in many cases drawn into the research areas that he loves. And, then, there are the many thousands of other students who, through his books, have learned Kardar's perspective on Statistical Mechanics, which both derives from and animates his research.

Kardar's meticulous style of teaching, selfless devotion to his students, and skillful mentorship of graduate research over the past 30 years have inspired a generation of graduate students to modern statistical physics, and transformed the lives of all the graduate students he has mentored. As his disciples mature and flourish in different areas of statistical physics, condensed matter physics, biological physics, and computer science, his style and devotion to graduate physics education are being propagated to all these diverse disciplines.
(http://www.aapt.org/aboutaapt/Mehran-Kardar-2018-John-David-Jackson-Award.cfm)



Named in honor of outstanding physicist and teacher, John David Jackson, this award recognizes physicists and physics educators who, like John David Jackson, have made outstanding contributions to curriculum development, mentorship, or classroom teaching in graduate physics education. This award recognizes that great teaching CAN be done and should be expected of great scientists at leading institutions, not only from people whose primary or entire focus is on teaching. It was established in 2010 and is presented only occasionally.

2018 Richtmyer Memorial Lecture Award Awarded to Mark Beck

Mark Beck

Preparing Our Students for Quantum 2.0

Tuesday, January 9
10:30–11:30 a.m.
Golden Ballroom

Mark Beck is Benjamin H. Brown Professor of Physics and Chair of the Department of Physics at Whitman College in Walla Walla, WA. He earned his BS and PhD in Optics at The Institute of Optics, University of Rochester, Rochester, New York.

Regarding his selection as the Richtmyer Memorial Lecture Award Beck said, "I'm honored to receive this award from the AAPT, and humbled to be associated with those who have received it previously. I'd like to thank my mentors, colleagues and students, as I've learned a great deal from all of them."

In 1994 Beck took a visiting faculty position at Reed College because of his attraction to teaching and working with undergraduates on research. During his time at Reed he began working with students on modern quantum optics experiments. In 1996 Beck moved to Whitman College, and shortly after that he, and others, realized that advances in laser technologies, nonlinear optics and electronics were on the verge of making it possible and affordable to construct apparatus to perform fundamental experimental tests of quantum theory in an undergraduate teaching laboratory.

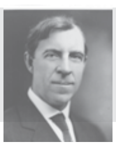
Beck and several of his undergraduate students designed and produced such apparatus and, with it, tested quantum mechanical predictions in teaching laboratories. In addition to demonstrating the single-photon nature of light emitted in certain nonlinear-optical experiments, his students were able to verify that local realism is violated in Hardy's test, providing strong support for the quantum nature of the physical world. These tests also served to demonstrate quantum entanglement, a uniquely quantum feature, which underlies efforts to build quantum computers. The fact that undergrads could see for themselves the quantum nature of light, and learn modern optical techniques at the core of quantum information science, was revolutionary. Beck published these experimental setups in several influential peer-reviewed papers, which were some of the first documented instances of undergraduates successfully performing such experiments.

He currently holds the Benjamin Brown Professorship, which is named and endowed in honor of a much-respected member of Whitman's Physics Department who received AAPT's Oersted Medal in 1939. That Beck holds this position is particularly apropos as he, like Brown before him, has made significant contributions to the teaching of physics, the most important being his role in reformulating the approach to teaching Quantum Mechanics.

Beck has been acknowledged at Whitman College as a master teacher and received two in-house awards, the Garret Fellowship and the Lange Distinguished Teaching Award. He has been active in the Northwest Chapter of the APS and is a member of the Distinguished Traveling Lecturer Committee for APS's Division of Laser Sciences.

Beck has become a prominent contributor to efforts to reformulate the teaching of Quantum Mechanics, and has authored a textbook that takes a new approach to the subject. He has proven himself a gifted and highly productive educator. He has contributed to the discipline at his home institution, nationally, and even internationally. His work to allow the tenets of Quantum Mechanics to be taught more effectively is exactly the sort of transformative effort that must be encouraged, then acknowledged and rewarded as our discipline seeks to assert its continued relevance in an ever more rapidly changing world.

A colleague at Whitman College remarked, "Beck's single greatest accomplishment is a reformulation of the teaching of undergraduate Quantum Mechanics. His intellect and vision allowed him to develop instrumentation, curricular materials and an accompanying text all of which have been popularly received and are becoming widely used. He is a talented physicist and consummate teacher who has made substantial, creative contributions to the teaching of physics at the local, regional and national levels."



Named for Floyd K. Richtmyer, distinguished physicist, teacher, and administrator and one of the founders of AAPT, the Richtmyer Memorial Lecture Award recognizes those who have made outstanding contributions to physics and their communication to physics educators. The award was established in 1941.

AIP Science Communication Awards

Monday, January 8 10:30–11:30 a.m. Location: Golden Ballroom

The Science Communication Awards of the American Institute of Physics were established in the 1960s to recognize some of the best science writing of the previous year. Entries aim to improve the general public's appreciation of the physical sciences, astronomy, math and related science fields. Entries are judged by committees of scientists and journalists, and winning authors receive a prize of $3,000, an engraved Windsor chair, and a certificate of recognition.

Paula Ayer

Paula Ayer, winner of the Writing for Children Award

Paula Ayer is an editor at Greystone Books and an accomplished translator and award-winning author of four books for both teens and children. She grew up in Calgary, Alberta, and studied at the University of Calgary and Simon Fraser University. Ayer now resides in Vancouver with her husband and daughter.

Noah Baker

Noah Baker, winner of the Broadcast and New Media Award

Noah Baker is a senior editor for *Nature and Scientific American*, reporting on stories from across the spectrum of science in online video and weekly podcast formats. He earned his bachelor's degree in zoology and master's degree in science media production from Imperial College London.

Antonia Banyard

Antonia Banyard, winner of the Writing for Children Award

Antonia Banyard has authored many works, including three nonfiction books, one novel and various poems. She holds multiple degrees in creative writing from the University of Victoria and the University of Queensland, and has worked in publishing for over 20 years.

Homer L. Dodge Citations for Distinguished Service to AAPT

Tuesday, January 9 • 11:30 a.m.–12 p.m. • Location: Golden Ballroom

Nancy Easterly

Nancy Easterly

Nancy Easterly earned her BA in physics with a minor in mathematics at Ohio Wesleyan University, Delaware, Ohio. Her MEd is in Curriculum and Instruction with a minor in oceanography from Texas A&M University, College Station, Texas. She began teaching as a Science and Math teacher for grades six through eight in 1975 at Wunderlich Intermediate School, Houston, Texas. In 1978 she took a position as physics teacher at Cypress Creek High School in Houston teaching Regular Physics, Honors Physics, AP-C, and serving as Physics Team Leader. In 2004 she started teaching Physical Science for Elementary Education Majors at the University of Houston-Downtown, as an adjunct professor. Since 2008 she has taught Elementary Physics at Lone Star College North Harris/Greenspoint.

http://www.aapt.org/aboutaapt/Nancy-Easterly-2018-Dodge-Citation.cfm

Daniel V. Schroeder

Daniel V. Schroeder

Daniel Schroeder earned his BA in physics at Carleton College and his PhD in physics at Stanford University. He began teaching at Weber State University in 1993 and continues to teach there. He is probably best known among physicists as the author of *An Introduction to Thermal Physics* (2000) and coauthor, with Michael Peskin, of *An Introduction to Quantum Field Theory* (1995). He has been an active member of the Idaho-Utah Section of AAPT since 1993, serving as its President in 2003. His service to the *American Journal of Physics* began in 1998 when he was appointed to the Editorial Board. He served as Book Review Editor from 2003 through 2008 and as Associate Editor from 2012 to 2016. He now serves as a Consulting Editor.

Mary Ann Hickman Klassen

Mary Ann Hickman Klassen

Klassen earned her BA in Astrophysics at Agnes Scott College and her MS in Physics at the University of Wyoming. She started her career at Swarthmore College as Lab Coordinator in 1995 and is currently Senior Lecturer at Swarthmore. An active member of AAPT since 1995, Klassen has volunteered in the Southeastern Pennsylvania Section of AAPT, serving as President from 2010-11. Her AAPT committee service has included the Committee on Laboratories 2008-2011 and 2016-18, serving as Chair 2017-18; Programs Committee 2017-18; and Meetings Committee 2017-19. She has organized or presented in the Introductory Laboratories workshops at Summer AAPT meetings since 2007 and served as a reviewer for *The Physics Teacher* in 2016.

Steve Spicklemire

Steve Spicklemire

Steve Spicklemire earned his B.S. in physics at Rose Hulman Institute of Technology, Terre Haute, IN. His M.S. and Ph.D. in physics were earned at California Institute of Technology, Pasadena, CA. His teaching career began at the University of Indianapolis (UIndy), Indianapolis, Indiana, in 1988. He was Assistant Professor of Physics in the Department of Physics and Earth-Space Science and was recognized as "Outstanding Teacher of the Year" in the division of science and mathematics for the academic year 1992-1993. In 1996 he became Associate Professor of Physics and Astronomy, Department of Physics and Earth-Space Science, University of Indianapolis where he focused on development of web based distance learning resources, and web interfaces to undergraduate research projects such as their radio telescope, high altitude ballooning, laboratory instrumentation, and parallel/cluster computer**s.**

Jon Anderson

Jon Anderson

Jon Anderson earned his BS and MEd. at the University of Minnesota and took Post-MEd courses at Aurora University. He began his teaching career as a high school science teacher in 1986 and has taught at Southwest High School (Minneapolis), Thomas Jefferson High School (Bloomington), Mounds View High School (Arden Hills), and Centennial High School (Circle Pines), Minnesota. As a long-time member of AAPT, Anderson has attended numerous national meetings as both a presenter and a participant. He is currently serving on the Committee on High School Physics, is the new Academic Coordinator for the PhysicsBowl, and was named an AAPT Fellow in the spring of 2017. Anderson has been involved in the PhysTEC project since 2007, first serving as a Teacher in Residence (TIR) at the University of Minnesota. He became the coordinator of TIRs and Visiting Master Teachers (VMT), an AAPT position in the PhysTEC project, in 2009.

http://www.aapt.org/aboutaapt/Jon-Anderson-2018-Dodge-Citation-for-Distinguished-Service.cfm

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.

Committee Meetings at Winter Meeting

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

Friday, January 5

New Board Orientation	5–6 p.m.	Royal Palm One
Board of Directors I	6:30–9:30 p.m.	Royal Palm One

Saturday, January 6

Meetings Committee	8–9:30 a.m.	Royal Palm Two
Publications Committee	8–9:30 a.m.	Royal Palm One
Board of Directors II	10:15 a.m.–4:45 p.m.	Royal Palm One
Resource Letters Committee	11:30 a.m.–2:30 p.m.	Royal Palm Three
Nominating Committee I	3–4:30 p.m.	Royal Palm Two
AAPT-ALPhA Award Committee	5–6:30 p.m.	Royal Palm One
Section Officers and Representatives	5:30–6:30 p.m.	Pacific Salon One
New Chairs Orientation	5:30–6:30 p.m.	Pacific Salon Two
ALPhA Committee	6:30–8 p.m.	Royal Palm One
Programs I	6:30–8 p.m.	Pacific Salon Two

Sunday, January 7

Review Board	7:30–9 a.m.	Royal Palm One/Two
Physics Bowl Advisory Committee	7:30–9 a.m.	Pacific Salon Six/Seven
Venture/Bauder Fund Review Committee	9–10 a.m.	Royal Palm One/Two
Governance Structure Committee	9–10 a.m.	Pacific Salon Six/Seven
Executive Programs Committee	9–10 a.m.	Royal Palm Five/Six
Laboratories Committee*	12:30–1:45 p.m.	Pacific Salon Two
History & Philosophy of Physics*	12:30–1:45 p.m.	Royal Palm Three/Four
Space Science & Astronomy Committee*	12:30–1:45 p.m.	Pacific Salon One
Modern Physics Committee*	12:30–1:45 p.m.	Terrace Salon Two
Science Education for the Public Committee*	12:30–1:45 p.m.	Pacific Salon Three
International Physics Education Committee*	6:15–7:30 p.m.	Royal Palm Five/Six
Interests of Senior Physicists Committee*	6:15–7:30 p.m.	Pacific Salon Four/Five
Teacher Preparation Committee*	6:15–7:30 p.m.	Pacific Salon Six/Seven
Physics in Undergraduate Education*	6:15–7:30 p.m.	Terrace Salon Two
Women in Physics Committee*	6:15–7:30 p.m.	Pacific Salon Two
Physics in High Schools Committee*	6:15–7:30 p.m.	Royal Palm Three/Four
Meeting of the Members*	8:30–10 p.m.	Golden Ballroom

Monday, January 8

Investment Advisory Committee	7:30–9 a.m.	N/A
Membership and Benefits Committee	7:30–8:30 a.m.	Pacific Salon Six/Seven
PTRA Oversight Committee	7:30–9 a.m.	Pacific Salon Four/Five
Educational Technologies Committee*	12:45–2 p.m.	Royal Palm One/Two
Graduate Education in Physics Committee*	12:45–2 p.m.	Terrace Salon Two
Physics in Two-Year Colleges Committee*	12:45–2 p.m.	Pacific Salon Three
Research in Physics Education Committee*	12:45–2 p.m.	Pacific Salon Oe
Awards Committee	5:30–6:45 p.m.	Royal Palm Five/Six
Apparatus Committee*	5:30–6:45 p.m.	California Room
Professional Concerns Committee*	5:30–6:45 p.m.	Terrace Salon Two
Physics in Pre-High School Education*	5:30–6:45 p.m.	Pacific Salon Six/Seven
Diversity in Physics Committee*	5:30–6:45 p.m.	Pacific Salon Four/Five
PERLOC*	5:30–6:45 p.m.	Royal Palm Three/Four

Tuesday, January 9

Programs II	7–8:30 a.m.	Sunrise
PERTG Town Hall	7:30–8:30 a.m.	Golden Ballroom
Nominating Committee II	2:30–3:30 p.m.	Sunrise
Paper Sorter SM18 Meeting	2:30–3:30 p.m.	Pacific Salon Four/Five
Board of Directors III	4–5 p.m.	Sunrise

Gabriela Gonzalez

Gravitational-wave Astronomy

Monday, January 8

9:30–10:30 a.m.

Golden Ballroom

NSHP Plenary Speaker: Gabriela Gonzalez

Gabriela González is a physicist working on the discovery of gravitational waves with the LIGO team. She was born in Córdoba, Argentina, studied physics at the University of Córdoba, and pursued her Ph.D. in Syracuse University, obtained in 1995. She worked as a staff scientist in the LIGO group at MIT until 1997, when she joined the faculty at Penn State.

In 2001 she joined the faculty at LSU, where she is a professor of physics and astronomy. She has received awards from the American Physical Society, the American Astronomical Society and the US National Academy of Sciences, and is a Fellow of the Academy of Arts and Sciences and a member of the National Academy of Sciences. She has been a member of the LIGO Scientific Collaboration since it was funded in 1997, served as the elected LSC spokesperson in 2011-2017, and is known for participating in the announcement of the discovery of gravitational waves in 2016.

Her work has focused on LIGO instrument development (especially reducing noise sources and tuning alignment systems) and LIGO data calibration and diagnostics, critical to increasing the astrophysical reach of data analysis methods.

Lynne Talley

Physics and the Changing Climate of the Southern Ocean and Antarctica

Monday, January 8

2–3 p.m.

Golden Ballroom

Plenary Speaker: Lynne Talley

Lynne Talley is a Distinguished Professor of Physical Oceanography in the Climate, Atmospheric Sciences, and Physical Oceanography division at Scripps Institution of Oceanography, University of California, San Diego.

Talley's research focuses on the general circulation of the ocean and the role of various oceanic and atmospheric conditions that affect ocean currents and property distributions, including salinity. Her work involves analysis of data from most of the world's oceans, depicting the movement of heat, salinity, and water masses, and the formation of water masses, particularly in subpolar regions.

She received a BA in physics and a BM in piano performance in 1976 from Oberlin College in Oberlin, OH. She received a PhD in physical oceanography from the Massachusetts Institute of Technology–Woods Hole Oceanographic Institution in 1982.

Prior to joining Scripps, Talley was a postdoctoral researcher at Oregon State University in Corvallis. While at Scripps, she has done research that combines analysis of ocean observations with advanced theoretical work to describe and map large-scale circulation, and understand the ocean's role in climate. Talley has spent many months on research ships collecting oceanographic data and is continuously active in international steering groups and oversight committees for collection and use of oceanographic data. She is the lead author of a graduate level textbook on descriptive physical oceanography.

She was a lead author of the IPCC Fourth Assessment Report Working Group I chapter "Observations: Oceanic Climate Change and Sea Level," which was released in February 2007. The report earned contributing scientists a share of the Nobel Peace Prize later that year. She was also a lead author on the same topic for the Fifth Assessment Report, released in 2013. She was elected a fellow of the American Academy of Arts and Sciences in 2003, a fellow of the American Geophysical Union in 2006, a fellow of the American Meteorological Society in 2008, a fellow of the ceanography Society in 2010, and a fellow of the American Association for the Advancement of Science in 2017. She was awarded the Rosenstiel Award (University of Miami's Rosenstiel School of Marine and Atmospheric Science) in 2001, the Huntsman Award (Bedford Institute of Oceanograp in 2003, the Henry Stommel Research Award
(American Meteorological Society) in 2017, and the Fridtjof Nansen Award (European Geosciences Union) in 2017.

Andrew Gemant Award Given to Don Lincoln

Monday, January 8 • 6:30–7:30 p.m. • Fleet Center buses will shuttle guests to and from the event.

Don Lincoln

The Andrew Gemant Award recognizes the accomplishments of a person who has made significant contributions to the cultural, artistic, or humanistic dimension of physics and is given annually. The award is made possible by a bequest of Andrew Gemant to the American Institute of Physics. The awardee receives a $5,000 cash award, designates an academic institution to receive a grant of $3,000 to further the public communication of physics, and is invited to deliver a public lecture in a suitable forum.

Don Lincoln is currently a senior scientist at Fermi National Accelerator Laboratory in Chicago, where, in addition to conducting research, he hosts dozens of particle physics videos for Fermilab's YouTube channel, the most popular of which has almost 3 million views. His distinguished research career, which has led to over 1,000 publications and includes major contributions to the discoveries of the top quark and the Higgs boson, is paralleled by an extensive resume of science communication work.

God's Thoughts: The Modern Search for a Theory of Everything

AIP Panel on Communicating Science to the Public

Monday, January 8 • 12:30–1:30 p.m. • Location: Golden Ballroom

A panel discussion focused on challenges and tips for communicating science to the public: Come hear stories from the field, tips on breaking into the publishing industry, and what can happen behind the book or camera.

Paula Ayer

Paula Ayer is an editor at Greystone Books and an accomplished translator and award-winning author of four books for both teens and children. She grew up in Calgary, Alberta, and studied at the University of Calgary and Simon Fraser University. Ayer now resides in Vancouver with her husband and daughter.

Noah Baker

Noah Baker is a senior editor for *Nature* and *Scientific American*, reporting on stories from across the spectrum of science in online video and weekly podcast formats. He earned his bachelor's degree in zoology and master's degree in science media production from Imperial College London.

Antonia Banyard

Antonia Banyard has authored many works, including three nonfiction books, one novel and various poems. She holds multiple degrees in creative writing from the University of Victoria and the University of Queensland, and has worked in publishing for over 20 years.

Don Lincoln

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The 2017 SPS Outstanding Chapter Advisor Award

Tuesday, January 9 • 1 p.m. • Location: Golden Ballroom

Michael "Bodhi" Rogers

The 2017 SPS Outstanding Chapter Advisor Award will be presented to Michael "Bodhi" Rogers of Ithaca College, NY. Rogers' passion and leadership has been described as "contagious," contributing to the level of success his endeavors achieve. His dedication to his students is shown through the time and guidance Rogers provides them, whether it be about academics, extracurricular activities, or personal decisions. What makes him an exceptional advisor in the eyes of his students is how he turns ideas into actions, and standing alongside the chapter through every step of their path. The "tremendously positive impact" Rogers has had on his students is illustrated in the way he helps them "find their path while maintaining their identity as physicists." For these reasons, the term "outstanding advisor" is something Rogers embodies every day to his students. The full bio and information about the award can be found here — https://www.spsnational.org/awards/outstanding-chapter-advisor-award/recipients/2017.

AAPT Fellows for 2017 Announced

Tuesday, January 9 • 11:30 a.m.–12 p.m. • Location: Golden Ballroom

Timothy A. Duman, Randall D. Knight, Laureen G. Reed, Carl T. Rutledge, Toni Sauncy, Steve Spicklemire, Tim J. Stelzer, Paul Tipler, and Barbara L. Whitten

CW01 Perimeter Institute: Teaching Astronomy to Grade 9 Students

• Location: California Room • Time: 1:00-2:00 p.m. • Date: Sunday, January 7 • Sponsor: Perimeter Institute

Leaders: Kelly Foyle and Dave Fish

Astronomy is one of the most fascinating topics in all of science. This session will discuss a new classroom resource for introducing high school freshmen (i.e. grade 9 students) to a range of astronomical topics including stars and stellar evolution, the Milky Way galaxy, exoplanets, and the Big Bang theory. It includes numerous hands-on activities, teaching tips, and a professionally produced classroom video.

CW02 Perimeter Institute: Cutting-Edge Physics

• Location: California Room • Time: 2:30-3:30 p.m. • Date: Sunday, January 7 • Sponsor: Perimeter Institute

Leaders: Kelly Foyle and Dave Fish

Join us as we take a look at the very coolest physics news items over the past year and what is coming next! This session will explore a variety of cutting-edge science subjects for teachers that are looking for current, real-world science connections in their classroom. Uncover what's happening in our world RIGHT NOW, and where we are at the cusp of the next major discovery!

CW03 Perimeter Institute: Black Holes

• Location: California Room • Time: 11:00 a.m.-12:00 p.m. Date: Monday, January 8 • Sponsor: Perimeter Institute

Leaders: Kelly Foyle and Dave Fish

Black Holes are fascinating objects that capture the imagination of students everywhere. In this workshop we will explore the basic Physics behind Black Holes, the latest observational evidence for them, some of their more exotic features, such as time slowing down, and we will introduce some classroom resources that you can take back with you to bring this awesome topic into your classroom.

CW04 Perimeter Institute: Spicing Up Classical Physics with Modern Examples

• Location: California Room • Time: 12:30-1:30 p.m. • Date: Monday, January 8 • Sponsor: Perimeter Institute

Leaders: Kelly Foyle and Dave Fish

Are YOU tired of using the same examples to illustrate concepts in classical physics year after year? Are you looking for ways to expose your students to modern physics without taking extra time? This session will show you that what you do every day can easily be applied to new, interesting concepts in modern physics! We'll discover how to use dark matter in lessons about circular motion, and how to incorporate an introduction to quantum when teaching about waves. Come see how modern physics can be explored within a classical curriculum in these easy-to-adapt, hands-on activities!

CW05 Vernier: Introducing Pivot Interactives from Vernier

• Location: Pacific Salon Six/Seven • Time: 11:00 a.m.-12:00 p.m. • Date: Sunday, January 7 • Sponsor: Vernier Software & Technology

Leaders: Fran Poodry, David Vernier, John Gastineau

Pivot Interactives is a customizable online-video environment that is a superb complement to hands-on experiments with Vernier sensors. Students are quickly engaged by these high-production-quality videos of hard-to-implement phenomena, which are a powerful supplement to hands-on experimentation. Explore the possibilities with us!

CW06 Vernier: Solutions for Physics and Chromebooks

• Location: Pacific Salon Six/Seven • Time: 12:00-1:00 p.m. Date: • Date: Sunday, January 7 • Sponsor: Vernier Software & Technology

Leaders: Fran Poodry, David Vernier, John Gastineau

Bring your Chromebook (or use one of ours) and learn how easy it is to connect sensors and collect and analyze data. Explore the free Graphical Analysis 4 app data collection.

CW07 Pearson: College Physics: Explore and Apply 2nd Edition – Help Students Learn Physics by Doing Physics

• Location: Pacific Salon Four/Five • Time: 12:30-1:30 p.m. • Date: Monday, January 8 • Sponsor: Pearson

Leader: Eugenia Etkina

The lead author of *College Physics: Explore and Apply,* Eugenia Etkina, will discuss how she employs an active learning approach with her students and how the changes in the second edition of *College Physics* addresses the needs of the changing world. She will show how the written text, *Active Learning Guide, and Mastering Physics* can engage students in practicing science while learning physics. A myriad of new experiments and innovative problems will motivate your students to learn physics and help them succeed on revised assessments – such as AP exams and the MCAT. Come and learn about the exciting developments in the whole learning system and receive a signed book by the authors, while enjoying refreshments!

CW08 Expert TA: When Was The Last Time You Really Thought About How Your Students Do Homework?

• Location: Pacific Salon Four/Five • Time: 12:30-1:30 p.m. (*lunch provided*) • Date: Sunday, January 7 • Sponsor: Expert TA

Leader: Jeremy Morton

Advancements have been made in online homework that are transforming the way students learn. Unfortunately, the internet has also made it easy for students to cheat online. Today, using an app on their smartphone, a student can upload a picture of their physics homework and a solution is posted within 15 minutes (even for a paper-based question handed out in class). You can't solve a problem like that without sophisticated technology. Expert TA addresses these negative aspects of the changing educational landscape, while continuing to build advanced tools designed to help students learn physics. Did you know that we: a) have automatically graded Vector and Free Body Diagram questions, complete with feedback and partial credit, b) have data-mined every incorrect answer ever submitted, and had experts write specific and Socratic feedback for the top 20 most common wrong answers for each question, c) provide "IBM Watson" style analytics about each class, d) web crawl solution-sharing sites to remove our problems, and e) have an Academic Integrity suite designed to keep students off those sites in the first place? Is your homework system doing everything it can for you and your students? Have lunch with us and see what's out there.

CW09 PASCO scientific: How Much Physics Can You Do with the Wireless Smart Cart?

• Location: Pacific Salon Six/Seven • Time: 10:30-11:30 a.m. • Date: Monday, January 8 • Sponsor: PASCO scientific

Leader: Brett Sackett

PASCO's Wireless Smart Cart is the new must-have tool for the physics lab! Join us to get hands-on with the Smart Cart and experience Kinematics, Dynamics, Work & Energy, Impulse and Momentum experiments without wires or interfaces. The Smart Cart provides real time wireless measurements of Position, Velocity, Acceleration along all axis, Force, and 3 dimensions of angular velocity. The fully sensor-integrated Smart Cart means less equipment to manage and set up, while providing the most economical single piece of lab instrumentation for physics. The Smart Cart really is the dynamics cart you are looking for! We will be giving away a free Smart Cart!

CW10 PASCO scientific: Untangling Basic Circuits

• Location: Pacific Salon Six/Seven • Time: 11:45 a.m.–12:45 p.m. • Date: Monday, January 8 • Sponsor: PASCO scientific

Leader: Sackett Brett

Students are often confused when learning the basics of circuits because they cannot directly observe the phenomenon, or they become lost in the tangle of wires. There is a simpler way for students to not only learn the basics of circuits, but also gives them the freedom to easily explore their own circuit designs to gain a deeper understanding of the physics concepts. Get hands on with new technology to discover a better way to teach circuits! We will be giving away a complete Modular Circuits Set!

CW11 PASCO scientific: Essential Physics Equations and Simulations

• Location: Pacific Salon Six/Seven • Time: 1-2 p.m. • Date: Monday, January 8 • Sponsor: PASCO scientific

Leader: Brett Sackett

We all want students to understand physics, not memorize problem solving steps. Join us and play with essential interactive equations and simulations that span physics from Newton's Laws to the atom. Interactive equations are powerful teaching and learning tools that bridge between math and science. You probably can't get an alpha source in your classroom, but our Gold Foil simulation is the next best thing. The Essential Physics simulations are 100% HTML 5 and run on any device including Chromebook™, Android™, Mac®, iPAD®, Windows®, and even phones - without any installed software! Attendees will receive free trial access to the whole collection of simulations and interactive equations.

CW12 Honorarium-based Focus Group Opportunity

• Location: Pacific Salon Four/Five • Time: 10:30-11:30 a.m. • Date: Monday, January 8 • Sponsor: Expert TA

Leader: Jeremy Morton

Expert TA is seeking your feedback in order to evaluate our current platform and guide future development. We are offering $50.00 Amazon gift cards as incentive for participation in this session, which involves the completion of a focus group survey. Expert TA is an online homework provider for introductory algebra and calculus-based physics courses. Our key features include interactive free body diagram drawings that are automatically graded (including for proportionality), advanced symbolic question types, and instructor-authored feedback for the most common student mistakes, as determined by an ongoing incorrect answer data-mining process. We work alongside physics instructors when developing new features and tools, and would love your thoughts about our existing features, as we seek to expand our offering further. We value your input, as Physics Education professionals, regarding what additional features could be most helpful. Examples of topics to be discussed: a) Modifying our FDB drawing foundation to handle Ray Diagrams and Extended FBDs for objects experiencing rotation and b) What real-time analytics/statistical metrics are most helpful to you. Please join us and tell us how we can build the best educational tool for physics instructors and students.

CW13 Varafy Free-Body Diagram Assessment

• Location: Pacific Salon Four/Five • Time: 3-4 p.m.
• Date: Monday, January 8 • Sponsor: Varafy Corp.

Leader: Werner Biegler

The Varafy Free-Body Diagram (FBD) Assessment application is a learning and assessment tool for Physics and Engineering. Students studying Physics or Engineering are required to understand how to interpret forces acting on an object and illustrate their understanding by drawing a force diagram or free body diagram. This can be at times a challenging concept for students to apply their thinking. Other than resorting to seeing the correct FBD image, there exists no digital tool today for students to use for practicing their knowledge. The key benefits of the Varafy FBD Assessment application are: • Web-based easy to use Student facing user interface • "How to's" gifs provided • Adjustable grading rubric (including sensitivity) for vector (location, direction, angles, labels, head/tail) points (location) and moments (location) • Detailed feedback provided to student to guide their thinking • Can be applied for either practice or assessment purposes • FBD is authored in Varafy's Content platform which allows for 1,000s of unique iterations of the same problem to be generated with a click of a mouse

Attention High School Teachers!

Come to the HS Teachers' Lounge (Terrace Salon Three) to engage in hands-on activities, pick up lesson plans, review new DigiKits, and network with colleagues!

Sunday: *10:00 – 11:30 (Digi Kits)*
11:30 – 12:30 (Get the Facts Out)
12:30 – 2:00 (Open Lounge)
2:00 – 3:30 (Digi Kits)
4:00 – 5:00 (Digi Kits)
5:00 – 6:00 (STEP UP for Women)
6:00 – 10:00 (Open Lounge)

Monday: *8:00 – 9:30 (Computation w/Bootstrap)*
11:00 – 2:00 (Digi Kits)
4:00 – 5:30 (Digi Kits)
7:00 – 8:00 (Aspiring to Lead)
8:00 – 10:00 (Open Lounge)

Tuesday: *8:00 - 10:30 (Open Lounge)*

AAPT Exhibitors

Town and Country Ballroom: ***Saturday, 8-10 p.m., Sunday, 8 a.m.–5 p.m., Monday, 8 a.m.–4 p.m.***

AAPT Publications

Booth #208
One Physics Ellipse
College Park, MD 20740
301-209-3300, 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 Association of Physics Teachers

Booth #210
One Physics Ellipse
College Park, MD 20740
301-209-3300; www.aapt.org

Welcome to San Diego! Join us at the AAPT booth to enter the Great Book Giveaway free raffle and spin our prize wheel for your chance to win some free prizes. This year try out our interactive demos based on lesson plans created from *The Physics Teacher!* We will also have a large wide variety selection of educational resources available including resources to support teaching including our popular Physics in 21st Century Science Standards: The Role of Physics in the NGSS booklet.

AIP - Policy and Advocacy

Booth #408
AIP Government Relations
One Physics Ellipse
College Park, MD 20740, www.aip.org

Congress must hear from you, their constituents, about the importance of science and education. Increasing the quality of science education is critical to helping the nation strengthen its global competitiveness by preparing a workforce for the 21st century. Visit us at the AAPT exhibit hall to learn more about how you can be involved in science advocacy and policy at the state and federal level. The table will be staffed with a variety of individuals with different types of expertise to help you think about and engage in these efforts. This interactive table is also an opportunity for us to learn how we can serve you better in doing this important work. After San Diego keep an eye out for two training webinars that will be offered before the AAPT 2018 Summer Meeting on 101 Science Policy and How To Engage With Policy Makers. Then join us in DC and attend workshops on Science policy and advocacy.

American Institute of Physics

Booth #403
One Physics Ellipse
College Park, MD 20740
301-209-3100; www.aip.org

For over sixty years, the American Institute of Physics (AIP) has provided AAPT members with *Physics Today* magazine. Visit the AIP booth and learn about all the other ways that AAPT works with AIP to produce career resources, statistical trends in education and employment, undergraduate support through the Society of Physics Students, and more.

American Physical Society

Booth #402
One Physics Ellipse
College Park, MD 20740
301-209-3206, 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 #209
PO Box 2750
Ann Arbor, MI 48106
800-367-6695, www.arborsci.com

For 30 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, engaging and relevant for students and teacher's alike. 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 Ave., Suite 220
Tulsa, OK 74119
877-572-0734, www.theexpertta.com

Expert TA is an online homework system specifically developed for introductory physics courses. Emphasizing the problem solving process by allowing students to work with symbolic expressions has always been central to Expert TA. We have an intuitive interface for students to enter symbolic expressions, a robust math engine that recognizes mathematically equivalent answers, and specific feedback for the most common student mistakes developed through an ongoing data-mining approach. Additionally, students can now draw Free Body Diagrams in Expert TA that are equipped with feedback and are automatically graded. Finally, we recognize that these educational exercises are only meaningful if students do the work themselves. We have developed a suite of Academic Integrity tools, and we work to keep solutions to our problems off of the internet.

Foster Learning LLC

Booth #110
900 Timberlake Dr.
Edwardsville, IL 62026
618-656-6836, fosterlearning.education/

PathPlan is a tablet-based digital learning platform designed to teach students how to systematically solve problems. It de-emphasizes the answer and reinforces the process of solving problems. PathPlan has over 100 problems in its database with different scaffolding assignable to each. In addition, PathPlan provides partial credit for answers .

Johns Hopkins Center for Talented Youth (CTY)

Booth #401
5801 Smith Avenue
#400 McAuley Hall
Baltimore, Maryland 21209
410-735-6182
ctyinfo@jhu.edu

The world leader in gifted education, Johns Hopkins Center for Talented Youth is a nonprofit dedicated to identifying and developing the talents of academically advanced pre-college students. We serve bright learners through summer, online, and family programs, and seek to hire qualified staff to work with our students.

Liquid Instruments

Booth #111
Bldg. 38a, The Australian National University
Canberra, Australia 0261
650-646-4713, www.liquidinstruments.com

Moku:Lab is a new breed of test and measurement instrumentation that helps scientists, engineers, students and professionals seamlessly acquire data and control their experiments. Moku:Lab's reconfigurable hardware and revolutionary wireless user interface enable many instrument modes using one unique device, including a Lock-in Amplifier, PID controller, Bode Analyzer, Oscilloscope, Spectrum Analyzer, Arbitrary Waveform Generator, Data Logger, etc.

Local SPS Chapters

Booth #406
Society of Physics Students & Sigma Pi Sigma (ΣΠΣ)
One Physics Ellipse
College Park, MD 20740
www.aip.org
Come interact with the local chapters of the Society of Physics Students! Undergraduate physics and astronomy students of regional SPS chapters will be available to show off their activities, outreach, demos, and chapters. Stop by to learn or just connect.

Macmillan Learning

Booth #205
One New York Plaza
New York, NY 10004
800-446-8923
www.macmillanlearning.com
Macmillan Learning strives to support and enhance the Physics and Astronomy teaching and learning experience. Stop by the booth to see how we are bringing together innovative digital programs with respected authorship like the new SaplingPlus available with the just published second edition of College Physics by Roger Freedman, Todd Ruskell, Philip Kesten and David Tauck. Visit with us and 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). Interact with FlipItPhysics and Sapling Learning to see 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 at www.macmillanlearning.com.

Morgan and Claypool Publishers

Booth #101
1210 5th Ave. Suite 250
San Rafael, CA 94901
908-630-7188, www.morganclaypool.com
IOP Concise Physics (by Morgan & Claypool) publishes short texts in over 30 distinct areas of physics. These books provide researchers, teachers, and students with an introduction to key principles in multiple areas, a look back at historical events and people, and also delve into issues surrounding effective teaching methods.

PASCO scientific

Booth #202
10101 Foothills Blvd.
Roseville, CA 95747
800-772-8700, www.pasco.com
PASCO designs and manufactures a wide range of Physics apparatus including the revolutionary Smart Cart (the Physics Lab on Wheels). Drop by our booth or attend one of our workshops to learn how the Smart Cart, the new Modular Circuits, and PASCO's Essential Physics Curriculum can make your classes easier to teach. One workshop participant will win a free Smart Cart and one will win a Modular Circuits Kit.

Pearson

Booth #303
221 River St.
Hoboken, NJ 07030
201-236-5885, 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 #211
31 Caroline Street N.
Waterloo ONT, Canada
519-569-7600; 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.

Quantum Design

Booth #204
10307 Pacific Center Ct.
San Diego, CA 92121
858-481-4400, 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.

Qubitekk, Inc.

Booth #305
1216 Liberty Way
Vista, CA 92081
858-750-9353, www.qubitekk.com
Qubitekk's Quantum Mechanics Lab Kit gives you the tools to explore and more deeply understand quantum physics. Suitable for both classroom instruction and R&D, this kit includes all of the equipment and instructions needed to perform seven fundamental experiments in quantum mechanics.

Society of Physics Students

Booth #404
One Physics Ellipse
College Park, MD 20740
301-209-3008, 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).

Texas Instruments

Booth #103
13532 N. Central Expressway
Dallas, TX 75243
1-800-842-2737, www.education.ti.com
TI provides free classroom activities that enhance math, science and STEM curricula, technology that encourages students to develop a deeper understanding of concepts, and professional development that maximizes your investment in TI technology. Visit education.ti.com

University Science Books

Booth #108
111 Prospect Place
South Orange, NJ 7079
973-378-3900
University Science Books is proud to feature our newly released physics text, COLLEGE PHYSICS: PUTTING IT ALL TOGETHER by Hellings, Adams and Francis. This is an algebra-based book, designed for the first year, non-calculus college course. Although it covers the traditional topics in the traditional order, this streamlined, engaging and affordable book

is very different from its over-inflated and overpriced competitors. If you teach this course and are looking for a new book, we invite you to stop by our booth. Also on display are our internationally best-selling physics titles by John Taylor, John Townsend, Thomas Moore, and others.

Varafy Corporation

Booth #400
#202-10359 104th St.
Edmonton, AB 0
780-232-6264, www.varafy.com
Varafy Corporation is a learning technology software company. Varafy's mission is to improve student outcomes in learning STEM in K-12 and Higher Education. Varafy has also developed a Free-Body Diagram Assessment web application that allows a student to draw a Free-Body Diagram and receive immediate and detailed feedback on their answer. Please drop by our booth 400 to test the FBD yourself.

Vernier Software and Technology

Booths #102,104
13979 SW Millikan Way
Beaverton, OR 97005
888-837-6437, 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 Go Direct Force and Acceleration and Go Direct 3-Axis Magnetic Field sensors, as well as our new Graphical Analysis 4 software.

Wiley

Booth #105
111 River St.
Hoboken, NJ 07030
201-748-6518
www.wiley.com
Wiley is a global provider of knowledge and knowledge-enabled services in research, professional practice and education. Developing digital education, learning, assessment and certification, partnering with societies and communicating research discoveries.

– T02 Improving the Epistemological Beliefs of Non-STEM Majors **Sponsor: Committee on Space Science and Astronomy**
Time: 9:00-11:00 a.m. Sunday Member Price: $70 Non-Member Price: $95 Location: Pacific Salon Four/Five (at Town and Country)

Keith Johnson, Montana State University, Physics 264 Barnard Hall, Bozeman, MT 59717; keith.johnson12@montana.edu Shannon Willoughby

– T03 PTRA: Quantum Cryptography: An Applied Way to Teach the Basics of Quantum Mechanics **Sponsor: Committee on Physics in Pre-High School Education Co-sponsor: Committee on Physics in High Schools Time: 9:00-11:00 a.m. Sunday Member Price: $75 Non-Member Price: $100 Location: Sunrise (at Town and Country)**

Tommi Holsenbeck, 5062 County Rd 13; eholsenbeck@alasu.edu; Karen Jo Matsler, Jan Mader, Janie Head, Elaine Gwinn

– W02 Tools for Departmental Self-Study and External Review **Sponsor: Committee on Research in Physics Education**
Time: 8:00 a.m.-12:00 p.m. Saturday Member Price: $60 Non-Member Price: $85 Location: 231

Toni Sauncy, Texas Lutheran University, Department of Physics, 1000 West Court St., Seguin, TX 78155; tsauncy@tlu.edu; Brad Conrad

– W03 Using Glowscript in the Introductory Physics Classroom **Sponsor: Committee on Physics in Two-Year Colleges**
Time: 8:00 a.m.-12:00 p.m. Saturday Member Price: $60 Non-Member Price: $85 Location: 233

Dwain Desbien, 3000 N Dysart Rd., Avondale, AZ 85392; dwain.desbien@estrellamountain.edu; Thomas O'kuma

– W04 Learn to Create Interactive Physics Simulations for Phones, Tablets, and Computers in Just 4 Hours **Sponsor: Committee on Educational Technologies Time: 8:00 a.m.-12:00 p.m. Saturday Member Price: $70 Non-Member Price: $95 Location: 235**

Andrew Duffy, Departme\f Physics, Boston Univ., 590 Commonwealth Ave., Boston, MA 02215; aduffy@bu.edu; Wolfgang Bauer

– W10 Making Good Physics Videos **Sponsor: Committee on Apparatus Time: 8:00 a.m.-12:00 p.m. Saturday Member Price: $85 Non-Member Price: $110 Location: 252**

James Lincoln, PhysicsVideos.com, PO Box 11032, Newport Beach, CA 92658; james@physicsvideos.com

– W09 Improv for Physics **Sponsors: Committee on Physics in Undergraduate Education, Committee on Science Education for the Public**
Time: 8:00 a.m.-5:00 p.m. Saturday Member Price: $95 Non-Member Price: $120 Location: 230

Carolyn Sealfon; csealfon@alumni.upenn.edu; Nancy Watt

– W11 Designing Project-based Instructional Environments **Sponsor: Committee on Physics in Undergraduate Education Co-sponsor: Committee on Physics in High Schools Time: 8:00 a.m.-5:00 p.m. Saturday Member Price: $100 Non-Member Price: $125 Location: 229**

Paul J. Camp, Georgia Gwinnett, College School of Science and Technology, 1000 University Center Lane, Lawrenceville, GA 30043; pjcamp@curmudgeonhill.org; Eric Mazur, Kelly Miller, Laura Tucker,

– W12 Preparing to Succeed in AP Physics 1 and 2 **Sponsor: Committee on Physics in High Schools Time: 8:00 a.m.-5:00 p.m. Saturday Member Price: $89 Non-Member Price: $114 Location: 232**

Angela Jensvold, 231 N Canyon Blvd., Monrovia, CA 91016; angelajensvold@yahoo.com

– W13 Beginning Arduino and ROVs **Sponsor: Committee on Physics in Two-Year Colleges Time: 8:00 a.m.-5:00 p.m. Saturday Member Price: $205 Non-Member Price: $230 Location: 290**

Gregory Mulder, Department of Physical Sciences, Linn-Benton Community College, 6500 Pacific Blvd. SW, Albany, OR 97321 ; mulderg@linnbenton.edu Evan Thatcher, Heather Hill

– W17 Writing and Evaluating Curricular Materials for the IPLS Portal **Sponsor: Committee on Physics in Undergraduate Education**
Time: 1:00-5:00 p.m. Saturday Member Price: $65 Non-Member Price: $90 Location: 233

Juan Burciaga, Department of Physics and Astronomy, Bowdoin College, 8800 College Station Brunswick, ME 04011; Juan.Burciaga@ColoradoCollege.edu

– W19 Introduction to LaTeX for Teachers and Students **Sponsor: Committee on Educational Technologies Co-sponsor: Committee on Graduate Education in Physics Time: 1:00-5:00 p.m. Saturday Member Price: $60 Non-Member Price: $85 Location: 235**

Joe Heafner, 3990 Herman Sipe Rd., Conover, NC 28613-8907; heafnerj@gmail.com

– W25 Fun and Engaging Labs **Sponsor: Committee on Teacher Preparation Co-sponsor: Committee on Physics in High Schools Time: 8:00 a.m.-12:00 p.m. Sunday Member Price: $60 Non-Member Price: $85 Location: 233**

Wendy Adams, University of Northern Colorado, 501 20th St., Greeley, CO 80639; wendy.adams@colorado.edu; Duane Merrell

– W26 Environmental Physics with Satellite Imagery and the Google Earth Engine **Sponsor: Committee on Educational Technologies**
Time: 8:00 a.m.-12:00 p.m. Sunday Member Price: $60 Non-Member Price: $85 Location: 7

JB Sharma, Department of Physics, University of North Georgia, Gainesville, GA 3050

– W27 Integrating Computation into Undergraduate Education **Sponsor: Committee on Educational Technologies Co-sponsor: Committee on Physics in Undergraduate Education Time: 8:00 a.m.-12:00 p.m. Sunday Member Price: $20 Non-Member Price: $45 Location: 130**

Larry Engelhardt, Francis Marion University PO Box 100547 Florence, SC 29506 ; lengelhardt@fmarion.edu; Marie Lopez del Puerto, Kelly Roos, Danny Caballero, Norman Chonacky

– W28 LIGO and Interferometers **Sponsor: Committee on Apparatus Co-sponsor: Committee on Modern Physics Time: 8:00 a.m.-12:00 p.m. Sunday Member Price: $80 Non-Member Price: $105 Location: 235**

Ken Ciceri, Department of Physics, 225 Nieuwland Science Hall, Notre Dame IN 46556; Kenneth.W.Cecire.1@nd.edu, debeeker@indiana.edu; Dan Beeker

– W29 A Suite of Research-based Physics Labs for Mechanics and E&M **Sponsor: Committee on Research in Physics Education Co-sponsor: Committee on Laboratories Time: 8:00 a.m.-12:00 p.m. Sunday Member Price: $60 Non-Member Price: $85 Location: 173**

Andrew Boudreaux, Western Washington University, Department of Physics, 516 High St., Bellingham, WA 98225-9164; andrew.boudreaux@wwu.edu Brian Stephanik

2018 AAPT Winter Meeting – Shared Books

Princeton University Press

1. Paul Charbonneau, *Natural Complexity: A Modeling Handbook*
2. Steven S. Gubser and Frans Pretorius, *The Little Book of Black Holes*
3. Alan P. Lightman and William H. Press, *Problem Book in Relativity and Gravitation*
4. Carolyn A. MacDonald, *An Introduction to X-Ray Physics, Optics, and Applications*
5. Charles W. Misner and Kip S. Thorne, *Gravitation*
6. Philip Nelson, *From Photon to Neuron: Light, Imaging, Vision*
7. Roger Penrose, *Faith, and Fantasy in the New Physics of the Universes*
8. Kip S. Thorne and Roger D. Blandford, *Modern Classical Physics: Optics, Fluids, Plasmas, Elasticity, Relativity, and Statistical Physics*
9. Neil deGrasse Tyson and Michael A. Strauss, *Welcome to the Universe: An Astrophysical Tour*
10. Neil deGrasse Tyson and Michael A. Strauss, *Welcome to the Universe: The Problem Book*

Loose Line Productions Inc.

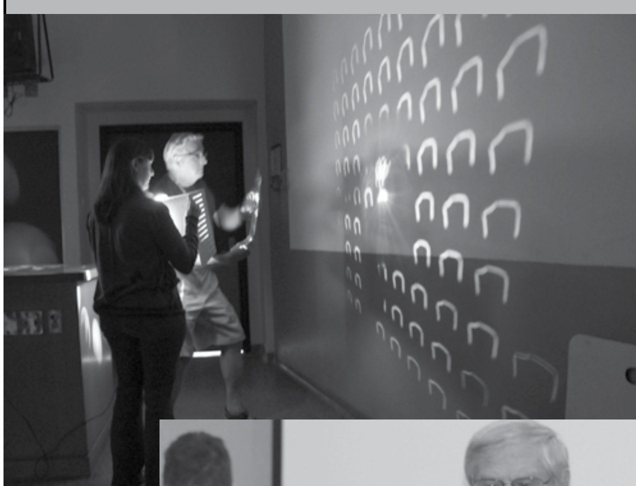
1. Assa Auerbach and Richard Codor, *Max The Demon vs. Entropy of Doom*

Great Book Giveaway

Monday, January 8 3:30 p.m. Exhibit Hall!

Get your raffle tickets at the AAPT Booth

High School Share-a-Thon



Show and Tell!

Not for HS teachers only!

Note Time!

Sunday, 8:30-10 a.m.
Pacific Salon One

AAPT PHYSICS EDUCATION 2018 WINTER MEETING
January 6-9 San Diego, CA

Get your Pronoun Stickers!

As part of our ongoing efforts to improve inclusiveness at AAPT National Meetings, we are providing stickers with pronouns that can be attached to name badges. In doing so, we aim to:

- Make it easy for you to know which pronouns to use for someone you just met, especially if you're unsure about their pronouns.
- Make it easy for people to communicate their pronoun sets to others, especially for people who use uncommon pronouns or who have recently changed which pronouns they use.
- Prompt conversations among AAPT members about gender, and raise awareness that gender is complicated.
- Create a welcoming environment for people of all genders.

In addition to **she/her/hers** and **he/him/his**, other pronoun sets include **they/them/theirs** and **ze/zir/zirs**. Each of these pronoun sets includes subjective, objective, and possessive cases. Gender can be fluid, and many of the people you will encounter at WM18 will fall at various places across the spectrum. To reduce instances of misgendering at WM18, please use the pronouns indicated on attendees' name badges.

There are several resources at this meeting that you may find helpful:

Session BB: Addressing Diversity in Science Museums, Sunday, January 7, 2-3:30 p.m., Royal Palm One/Two

Session DC: Gender Bias in Teaching Evaluations, Recommendations and Recognition, Monday, January 8, 11 a.m.-12:10 p.m., Royal Palm Three/Four

Meet-up for Members and Supporters of LGBTQ Community
12:30–2, Sunday, January 7, Towne Room

A Quiet Room will be available at the Town and Country – Old MSI, upstairs on the North Atlas Foyer.

Session SPS: SPS Undergraduate Research and Outreach Posters

Location: Town and Country Room **Sponsor:** AAPT/SPS **Time:** 8–10 p.m. **Date:** Saturday, January 6 **Presider:** Brad Conrad

SPS01 8:00-10:00 p.m. Preliminary Cosmic Ray Muon Flux Investigation for Solar Eclipse Experiment

Poster – Clarissa Carr, Glenbrook North High School, 2300 Shermer Rd., Northbrook, IL 60062; clarissalcarrh@gmail.com
Jacob Rosenberg, Anthony Valsamis, Glenbrook North High School

Tamar Dallal, Allen Sears, Ida Crown Jewish Academy

A cosmic ray experiment was conducted in order to observe the muon flux rate during a total solar eclipse. To achieve the purpose of the central experiment, collecting data regarding solar and lunar transit along with data obtained of empty sky was essential. Information regarding the results of the data accumulated throughout the initial stages of the experiment will be explored. This poster elaborates on the preliminary data collections of the experiment.

SPS02 8:00-10:00 p.m. Proof of Concept for Data Collection Methods for Measuring Muon Flux During a Solar Eclipse

Poster – Michelle Matten, Ida Crown Jewish Academy, 6721 n Francisco, Chicago, IL 60645; mashamatten@gmail.com*

Tamar Dallal, Ezra Schur, Jacob Miller, Allen Sears, Ida Crown Jewish Academy

Detecting muons may seem to be a simple process today, but detecting a change in the muon flux during a solar eclipse more complicated. How the be arranged to get the best results and minimize errors? What type of should be expected from the arrangement? This poster presents the different overlaps and configurations of QuarkNet muon counters used to take data before and during the solar eclipse of August 2017.

*Sponsored by Allen Sears

SPS03 8:00-10:00 p.m. Using a Local Positioning System as a Kinematics Lab

Poster – Cora Siebert, Portland State University, 1719 SW 10th Ave., Room 134, Portland, OR 97201; cora@pdx.edu;*

Thomas Allen, Gabriel Mukobi, Ralf Widenhorn, Portland State University Physics Department

The use of commercially available local positioning devices and their applications in the physics classroom will be presented. Using these positioning devices, students have a hands-on way of engaging with the relationships between position, velocity, and acceleration in 1-dimensional, 3-dimensional, and rotational systems. Students will be able to connect these concepts with their graphical and mathematical representations by completing various kinesthetic activities that include walking, running, jumping, spinning, and tossing objects.

*Sponsored by Ralf Widenhorn

SPS04 8:00-10:00 p.m. Video Analysis of Argument and Explanation in an Introductory Classroom

Poster – Eduardo A. Velazquez, St. Mary's University, 9642 Spring Harvest, San Antonio, TX 78254-6104; evelazquez4@mail.stmary.edu;

James T. Laverty, KSU

Recent efforts to transform science education have highlighted the importance of engaging students in scientific practices in order to develop their understanding of both the process and knowledge of science. This work focuses on identifying the scientific practices of Engaging in Argument from Evidence and Constructing Explanations in classroom video data. Our goal is to answer, "How can we identify when students are engaging in scientific practices in the classroom?" We are analyzing video recordings from an introductory physics class where students work on problems in groups of four for the entire two-hour class period. I have analyzed these videos for signs of students both engaging in argument and constructing explanations. This poster will discuss similarities and differences between these two practices and discuss how we can identify these practices in a valid and reliable way. This will allow us to investigate how students' use these practices throughout a semester.

SPS05 8:00-10:00 p.m. Citizen CATE: The Science Behind Eclipse Day Sun Funnels

Poster – Jordan R. Duncan, Department of Physics and Engineering, Southeast Missouri State, 1475 Kingsway Dr., Cape Girardeau, MO 63701-2229; jrduncan1s@semo.edu*

Sam Fincher, Margaret Hill, Southeast Missouri State

With much enthusiasm surrounding the August 21st trans-American eclipse, many individuals from around the globe traveled to the path of totality. As a member of the citizen CATE Team-040, located in Southeast Missouri, our team was responsible for collecting data pertaining to the solar corona. At our site location, the duration for totality was amongst the longest across the path, making our location prime for eclipse day adventurers. With this in mind our team desired to protect our data from overzealous folks, and hoped to educate eclipse goers about the astronomical event at the same time. We decided to build a sun funnel and to our boundless pleasure it not only educated but also created distance between our sensitive data acquisition and interested spectators. This poster relates to the science behind the building of our sun funnel, how we designed it, and the impact it had on site.

*Sponsored by Margaret Hill

SPS06 8:00-10:00 p.m. Cooperative Student-Built Multi-Payload Balloon-Satellite Eclipse Measurement

Poster – Russell Jeffery, The University of Central Arkansas, 201 Donaghey Ave., Dept of Physics & Astronomy, Conway, AR 72034; rjeffery2@cub.uca.edu;
William Slaton, The University of Central Arkansas

Six high-altitude balloon payloads were built and flown in the path of totality during the 2017 total solar eclipse across the U.S. The payload flight controllers consisted of Raspberry Pi computers running code written in Bash and Python 3.4 to collect and store data from sensors. The program on each payload collected data from an external temperature sensor, an internal temperature sensor, a pressure sensor, a light sensor, a GPS unit, and a camera. The design also incorporated a smart internal heater to prevent the payload from freezing. The payload design, circuit, and code will be presented along with lessons learned and plans for future work. This project was made possible by a Robert Noyce Teacher Scholarship, a subaward from the Arkansas Space Grant Consortium, and Student Research Funds from the Department of Physics and Astronomy at the University of Central Arkansas.

SPS07 8:00-10:00 p.m. Coronal Research: The Citizen CATE Project

Poster – Samuel N. Fincher, Southeast Missouri State University, Dept. of Physics & Engineering Physics, 1 University Plaza, MS6600, Cape Girardeau, MO 63701; sfincher1s@semo.edu;*

Jordan Duncan, Peggy Hill, Southeast Missouri State University

The Citizen CATE project was conducted this past summer with the goal of collecting data on the behavior of the inner solar corona during the total solar eclipse that crossed the breadth of the United States. Armed with almost 70 sites arrayed across the U.S., Citizen CATE aimed to collect a continuous stream of data from one side of the county to another. This poster outlines the efforts leading up to the eclipse and the results that our particular site, CATE site 40, achieved on eclipse day.

*Sponsored by Margret Hill

SPS08 8:00-10:00 p.m. Cosmic Ray Experiment Measuring How Solar Eclipse Effects Muon Flux

Poster – Ezra G. Schur, Ida Crown Jewish Academy, 9200 Kildare Ave., Skokie, IL 60076-1630; zera11001@gmail.com*

Jacob Miller, Allen Sears, Ida Crown Jewish Academy

Nathan A. Unterman, Emeritus Glenbrook North High School

During the recent August 2017 solar eclipse, cosmic ray experiments were conducted to establish the effect of the eclipse on muon flux using QuarkNet cosmic ray muon detectors, both before and during the eclipse. Flux rates were determined using a fixed array of counters, capturing data on muon flux from an angle of acceptance of 30 degrees centered at totality; a tracking telescope of counters that captured a 22 degree angle of acceptance, and a small stack of counters that was used to establish a control measure of muon flux from the vertical. We hypothesized that there would be a change in the muon flux during the eclipse.

*Sponsored by Allen Sears

SPS09 8:00-10:00 p.m. Controlled Thermal Emission Thermoelectric Generators – a Comsol Model

Poster – Daniela Buna, Ramapo College of NJ, 505 Ramapo Valley Rd., Boonton, NJ 07005; dbuna@ramapo.edu

Lejla Hoxha, Kamil Nowak, Daniel Tafone, Ramapo College of NJ

Comsol Multiphysics software is a very useful and intuitive environment for undergraduate physics education in the sense that it allows the student to design and test a full project, from a simple geometry to visualizing the solution and testing a prototype. While thermoelectric generators (TEG) have been studied intensely in the past decades, a recent breakthrough material shows unprecedented efficiency in the high temperature range (1000C). The breakthrough material is a refractory W-HfO2 metamaterial, which controls thermal emission by selectively enhancing and suppressing the thermal emission in the near-infrared spectrum. The goal of this project is a) to offer the undergraduate student programming experience with Comsol by developing a model for a commercial TEG product, b) to refine the model by adding a material equivalent to the W-HfO2 and finally, to study this model in the lower range of temperatures, below 300C, applicable to a larger number of practical applications.

SPS10 8:00-10:00 p.m. Polarization of a Metal Block Simulated Using GPU Computing

Poster – Nolan Roth, High Point University, 574 Cherry Ave., West Jefferson, NC 28694; nroth@highpoint.edu

Noah Worley, High Point University

When a charged particle is brought near a neutral metal object, the electrons distribute along the surface of the metal in such a way that the net electric field inside the block approaches zero. This process can be seen using computer simulations, however simulations of similar detail have been measured to take multiple minutes to run. The goal of this project is to calculate the polarization of a metal block due to the electric field of an external charged particle using parallel computation on a NVIDIA GPU using CUDA (Compute Unified Device Architecture) to yield a faster simulation. To do this, we use the GPU (Graphics Processing Unit) to simultaneously calculate the charge on each piece of the surface of the metal object during the transient phase of the polarization. To check the accuracy of the calculation and the improvement in performance provided by CUDA, we compare results to a previous program written by Bruce Sherwood and Ruth Chabay in Python.

SPS11 8:00-10:00 p.m. Translating Orientation into Electrical Commands

Poster – Michael T. Welter, High Point University, 6719 Kelker St., Toledo, OH 43617; mwelter@highpoint.edu

Many smartphones contain an accelerometer–a device used to measure acceleration forces such as gravity–which can be used to detect the phone's orientation. With an accelerometer, a device's orientation relative to an established xyz-plane can be used as a control mechanism for an outside system. Similar to joystick control systems used in most video game controllers, orientation can be translated into movement commands. The Arduino Esplora is a microcontroller board that provides a set of built-in, ready-to-use onboard sensors, such as a microphone, joystick, pushbuttons, and an accelerometer. I have used the accelerometer capabilities of the Esplora to control a multi-motor robotic device.

SPS12 8:00-10:00 p.m. Electro-optical Properties of 5CB Nematic Liquid Crystal

Poster – Jacob M. Gingles, Centenary College of Louisiana 2911 Centenary Blvd. Box #873 Shreveport, LA 71104 jgingles@my.centenary.edu

Chandra Pokhrel, Centenary College of Louisiana

We have measured the birefringence properties and the effect of electric field on the optical transmission of 5CB (4'-pentyl-4-cyanobiphenyl) liquid crystal. The birefringence was calculated by measuring the transmitted light intensity from the 5CB sample with planar alignment placed between two cross polarizers as a function of director angle. The signal maxima were obtained when the sample director is 45 degrees with the polarization axis of the laser and with the analyzer axis, and minima were obtained when the director is either parallel to the polarizer or to the analyzer. The electric field response of the 5CB liquid crystal was measured by measuring polarized light transmission through a twisted nematic 5CB cell placed between cross polarizers. The 90% transmission occurred when the electric field was 2.7 MV/m.

Session AA: 21st Century Physics in the High School Classroom

Location: California Room **Sponsor:** Committee on Physics in High Schools **Time:** 10:30 a.m.–12:30 p.m. **Date:** Sunday, January 7 **Presider:** Kenneth Cecire

AA01 10:30-11:00 a.m. Neutrino Experiments Inspire Students

Invited – Marla J. Glover, Rossville High School, 1 Robert Egly Dr., Rossville, IN 46065; mglover@rcsd.k12.in.us

Many students in high schools have misconceptions about frontier science experiments. They may think that there is nothing new for them to discover or that they do not have the background necessary to understand what is happening in these experiments. Yet students can use classical physics to analyze neutrino experimental data and draw conclusions. This talk will describe my students' analysis of neutrino data through conservation of momentum. The audience can participate as students for a very brief time to get the feel of being the investigator. I will also share the reaction of my students to using this activity.

AA02 11:00-11:30 a.m. Employing Contemporary Physics Concepts When the Standards Stop at 1887

Invited – Nathan A. Unterman, Emeritus, Glenbrook North High School, 2300 Shermer Rd., Northbrook, IL 60062; nunterman@gmail.com

Although NGSS and several state standards do not require newer physics than Hertz's discovery in 1887 of the photoelectric effect, there are still many occasions to introduce and explore concepts of 21st century physics in the high school physics classroom. Opportunities to use large data sets such as CMS or Cosmic Ray data through QuarkNet, develop ideas of size and scale – including the nano scale, map fields, and understand what a computer image is and how it is made, are among the topics that will be presented.

AA03 11:30-11:40 a.m. Bringing Underground Science to the Classroom

Contributed – Margaret A. Norris, BHSU / Sanford Underground Research Facility, 630 E. Summit St., Lead, SD 57754; pnorris@sanfordlab.org

Becky Bundy, Kari Webb, Julie Dahl, June Apaza, BHSU / Sanford Underground Research Facility

At the Sanford Underground Research Facility in Lead, SD, scientists explore fundamental mysteries about our universe from nearly a mile underground. Sanford Lab is the home of the LUX-Zeplin dark matter detector, an accelerator to study nuclear reactions that take place in stars, a demonstration search for neutrinoless double-beta decay and the future Long Baseline Neutrino Facility. Sanford Lab's education team takes that world-leading but often esoteric science into the K-12 classroom at every grade level. This presentation will focus on NGSS earth, space and physical science core disciplinary ideas and performance standards, and give examples of how they can be connected to current and future underground physics experiments through engaging classroom activities and curriculum units which model best practices in the modern classroom.

AA04 11:40-11:50 a.m. An Alternative Proposal for the Graphical Representation of Anticolor Charge

Contributed – Jeff Wiener, CERN, Rue Dr-Alfred-Vincent 12, Geneva, Geneva 1201 Switzerland jeff.wiener@cern.ch*

Sascha Schmeling, CERN

Martin Hopf, University of Vienna

We have developed a learning unit based on the Standard Model of particle physics, featuring novel typographic illustrations of elementary particles and particle systems. Since the unit includes antiparticles and systems of antiparticles, a visualization of anticolor charge was required. We propose an alternative to the commonly used complementary-color method, whereby antiparticles and antiparticle systems are identified through the use of stripes instead of a change in color. We presented our proposal to high school students and physics teachers, who evaluated it to be a more helpful way of distinguishing between color charge and anticolor charge. We present the alternative proposal in detail and highlight the main implications of our research, which we consider to be most promising for use in the physics classroom.

*Sponsored by Ian Bearden

AA05 11:50 a.m.-12:00 p.m. The Value in Physics Teachers Doing Modern Physics Research

Contributed – Joseph M. Milliano, Lee's Summit West High School, 1576 SW Manor Lake Dr., Lee's Summit, MO 64082; jmm2752@truman.edu

The Student Teacher and Researcher (STAR) program takes highly qualified pre-service STEM teachers and immerses them into modern-day cutting-edge research. As a STAR Fellow and now a first-year high school physics teacher, I will discusses how my research experience at LIGO (the Laser Interferometer Gravitational-Wave Observatory) has helped me incorporated modern-day physics skills and 21st-century physics topics into my classroom. Educators working in Physics Teacher Preparation Programs are especially encouraged to intend to discuss the value in providing similar experiences for your pre-service physics teachers.

AA06 12:00-12:10 p.m. Bringing Authentic NASA Content to the Physics Classroom: Exploring Exoplanets

Contributed – Brandon Rodriguez, NASA Jet Propulsion Laboratory, 4800 Oak Grove Dr., 180-101, Pasadena, CA 91101; brandon.rodriguez@jpl.nasa.gov

Astronomy is undergoing an exciting renaissance as technology catches up to the imaginings of what life would look like in the universe. The discovery of exoplanets, including those similar to Earth, have in particular exploded, with thousands of new planets found. All of these discoveries draw heavily on the physics curriculum—namely around spectroscopy, gravitation, and Kepler's laws. At NASA Education, we have developed several new NGSS activities focused on these topics as part of a unit where students locate their own exoplanet systems. These activities unite math and physics with cutting-edge NASA research that our students could soon be contributing to as we further explore our universe.

AA07 12:10-12:20 p.m. Using the Methodological Principle of Correspondence in Learning Physics

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

Correspondence principle reveals the relationship between a new theory and an earlier theory when the previous theory becomes a limiting case in a new, more general theory. In the history of science this principle was discovered during the science revolution in the beginning of the 20th century, when it became necessary to define the order of interrelations between the old, classical, and the new, modern, theories. The answer was given by Niels Bohr. The idea of correspondence was as Bohr put it, "a magic wand" in the initial period of the atomic theory. Bohr's correspondence principle demands that classical mechanics and quantum mechanics give the same solution when the systems become large. The transition from the special theory of relativity (STR) formulas to the formulas of classical mechanics could be one more justification test for the principle of correspondence, because STR reduces to classical mechanics in the limit of small velocities compared to the speed of light. General relativity reduces to Newtonian gravity in the limit of weak gravitational field. Statistical mechanics reproduces thermodynamics when the number of particles is large, etc. In high school and college courses the understanding of correspondence principle helps students to develop deeper comprehension of the modern physics while learning the classical physics.

AA08 12:20-12:30 p.m. Phantom of the Universe: A Planetarium Show on Dark Matter

Contributed – Michael Barnett, Lawrence Berkeley National Laboratory, MS 50R-6008, 1 Cyclotron Rd., Berkeley, CA 94720; rmbarnett@lbl.gov

Kaushik De, University of Texas at Arlington

Reinhard Schwienhorst, Michigan State University

We describe a new planetarium show about Dark Matter entitled "Phantom of the Universe." It features the exciting story of dark matter, from the Big Bang to its anticipated discovery at experiments deep underground and at the Large Hadron Collider. It is available to planetariums worldwide for free, and is currently being shown in 37 countries on five continents. The show features narration by Academy-Award winning actress Tilda Swinton and sound by Skywalker Sound. Dark Matter is one of the greatest mysteries of the universe, and we still don't know what it is. Just as Copernicus showed that that Earth was not the center of the universe, dark matter has evolved our understanding of visible matter, which is just 15% of the total mass of the universe. This show gives you a new perspective on why we must continue searching for the unknown.

Session AB: Astronomy Education Research

Location: Royal Palm Five/Six **Sponsor:** Committee on Space Science and Astronomy **Time:** 10:30 a.m.–12:30 p.m. **Date:** Sunday, January 7
Presider: Doug Lombardi

AB01 10:30-11:00 a.m. Assessing Astronomy Students' Views about the Nature of Scientific Inquiry

Invited – Jennifer Blue, Miami University, 500 E Spring St., Oxford, OH 45056; bluejm@miamioh.edu

Students taking a second astronomy course for non-scientists were asked to reflect on the nature of scientific inquiry three times during the first half of the semester. First they were assigned a short paper in which they were asked to argue for or against the thesis that observers of the night sky in ancient civilizations were scientists, and nearly all of the students argued that yes, they were. Second, they were asked to write a second paper in which they argued the opposite of their first thesis. Lastly, they were asked, on a midterm exam, to write an essay about whether the Ancient Greek astronomers were good scientists. In writing these papers and essays, many students included definitions of science or scientists, and these definitions progressed from paper to paper. In addition, the evidence students used to argue that ancient observers were scientists changed, with students becoming more expert-like.

AB02 11:00-11:30 a.m. Exploring College Students' Conceptual Modules of Lunar Phases

Invited – Rebecca Lindell, Tiliadal STEM Education Solutions, 5 N 10th St Suite A-1, Lafayette, IN 47905 rlindell@tiliadal.com

Adrienne Traxler, Wright State University

By combining student performance on multiple-choice assessments with network analysis, Brewe, Bruun and Bearden developed Module Analysis of Multiple Choice Responses (MAMCR). One such assessment is the Lunar Phases Concept Inventory (LPCI), a 20-item 10-response conceptual assessment instrument developed to evaluate college students' understanding of lunar phases over eight separate dimensions based on the results of a detailed qualitative phenomengraphy of college students' understanding of lunar phases. Previous research utilized MAMCR to analyze college students' pre-instructional conceptual modules of lunar phases. This study showed that three of the eight dimensions of understanding of lunar phases, either scientifically correct or incorrect, underlies most students' conceptual modules. In this research, we investigate how post-instruction conceptual modules of student understanding of lunar phases compared to the pre-instruction conceptual modules. To minimize sources of error, only courses from one instructor were investigated.

AB03 11:30-12:00 p.m. Using Two Simulation Tools to Teach Introductory Astronomy

Invited – Pamela A. Maher, College of Southern Nevada Planetarium, 718 Lacy Lane, Las Vegas, NV 89107 maherp@unlv.nevada.edu

Technology in college classrooms has gone from being an enhancement to the learning experience to being something expected by both instructors and students. This research took technology one-step further, putting the tools used to teach, a motion sensor device used in a fulldome planetarium and a virtual reality headset, directly in the hands of students. Affordances and constraints of these tools for use in introductory astronomy courses were examined to discover the optimal flyby speed for the Moon and the variety of experiences participants had using the tools. Optimal flyby speed of the Moon was determined using a design-based research approach and the variety of experiences participants had using the tools were collected using phenomenography as a methodological approach. Data were collected using two questionnaires and small group interviews informed by multimedia design principles.

AB04 12:00-12:30 p.m. Family Learning at Telescope Observing Events

Invited – Matthew C. Wenger, University of Arizona, 933 N Cherry Ave., Tucson, AZ 85719 mwenger@email.arizona.edu

Much of the science we learn comes from out-of-school learning experiences, and our families are our earliest learning communities. Researchers who study free-choice learning or "informal" educational experiences are interested in how learning occurs in these family settings. Previous research has shown that cognitive and affective learning experiences are influenced by individual and family identities and agendas. In this talk, I will describe novel data collection methods and discuss findings from a case-study of family learning in the context of night-time telescope observing events (also known as star parties). The results of this study confirm that, in addition to learning science content, visitors are actively negotiating their individual and family identities and that, regardless of the goals of the facilitators, families have their own agendas and needs for learning. The more we understand about these identities and agendas, the better we can support science learning as well as the development of personal and family identities related to science.

Session AC: State of Online Physics Courses & Building Online Communities of Learning

Location: Pacific Salon Two **Sponsors:** Committee on Physics in Undergraduate Education, Committee on Research in Physics Education
Time: 10:30 a.m.–12:10 p.m. **Date:** Sunday, January 7 **Presider:** Duncan Carlsmith

AC01 10:30-11:00 a.m. The Online Physics Program at Michigan State University

Invited – Wolfgang Bauer, Florida International University, Michigan State University, Hannah Administration Building, 426 Auditorium Rd., Room 412, East Lansing, MI 48824 bauer@pa.msu.edu

Michigan State University has been offering completely online introductory physics classes since 1997. In these classes all lectures, homework assignments, as well as exams can be accessed online. In contrast to MOOCs, these classes can only be taken for credit, and they are offered three times per year. The primary interaction with the professors and teaching assistants takes place via dedicated chat rooms and email. This talk will focus on lessons learned from offering these online classes for more than two decades to more than 10,000 students.

AC02 11:00-11:30 a.m. Searchable, Assignable Resources for Your Class: Instruction, Homework, Assessments, and In-Class

Invited – David Pritchard, MIT, MIT Room 26-241, 77 Mass Ave., Cambridge, MA 02139-4307 dpritch@mit.edu

Isaac Chuang, Saif Rayyan, MIT

Daniel Seaton, Harvard

Chandra Singh, Pittsburgh

The MIT Office of Digital Research, the Harvard Office of the Vice Provost for Advances in Learning, and the RELATE.mit.edu group have built a library incorporating etexts, videos, concept questions, standardized weekly assessments, homework, and some in-class activities. Curating these adds metadata, enabling collaborating teachers to select and assemble a variety of full online courses that are assignable to their classes, with real-time analytics and researcher access to detailed logs. The library contains thousands of introductory physics resources perfected for MOOCs and college classes by MIT, NJCTL.org, BU, and others, and hundreds of PER research-based resources and assessments including newly developed research-based weekly assessments. The full variety of courses and resources can be deployed in open edX, as custom edx courses, or incorporated in learning management systems like Canvass. We will discuss opportunities for collaboration as curators, expert course author, content/assessment authors, and beta-tester-teachers.

AC03 11:30-11:40 a.m. Conceptual Physics: Translating In-class Reasoning Activities to the Online Environment

Contributed – Teresa E. Burns, Coastal Carolina University, PO Box 261954, Conway, SC 29526; tburns@coastal.edu

PHYS 103 is a physical science course for non-science majors used to satisfy general education requirements and a physical science choice for elementary education majors. Students are trained to construct scientific arguments using If-And-Then (IAT) statements. For the in-class version, student performance on the Lawson Classroom Test of Scientific Reasoning was measured pre- and post-instruction, and students demonstrated improved scientific reasoning compared to a control class. For the online class, we sought to translate the in-class IAT activities to the online environment, using a combination of lecture-video exemplars, discussion board questions, and HW and exam questions. We discuss the successes and challenges in this process, including the assessment of reasoning gains in this environment.

AC04 11:40-11:50 a.m. Evolution of Blended Learning for Large Engineering Physics Classes

Contributed – Shen Y. Ho, Nanyang Technological University, 21 Nanyang Link, SPMS - PAP, Singapore, 637371 Singapore; hosy@ntu.edu.sg

Typically, introductory Engineering Physics classes have large populations of students from diverse backgrounds. It has always been a challenge to keep students engaged and keep pace with the progress of the lesson. The author will discuss how various strategies developed successively over the last few years have been used to tackle these challenges for his course at Nanyang Technological University, Singapore. Some of these strategies include using small hands-on tasks during tutorials to deepen learning and deploying Learning Catalytics to probe students' thinking and steer them in the right directions. The time for these activities are created by doing selected lecture worked examples and tutorial problems as online videos. We will discuss the key approaches in the designing of the hands-on tasks and the Learning Catalytics questions to effectively align them with the intended learning outcomes and create an integrated learning experience.

AC05 11:50 a.m.-12:00 p.m. Creating Online Communities of Learning by Using Social Media

Contributed – Andrew D. Gavrin, Indiana University Purdue University Indianapolis IUPUI Dept. of Physics, LD154, 402 N. Blackford St Indianapolis, IN 46202; agavrin@iupui.edu

Since fall of 2014, I have used an academically focused social media platform in an introductory calculus-based physics class at an urban, public university. The class is taught face-to-face, but makes heavy use of a variety of technologies to promote communication and engagement. Enrollment ranges from 150-200 students, and is composed primarily of engineering majors. My primary goal for the social media platform is to facilitate student-student interactions. Overall, the project has been successful in that student use of the system is robust, and students generally rate the system quite highly. In this talk, I will introduce the system, outline the various means I have used to encourage student use, and give examples of students' work, with an emphasis on the creation of a community. In particular, I will explore uses that go beyond simple "information sharing" to include, e.g., students providing one another emotional support.

AC06 12:00-12:10 p.m. Modifying Peer Instruction for the Online Classroom

Contributed – Cynthia J. Sisson, Louisiana State University in Shreveport, P.O. Box 909, Mountainair, NM 87036 cynthia.sisson@lsus.edu

The Peer Instruction technique created by Mazur in the early 1990's has been widely used in face-to-face classrooms to foster engagement, create learning communities, and improve student understanding. However, modifying the method for an asynchronous online classroom is not an obvious process. This talk describes the evolution of a Peer Instruction process for an asynchronous online classroom over the course of five years, ending with the current implementation in which students rate the two Peer Instruction aspects of the course as the top two items that helped them learn the material and succeed in the class.

Session AD: What to do When a Student Asks About...

Location: Tiki Pavilion **Sponsors:** Committee on Modern Physics, Committee on Physics in High Schools
Time: 10:30 a.m.-12:30 p.m. **Date:** Sunday, January 7 **Presider:** Shane Wood

AD01 10:30-10:50 a.m. What to do When a Student Asks About Condensed Matter Physics?

Invited – Danielle McDermott, Pacific University, Dept. of Physics, UC A121, 2043 College Way, Forest Grove, OR 97116-1797; mcd.danielle@gmail.com

Condensed matter physics is the most useful but least well-known branch of physics. Recent physics Nobel prizes have been awarded for the following condensed matter technologies: semiconductors, fiber optics, blue light-emitting diodes (LED's), graphene (exfoliated pencil lead!), integrated circuits, liquid crystals and many others. It's a beautiful topic; the science of the infinitely complex interactions of many particles leads to the emergence of order such as electric current and heat conduction. So what do you say to a student who asks about the technology in their cell phone, exotic states of matter such as superconductors, or simply the overlap between physics and chemistry? The talk is intended for secondary science teachers -- both high school and middle school. It will give a very brief outline of the field, discuss interesting questions of condensed matter physics, and point you to condensed matter resources including: Fun Size Physics (https://funsizephysics.com), the So Close Project (http://www.uam.es/otros/soclose/), and the Division of Condensed Matter Physics (https://www.aps.org/units/dcmp/outreach/)

AD02 10:50-11:10 a.m. Gravitational Waves and LIGO: A New Window into the Universe

Invited – Amber Strunk Henry, LIGO Hanford Observatory, 65 Canyon St., Richland, WA 99352; amber.strunk@ligo-wa.caltech.edu

With LIGO's ground breaking direct detection of gravitational waves in 2015, students are coming to class with many new questions: "What are gravitational waves? How does LIGO detect them? Why are they so difficult to detect? How do we know what caused them? Do we know where they come from? Are there more detectors?" In this talk I will address these questions and more giving you the answers you need when these questions arise. I will also touch on resources available through LIGO to help not only teach students about gravitational waves but ways to connect LIGO to the classical physics.

AD03 11:10-11:30 a.m. Awesome Physics from the CERN Large Hadron Collider!*

Invited – Vivek A. Sharma, University Of California, San Diego 9500 Gilman Dr., La Jolla, CA 92093; Vsharma@ucsd.edu

In this talk I will discuss the latest results on the nature of the Higgs boson, Matter-antimatter oscillations, the search for WIMP Dark Matter and other New Physics phenomena with the Large Hadron Collider at CERN.

*Work supported by grant DE–SC0009919 of the United States Department of Energy

AD04 11:30-11:50 a.m. What is in the Space Between Galaxies?

Invited – Kate Rubin, San Diego State University, Department of Astronomy, 5500 Campanile Dr., San Diego, CA 92182; krubin@sdsu.edu

Using powerful telescopes, we have now measured the distribution of galaxies from a time less than a billion years after the Big Bang. However, all of the stars in all of the galaxies in the universe account for a mere 6% of the cosmic energy density of normal (a.k.a. baryonic) matter at the current epoch. To search for the remaining baryons, astronomers have designed experiments sensitive to a much more diffuse phase: using spectroscopy of bright background light sources (e.g., quasars), we identify foreground clouds of gas in absorption and count the hydrogen atoms and metal species they contain. I will describe recent studies using this technique that reveal a massive reservoir of diffuse, ionized gas extending hundreds of kiloparsecs from galaxies like our Milky Way. These results imply that most bright galaxies are surrounded by a gaseous halo containing at least as many baryons as all of the stars and nebulae in the galaxies' disks.

AD05 11:50 a.m.-12:10 p.m. Habitable Exoplanets: Applying Introductory Physics to Other Worlds

Invited – William F. Welsh, San Diego State University, Astronomy Dept., 5500 Campanile Dr., San Diego, CA 92182-1221 wwelsh@mail.sdsu.edu

Philip Blanco, Grossmont College

The number of exoplanets discovered now exceeds 3500, thanks to a large extent to NASA's Kepler Mission. In addition, there are over 2000 more candidate planets. The vast majority of these planets are not suitable for life (as we know it), but roughly two dozen are. How do we know this? How can we determine if a planet is "habitable"? Under the assumptions of thermal equilibrium it turns out to be a remarkably simple calculation. In our talk, we will discuss how astronomers routinely estimate a planet's temperature - and how your students can too. We will give a brief overview of the state-of-the-art in exoplanet science, and walk you through the derivation and the strengths and weaknesses of the "habitable zone" concept. We will then present some "tools you can use" in your classroom/lab to empower students to estimate surface temperatures and other characteristics of Earth-like exoplanets by using simple introductory physics.

Session AE: Effective Practices in Educational Technology

Location: Pacific Salon Three **Sponsor:** Committee on Educational Technologies **Time:** 10:30 a.m.-12:20 p.m. **Date:** Sunday, January 7
Presider: Eric Ayars

AE01 10:30-10:40 a.m. Use of Computer Simulations in Quantum Mechanics Labs

Contributed – Michael J. Ponnambalam, Holy Cross College, Nagercoil, 7-40 Sannathi Street, Vadakkankulam, Tamil Nadu, 627116; michael.ponnambalam@gmail.com

Many Third World countries suffer from a shortage of quality equipment for Quantum Mechanics Labs, due to lack of funds. Using computer simulations, this author prepared several experiments for the Quantum Mechanics Lab at the University of the West Indies, Jamaica campus. They were found to be much more useful than the essay projects of the previous years. Details of this project will be presented.

AE02 10:40-10:50 a.m. Teaching Quantum Mechanics with Python and Jupyter

Contributed – Andrew M. Dawes, Pacific University, 2043 College Way, Forest Grove, OR 97116-1797; dawes@pacificu.edu

A presentation and discussion of interactive computing activities aligned with an upper-division quantum mechanics course. These activities are written in python and use the Jupyter Notebook platform and the Quantum Toolbox in Python (QuTiP) software package. This talk provides an introduction to both Jupyter and QuTiP in the context of undergraduate physics. The activities presented include a mix of shorter in-class work and longer lab-length projects. No programming experience is expected of students in this course, instead it is based on the idea of coding across the curriculum: Students can be given challenge exercises and explore at their own pace and experience level.

AE03 10:50-11 a.m. Modelling Orbital Dynamics in Desmos

Contributed – Kalee Tock, Stanford Online High School, 220 Panama St., Stanford, CA 94305; kaleeg@stanford.edu

Hagan Hensley, Stanford Online High School

Solving the orbital elements of a binary star system based on limited and often inaccurate past observations is a complex problem due to the unknown inclination of the orbital plane from Earth's perspective. It involves optimizing seven orbital parameters, two of which are time-dependent. This can be hard for students to visualize, let alone optimize. As such, orbital solutions are traditionally not the purview of students, but instead of astrophysicists who specialize in this area. One of the authors, H. Hensley, has developed a visualization tool that can not only build students' intuition of the seven orbital parameters of a binary star system, but can actually allow students to easily solve orbits. The pedagogical benefits include helping students construct a model of complex and coherent motion from seemingly erratic and often distorted data sets.

AE04 11:00-11:10 a.m. Visualization of Real Magnetic Field Using Sensor and AR

Contributed – Junehee Yoo, Seoul National University, Kwanak ro 1 Kanakgu, Seoul, 151 742 Republic of Korea; yoo@snu.ac.kr

Jeongwoo Patk, Dongwook Lee, Suyoung Jin, Juno Hwang, Seoul National University

To visualize magnetic field of magnets or slownoid, we augumented real data which are sent by Arduino with bluetooth connection

AE05 11:10-11:20 a.m. A Controlled Study of Stereoscopic Virtual Reality in Freshman Electrostatics

Contributed – Christopher D. Porter, The Ohio State University, 191 W. Woodruff Ave., Columbus, OH 43210; porter.284@osu.edu

Chris M. Orban, The Ohio State University

The incorporation of virtual reality (VR) into instruction has been difficult due to high-cost headsets or "caves," and the challenge of serving an entire student population with only one or a few such devices. This has changed with the advent of smartphone-based stereoscopic VR. Inexpensive cardboard headsets and smartphones already in students' pockets are the only elements needed for a virtual reality experience. We have designed short VR training sessions and have studied the utility of this training in the context of Gauss's Law and electrostatics in a cohort of students in calculus-based introductory physics at The Ohio State University. We compare performance on pre-post tests between students trained using VR, those trained using a video of the VR content, and those trained using static 2D images as in a traditional text. Although data are preliminary in this growing study, we comment on possible reasons for differences among student groups.

AE06 11:20-11:30 a.m. Introducing Mobile Sensors Through Free Gamified App Challenges: Physics Toolbox Play

Contributed – Rebecca Vieyra, Vieyra Software, 225 C St. SE, Apt. B, Washington, DC 20003; rebecca.elizabeth.vieyra@gmail.com

Chrystian Vieyra, Vieyra Software

Learn about a new app that introduces students to sensors in their smartphones through gamified challenges. Funded through a mini grant from the American Physical Society, the app, "Physics Toolbox Play," was developed for use with students and their families during informal education events and for introduction to mobile sensors in formal settings. The app provides contextualized opportunities for students to accomplish challenges (such as increasing the ambient pressure around a smartphone), while learning about STEM careers (such as fluid dynamics engineers). During this presentation, learn about how the app was implemented with both the general public and a formal homeschooling group to provide novice learners with a taste of physics.

AE07 11:30-11:40 a.m. Monkeying Around in Mechanics: Student-Student Dialog Videos Increase Physics Learning

Contributed – Jerome Buerki, California State University, Sacramento, Dept. of Physics & Astronomy, 6000 J St., Sacramento, CA 95819; Buerki@csus.edu

Vera Margoniner, Micaela Kapp, California State University, Sacramento

We are developing a series of short videos to help our introductory physics students better comprehend concepts they tend to struggle with. We were inspired by the thesis of Derek Muller showing that lecture-based videos tend not only to be ineffective but actually reinforce students' misconceptions and increase their confidence in incorrect ideas. Much better learning outcomes can be achieved if videos are based on dialog and purposefully address misconceptions. Instead of the dialog between a student and a teacher used by Muller, we decided to mimic the dialog between two students who know how to work constructively together. The idea is to address misconceptions head-on and to model good study habits. Using a pre- and post-test for one video and comparing with the literature, we find that our dialog videos are significantly more effective than passively watching expository screencasts or video lectures.

AE08 11:40-11:50 a.m. Investigating RC Circuits and Sound with a Piezoelectric Buzzer and a Smartphone

Contributed – Katie Ansell, University of Illinois - Urbana Champaign, 1110 W Green St., Urbana, IL 61801; crimmin1@illinois.edu

Smartphones have an assortment of onboard sensors including accelerometers, magnetometers, and cameras that enable the study of physical phenomena. This talk presents a laboratory experiment to study RC circuits and sound using a piezoelectric buzzer and a smartphone. A capacitor is discharged through a resistor and the buzzer, and the intensity of the sound produced by the buzzer is recorded by a smartphone using a free app. The voltage supplied to the buzzer, and thus the intensity of the sound it produces, is related to the voltage across the capacitor as a function of time. As the capacitor discharges exponentially, the sound intensity decreases linearly since the intensity is recorded in units of decibels. This data can be fitted to estimate the decay time constant of the circuit.

AE09 11:50-12:00 p.m. Assessing Learners' Epistemic Networks in Undergraduate Physics

Contributed – Deepa Deshpande, University of Tennessee, 1208 Kirby Glen Dr., Knoxville, TN 37923; ddeshpan@vols.utk.edu

Simulation-based, spreadsheet-based, and hands-on inquiry activities are commonly used in introductory undergraduate physics to enable connections in learners' minds, between and within concepts, between their disciplinary representations, and between concepts and reality. 'Epistemic Network Analysis' has emerged as an effective tool, to model learners' cognitive connections by drawing upon digitally collected data (e.g. chat board conversations) on learners' thinking in the process of task performance. But face-to-face studio lab environments in undergraduate physics have not yet tapped into this powerful analytical tool for want of suitable data collection mechanisms. I recently explored the use of Twitter to collect contextual data on learners' thinking in these settings at my university. I will share details of my design experience with specific examples to demonstrate how Twitter can be used to develop formative assessments of student thinking. I will also discuss the significance of such assessments for designing inclusive learning environments.

AE10 12:00-12:10 p.m. HTML5 Simulations Accompanying Labs and Class Worksheets

Contributed – Andrew G. Duffy, Boston University, Department of Physics, 590 Commonwealth Ave., Boston, MA 02215; aduffy@bu.edu

Manher Jariwala, Emily Allen, Boston University

At Boston University, we have been developing HTML5 simulations that are used by introductory physics students in a studio class, as they work together on worksheets or in place of hands-on labs. In fall 2017, we carried out an A/B comparison study comparing outcomes with different groups, to try to assess whether there is a measurable difference associated with using the simulations. In this talk, we discuss preliminary results and show the simulations. A link to the simulations and accompanying materials will also be provided. This work is funded by NSF grant DUE 1712159.
Link is http://physics.bu.edu/~duffy/classroom.html

AE11 12:20-12:20 p.m. Responsive Resources: Finding the Right Tools for Physics Students Anywhere in their Academic Journey

Contributed – Moshe Pritsker, JoVE, 1 Alewife Center, Ste 200, Cambridge, MA 02140; chad.castro@jove.com

According to a recent nationwide study, 48% of Bachelor's degree STEM candidates changed their field of study or dropped out of school before graduating. One of the primary reasons according to many academics is a lack of student confidence and preparedness as they move through high school, undergraduate, and graduate courses into doctoral programs and post-doctoral careers. In this presentation, we propose a way to flatten the learning curve for physics students by equipping them with comprehensive resources that map to students' needs no matter where they are in their academic development. This session will explore technologies that physics teachers should adopt such as novel uses of video, methods and data repositories, and open-access scientific resources that can help students more quickly comprehend physics concepts and experimental methods, while also enabling more efficient knowledge transfer.

Session AF: Historically Important Physics Teachers

Location: Sunset **Sponsors:** Committee on the Interests of Senior Physicists, Committee on History and Philosophy in Physics
Time: 10:30 a.m.-12:30 p.m. **Date:** Sunday, January 7 **Presider:** Tom O'Kuma

AF01 10:30-11:00 a.m. Feynman in the Rough – Gems from the Audio Recordings of "The Lectures"

Invited – James Lincoln, PhysicsVideos.com, PO Box 11032, Newport Beach, CA 92658; james@physicsvideos.com

Last year I began listening to the original audio recordings of all of The Feynman Lectures. In these I found many jokes, stories, and interesting quips that have not been written down elsewhere. In this talk I share the highlights from this unexplored collection and provide a review of other Feynman related works.

AF02 11:00-11:30 a.m. The Unknown Physics Teacher and Her Place in History

Invited – Jill Marshall, University of Texas, 1 University Station D5700, Austin, TX 78712; marshall@austin.utexas.edu

At AAPT we are, or should be, well aware of women who are known for their contributions to the teaching of physics: Melba Phillips, Sarah Whiting, Maria Mitchell, Harriet Brooks, in addition to more recent contributors such as Ruth Chabay, Diane Riendeau, Jan Mader, Karen Jo Matsler, and others too numerous to mention. But many in our community are unaware of the contributions to the teaching of physics, particularly in pre-college and informal settings, by women whose names are largely lost to history. Before physics was designated as part of the accepted high school curriculum in the 1893 report of the Committee of Ten, these women worked to demonstrate, describe, and explain the concepts of natural science to children in homes and schools, as well as members of the public in lecture halls and salons. In the Nineteenth Century, the explication of science was largely the province of "the ladies".

AF03 11:30 a.m.-12:00 p.m. Robert Resnick, Author, Teacher, Friend

Invited – James H. Stith, American Institute of Physics, Vice President Emeritis, 2013 Clearwood Dr., Mitchville, MD 20721; jstith@aip.org

Robert (Bob) Resnick was arguably one of the most prolific physics text book authors of his generation. His first text, Physics for Students of Science and Engineering, written with David Halliday was published by Wiley and released in 1960. By the time of his death in 2014, there were few practicing physicists that had not been impacted by that classic or one of his other seven physics textbooks. Physicists spoke fondly of the edition they had used: the blue version, or the green version or the orange version etc. These texts ushered in the growth of physics fueled in part by the sputnik generation and nation's quest to compete. Bob's texts were modeled upon the authors' unique teaching styles, the most recent pedagogy and reflected his passion for physics as well as his sensor humor. While this talk will address some of the impact Bob's many texts had on physics and physics education, it will also address that sense of humor, especially his fascination with limericks. Additionally, Bob's love for classical music was only exceeded by his love of family, physics and limericks. Bob and I became friends in the late 80's and shared a passion for baseball (he the Baltimore Orioles and I the LA Dodgers), a deep commitment of diversity and a firm social conscience, a thirst for physics education and a love of family.

AF04 12:00-12:30 p.m. Robert Fuller: On the Cutting Edge in Technology and PER

Invited – Dean Zollman, Kansas State University, 116 Cardwell Hall, Manhattan, KS 66506-2601; dzollman@phys.ksu.edu

As university faculty, Bob Fuller became interested in understanding the difficulties that students faced as they learn physics. Thus, his research moved into an area that would later be called physics education research. While Bob was a creative force in many areas of PER, the use of innovative technology in physics teaching and learning was a particularly strong interest. His development of technological applications was always based research in the development of reasoning. With his colleagues, he moved from lessons based on Super-8 silent films to several interactive videodiscs, each of which used the learning cycle as the pedagogical strategy. A large database (when 640 KB was considered large) introduced high school teachers to active learning methods and materials. These and other multimedia efforts as well as his other PER helped pave the way for many of the approaches that are now considered standard for helping students learn physics.

Session AG: New Trends in IPLS Resources and Pedagogy

Location: Royal Palm One/Two **Sponsor:** Committee on Physics in Undergraduate Education **Time:** 10:30 a.m.-12:30 p.m. **Date:** Sunday, January 7
Presider: Nancy Beverly

AG01 10:30-11:00 a.m. Engaging in the Living Physics Portal for IPLS Resources*

Invited – Bruce Mason, University of Oklahoma, 440 W. Brooks St., Norman, OK 73019; bmason@ou.edu

The AAPT Introductory Physics for Life Sciences Portal project now has a name, Living Physics Portal, and a presence where contributors can participate. We are inviting all IPLS Community members interested in sharing their work to join this effort. This presentation will explain what the portal contains, how contributions happen, and the ways the contributors and editors are working to make the resources available as useful as possible.

*Supported by the NSF, Grant 1624185

AG02 11:00-11:30 a.m. Sharing IPLS Curriculum with the Physics Education Community*

Invited – Ralf Widenhorn, Portland State University, Department of Physics, SRTC, 1719 SW 10th Ave., Room 134, Portland, OR 97201; ralfw@pdx.edu

Physics educators across the country have developed curriculum to best serve pre-health and life science students in their introductory physics courses. This upcoming year a multi-institutional grant from NSF aims to allow educators to share their best teaching materials with the wider teaching community. We will present curriculum for pre-health students that has been developed at Portland State University over the past several years. The presentation will provide an example of how physics instructors can prepare and share their curriculum on this new introductory physics for the life sciences portal. The materials will be characterized by granular size from full courses, to smaller modules and collections, to individual items like homework questions. To help other instructors with the implementation of the curriculum we will show how it is prepared such that it is searchable by characteristics like physics topic, biomedical context, or pedagogy.

*This work was supported by grants (DUE-1624192, DUE-1431447, and DUE-1141078) from the National Science Foundation.

AG03 11:30 a.m.-12:00 p.m. Interactive Engagement and Biological Relevance: Success at a Large Institution

Invited – Laurie McNeil, Univ. of North Carolina at Chapel Hill, Phillips Hall CB #3255, Chapel Hill, NC 27599-3255; mcneil@physics.unc.edu

At UNC-CH we have completely redesigned our IPLS sequence that enrolls ~500 students each semester. Our new courses operate in a highly interactive lecture/studio mode, in which students spend nearly all their class time in pairs or small groups working on activities designed according to PER findings. We eliminated topics with little or no connection to biology (e.g projectile motion) in favor of topics highly relevant to the life sciences (e.g. nonlinear stress-strain). Wherever possible the class activities make use of authentic biological data. The new courses require the same instructional resources as did our traditional sequence, and the instructors do not need biology expertise (although pedagogical training is important). Student learning gains on concept inventories show significant improvement over those previously recorded. The activities we developed for our lectures and studios are freely available for use at other institutions and can be adapted to suit different course structures.

AG04 12:00-12:30 p.m. Teaching Diffusion Using a Beach Ball*

Poster – James Vesenka, University of New England, Department of Chemistry and Physics, 11 Hills Beach Rd., Biddeford, ME 04005; jvesenka@une.edu

Bradley Moser, David Grimm, 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 different sized cells modeled by different sized beach balls. 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.

*Supported by NSF DUE grants 0737458 and 1044154

AG05 12:00-12:30 p.m. Assessment of a Biomedically Relevant Introductory Physics Course*

Poster – Ralf Widenhorn, Portland State University, Department of Physics, SRTC, 1719 SW 10th Ave., Room 134, Portland, OR 97201; ralfw@pdx.edu

Elliot Mylott, University of Portland

Warren Christensen, North Dakota State University

We present modular multimedia educational material developed for a pre-health-focused introductory physics course focused on optics and waves taught at Portland State University in spring term 2016. The modules include videos of biomedical experts detailing the physics behind medical instruments. We assessed student attitudes towards the course from student surveys and interviews. Here, we present assessment results on students' conceptual understanding and contextualization of physics material from this reformed course. Conceptual understanding of physics content was probed using open-ended, illustrated conceptual questions. The analysis was done by multiple raters using a multi-stage, inductive analysis of the emergent categories. The responses from students in the reformed, biomedically focused course are compared to responses from students in a traditional algebra-based physics course. *This work was supported by grants (DUE-1141078 and DUE-1431447) from the National Science Foundation.

AG06 12:00-12:30 p.m. Experimentation as Didactics in the Teaching of Physics

Poster – Andres Alberto Salinas Diaz, Institución Educativa Siete de Agosto, Cali, Valle del Cauca 760001 Colombia; asalinasyh2003@yahoo.com

This work is the result of the use of the ABP (Problem Based Learning) methodology, developed in three stages, which allows the possibility of an autonomous learning, when the student assumes an active role in its formative process, relegating to the teacher to assign his investiture and assume the role of observer and promoter. The proposal presents several daily scenarios to students of Physics, in which they will develop their praxis based on the reflection, investigation and concretion of activities through individual and group predictions to verify through meaningful autonomous learning, how capable are they to find the answers to their own hypotheses and using in a varied way the ICT platforms with their diverse software and technological means for a more accurate result with evidences that support it.

AG07 12-13:30 p.m. Cultivating a Community of STEM Polymaths with a Transdisciplinary Laboratory

Poster – Sarah Formica, University of North Georgia, 82 College Circle, Dahlonega, GA 30597; sarah.formica@ung.edu

Royce Dansby-Sparks, Margaret Smith, University of North Georgia

This poster describes an introductory, one-semester, transdisciplinary lab course that integrates concepts across biology, chemistry, physics, and mathematics, and develops basic quantitative literacy and stimulates student interest in STEM more effectively than traditional introductory lab courses in biology, chemistry, and physics. Students in the transdisciplinary lab showed higher quantitative reasoning and literacy gains than students in traditionally-taught science labs, and those gains were statistically significantly different between transdisciplinary students and traditionally-taught biology students. Retention rates of students in the transdisciplinary lab were also compared to students in the control groups and show that student retention in a STEM discipline was higher for students who participated in the transdisciplinary lab. These results suggest that a transdisciplinary approach to STEM lab classes benefits students by improving their mathematical reasoning skills and compelling students to continue with their STEM education.

Session AHA: PhysTec in 50 States

Location: Royal Palm Three/Four **Sponsor:** Committee on Teacher Preparation **Time:** 10:30-11:30 a.m. **Date:** Sunday, January 7
Presider: John Stewart

AHA01 10:30-10:40 a.m. Building Capacity for Training and Supporting Physics Teachers*

Contributed – Trevor I. Smith, Rowan University, 201 Mullica Hill Rd., Glassboro, NJ 08028-1701; smithtr@rowan.edu

Issam Abi-El-Mona, Patrick Chestnut, Philip La Porta, Karen Magee-Sauer, Rowan University

Rowan University is currently in its final year of funding as a PhysTEC Comprehensive Site. The major foci of our project have included expanding our learning assistant (LA) program and creating the Rowan Area Physics Teachers (RAPT) network. We present the results of our efforts, including the impact of the LA experience (in terms of LAs' physics content knowledge, attitudes about physics, and dispositions toward teaching), and the success of the RAPT meetings (in terms of bringing together a strong community of engaged teachers in southern New Jersey, and connecting preservice and inservice teachers). We explore the challenges of sustaining these efforts and discuss our plans for supporting their continued success in the long term.

*Funding provided by the National Science Foundation through a grant from the Physics Teacher Education Coalition

AHA02 10:40-10:50 a.m. Learning Assistant Program Impact on Non-Traditional Transfer Students

Contributed – Patrick L. Chestnut, Rowan University, 201 Mullica Hill Rd., Glassboro, NJ 08028; chestnut@rowan.edu

Trevor I Smith Rowan University

Rowan University, a public school located in southern New Jersey, serves a high number of non-traditional transfer students. Almost half of all upper-division students within the Department of Physics and Astronomy are transfer students, and one-tenth are over age 24. This student population often faces unique challenges compared to traditional students matriculating directly from high school. Our team presents findings from interviews with non-traditional transfer students who serve the department in the role of learning assistants (LAs) within introductory physics courses. Analysis of interview data provides insights into particular challenges this population faces and manners in which the LA program has been beneficial to psychosocial growth or career development.

AHA03 10:50-11:00 a.m. Marketing to Future Physics Teachers*

Contributed – Ronald H. Henderson, Middle Tennessee State University, 1301 E. Main St., Murfreesboro, TN 37132-0001; Ron.Henderson@mtsu.edu

MTSU used PhysTEC funding to develop and reform courses, jumpstart a teacher advisory group, fund learning assistants, and study ways to market our program. Each effort provided incremental improvements toward our goal of graduating more physics teachers, but we were surprised at the major impact that studying the recruitment process had on the department. We discovered that high school seniors are very interested in the available job market for a potential college major. Our faculty were passionate and knowledgeable about science, but found that we were ill equipped to communicate how expertise in physics could translate into career opportunities. PhysTEC support provided the means to improve our recruiting and marketing strategies.

*MTSU is a PhysTEC Legacy Site

AHA04 11:00-11:10 a.m. PhysTEC Growing UTeach in West Virginia

Contributed – John C. Stewart, West Virginia University, White Hall, Morgantown, WV 26506; jcstewart1@mail.wvu.edu

Gay Stewart, West Virginia University

Ongoing PhysTEC support for physics teacher preparation at West Virginia University provides a model of how the PhysTEC program can support the implementation of broader initiatives in STEM teacher preparation. These broader initiatives and the partnerships they foster will feed back into the physics program providing badly needed physics teachers for West Virginia. PhysTEC has supported a Teacher-in-Residence (TIR) who has transitioned to the role of a master teacher in the WVUteach program. The TIR was instrumental in developing recruiting efforts and improving introductory physics labs. As a master teacher, he supports a more rapid implementation of the full WVUteach program.

AHA05 11:10-11:20 a.m. The PhysTEC Site at CSU Long Beach

Contributed – 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

California State University Long Beach has been a supported / legacy PhysTEC site since 2010. Key PhysTEC activities aimed at increasing the number of secondary teachers with a deep understanding of physics have resulted in explosive growth in the undergraduate program generally. Connecting students with a meaningful community of practice (regular high school open houses, monthly demo-sharing activities, physics mixers, the Learning Assistant program) has made all of the difference. This growth has been strongest with under-represented minority students, and with women.

AHA06 11:20-11:30 a.m. PhysTEC: Kicking off physics teacher preparation at the University of Arkansas

Contributed – Gay Stewart, West Virginia University

John Stewart, West Virginia University

University of Arkansas, Fayetteville was one of the six primary program institutions in this new thing called PhysTEC in 2001. WE had three core beliefs: 1. If there is a reason teachers should teach like that, why aren't we? 2. You never know who is going to be a future teacher. 3. In better-serving all students, a department also benefits. UA has seen a drastic change in number of majors, the number of students active in research and the number of graduates pursuing graduate work while also increasing the number of majors who decide to teach. In this talk we will discuss some of the highlights of the program that we believe contributed to its success.

Session AHB: Tech in High School Classrooms

Location: Royal Palm Three/Four **Sponsors:** Committee on Physics in High Schools, Committee on Educational Technologies
Time: 11:30 a.m.-12:30 p.m. **Date:** Sunday, January 7 **Presider:** Charlene Rydgren

AHB01 11:30-12:00 p.m. So Your Students Have An IPad; Now What?!

Invited – Katie Page, Prospect High School, 801 Kensington Rd., Mt. Prospect, IL 60056; katie.page@d214.org

Using ipads for seven years in my high school physics classroom has given me insight into what works, what doesn't work, and how you can incorporate one-to-one technology in physics. In my district, every student has a school issued ipad they are able to bring home and keep for their four years; this allows for an array of opportunities for learning both inside and outside the classroom. Focus of my session will be on learning management systems, managing a paperless classroom, using the ipad (tablet) for data collection and laboratory experiences, student engagement, and behavior management. Resources will be shared, bring a tablet or computer to the session!

AHB02 12:00-12:10 p.m. Using CK-12's Simulations to Overlay Physics onto Real-World Settings

Contributed – Sonia Tye, CK-12 Foundation, 3430 W. Bayshore Rd. #101, Palo Alto, CA 94303; Sonia.tye@ck12.org

CK-12's Physics Simulations (SIMs) are a groundbreaking new type of digital learning tool that overlay abstract scientific and mathematical principles upon everyday settings. CK-12 currently offers 100 free SIMs to enable students to discover the laws of physics that govern the world around them in a fun and interactive way. CK-12 SIMs can be easily accessed on all tablets, Chromebooks, laptops and desktops using HTML5. The free CK-12 Physics Simulations App for both iOS and Android tablets facilitates quick access to the SIMs and the added ability to download SIMs for offline use. This presentation will include some ideas for using the SIMs in class or at home, to differentiate instruction, and to dispel common physics misconceptions. Come learn more about CK-12 Physics Simulations — the free and fun way to learn physics (www.ck12.org/sims)!

AHB03 12:10-12:20 p.m. Classroom Response Made Easy with PLICKERS

Contributed – Joshua B. Winter, BASIS Independent Brooklyn, 148 Sackett Street, Apt 1, Brooklyn, NY 11231; joshua.winter@basisindependent.com

We all appreciate the value of formative assessments and know how valuable immediate feedback from our students can be. But paper and pencil quizzes are time consuming and many of the classroom response systems used to obtain this information quickly are clunky or prohibitively expensive. PLICKERS to the rescue! All you need is your smart phone (students don't need one). There are no expensive clickers for students to buy (and possibly lose). Learn how this FREE, easy to use, classroom response system can be implemented in your physics classes now.

AHB04 12:20-12:30 p.m. Liquid Crystal Devices

Contributed – Lily Wang, Franklin Regional Senior High School, 4016 Chelstead Way, Murrysville, PA 15668-1762; lilwang626@gmail.com

Amanda Zeng, Shady Side Academy

Ella Zhou, Sewickley Academy

Andrew Zhou, Indiana University of Pennsylvania

The liquid crystal display (LCD) is currently the most important display technology which has become an integral part of daily life. Replacing the outdated Cathode Ray Tube (CRT) displays, LCDs are lighter, thinner, and more environmentally friendly due to lower power consumption. By exploring the science and technology behind LCDs and closing the gap between the academic context and the real world, we developed a DIY LCD lab for students to learn concepts of physics related to LCDs through hands-on activities. In this work, we will show how to build a simple LCD step by step in the classroom, how to measure the performance of the LCD, and how to use the LCD as a tool for teaching and learning physics.

*Sponsored by Andrew Zhou

Session BA: PTRA: Learning on the Edge

Location: Pacific Salon One **Sponsor:** Committee on Physics in Pre-High School Education **Time:** 2:00-3:30 p.m. **Date:** Sunday, January 7
Presider: Tommi Holsenbeck

BA01 2:00-2:30 p.m. Push Your Students Over the Edge to Facilitate Learning

Invited – Duane Merrell, Brigham Young University, N-143 Eyring Science Center, Provo, UT 84602; duane_merrell@byu.edu

Where learning takes place is not in the clear, concise and easy to understand lesson. It is in the lesson where the student feels uncomfortable, awkward, uneasy, not sure. The edge is when the student knows they must learn because they don't understand or grasp the concept. A student pushed to learn, "Over the Edge" finds the critical time learning takes place. Can we as teachers help our students out of the comfort of the clear, concise, and easy to understand lesson, moving to lessons that push them and help them learn?

BA02 2:30-3:00 p.m. Fostering Learning: When Everyone Predicts the Incorrect Outcome

Invited – Richard Gelderman, Western Kentucky University, 1906 College Heights Blvd., Bowling Green, KY 42101-1077; gelderman@wku.edu

When the outcome of the phenomenon is surprising, when the result is not what was expected, it causes the observer to wonder what was responsible for the mismatch. But this, in itself is not learning, We have developed techniques to turn such discrepant events into a pedagogical sequence that results in improved learning. The lesson starts with questions and discussion of prior experience. After talking about their expectations, each student commits to a detailed prediction. A controlled demonstration (live or video) allows students to witness the actual result, with plenty of opportunity to replay and critique the observation. Students are then divided into small randomly selected groups to compare predictions versus results. Some discrepant event are stand-alone lessons, while others must be presented in series to fully appreciate the physical concept being investigated.

BA03 3:00-3:30 p.m. Conquering Misconceptions

Invited – Jan Mader

Having provided professional development and instruction in the physical sciences and physics for K – 16 instructors and students for the last 28 years, I have come to the realization that telling students the truth will not displace a deeply rooted misconception of a physics concept. In physics everyday experiences taint a student's understanding. If gravity causes objects to fall to the ground, then surely there has to be a limit to gravity's reach. Many believe astronauts are weightless because they are "outside" of the Earth's gravitational pull. Students of all ages must reach a point of disequilibration before forming a new schema of thought. Only when learners are challenged with experiences that directly contradict their previous beliefs will they be able to construct a new and true understanding of a physics concept.

Session BB: Addressing Diversity in Science Museums

Location: Royal Palm One/Two **Sponsors:** Committee on Science Education for the Public, Committee on Women in Physics
Time: 2:00-3:30 p.m. **Date:** Sunday, January 7 **Presider:** Jacquelyn Chini

BB01 2:00-2:30 p.m. Where We Live, Work and Play

Invited – Steven Snyder, Fleet Science Center, 1875 El Prado, San Diego, CA 92101-1625; ssnyder@rhfleet.org*

Diversity is about more than the demographic makeup of our visitors. For the Fleet Science Center it is about developing meaningful relationships with the diverse communities that make up San Diego. By turning our focus away from how we get underrepresented audiences to come to our center and instead working with communities to build programs that use STEM learning to meet neighborhood needs the Science Center has both diversified its audience and become more integrated into the community. This has meant rethinking the Science Center. We now view ourselves as a county-wide organization that runs a science center rather than just a museum. This change in perspective has resulted in new program models that find the Fleet in parks, businesses, bars, restaurants and other community locations around the county. As a result we reach new audiences and have found new relevance in the lives of the communities we serve.

*Sponsored by Jacquelyn Chini

BB02 2:30-3:00 p.m. Inquiry and Family Conversation at Science Museums

Invited – Lisa Szechter, California State University Monterey Bay, 400 Pine Ave., Pacific Grove, CA 93950; lszechter@csumb.edu

Family conversations in science museums support children's interest and understanding of science. Inquiry is an approach to science teaching that encourages conversation and deepens understanding, as individuals raise questions about a phenomenon and conduct investigations to answer those questions. In the present study, families were randomly assigned to participate in a guided inquiry activity about thin-film interference either before or after exploring an exhibit hall. Families who participated before visiting the exhibit hall had significantly different conversations than those who participated after: they used more science terms, constructed more explanations, and made more connections to prior experience. Engaging in inquiry activities at science museums may provide an opportunity for science teachers to help their students bring science home, and encourage meaningful conversations about science among parents, teachers, and students.

BB03 3:00-3:30 p.m. Reculturing Science Museums: Diversity, Equity, Social Justice and Transformation

Invited – Doris Ash, University of California Santa Cruz, 1156 High St., Santa Cruz, CA 95064; dash5@ucsc.edu

Science museums already know that they need to improve with respect to diversity and equitable access, thus they have over the past decade been conducting programmatic experiments, small and large, to see what works in helping to attract culturally, linguistically and economically diverse populations. These include targeting special populations, offering free days/hours, special weekend and summer programming, going into the community, and more. In this talk I will argue that these experiments are necessary but insufficient strategies. I suggest that pivotal core aspects within museums must also change and use the word reculturing to capture such transformation. I rely on my own sociocultural analysis of museums (Ash, in review), Dawson's (2017) view of social justice in out of school settings, Feinstein & Meshoulam's (2014) client vs. cooperative logic, as well as my own ethnography of museums in the process of reculturing.

Session BC: Aligning Labs with NGSS, AAPT Lab Guidelines, and AP Physics (Panel)

Location: Pacific Salon Three **Sponsors:** Committee on Laboratories, Committee on Research in Physics Education
Time: 2:00–3:30 p.m. **Date:** Sunday, January 7 **Presider:** Stephen Spicklemire

Representatives from NGSS, College Board, and AAPT Committee on Labs will be on hand to present suggestions and answer questions on how to align and implement the various programs' lab requirements in the classroom. The panel will be mostly a Q & A driven discussion, especially geared toward how best to design high school physics lab investigations in order to prepare students for the college or university lab setting.

Panelists:

Steve Spicklemire, University of Indianapolis
Justine Boecker, AAPT
David Jones
Dolores Gende, North Broward Preparatory School
Tom Haff, Forest Ridge School of the Sacred Heart

Session BD: Labs for Creativity and Invention in a High-Tech World

Location: Tiki Pavilion **Sponsors:** Committee on Laboratories, Committee on Apparatus **Time:** 2:00-3:00 p.m. **Date:** Sunday, January 7
Presider: Toni D. Sauncy

BD01 2:00-2:10 p.m. Large Scale, Problem Based, Advanced Experimental Physics Lab Work

Contributed – Lars A. Hellberg, Chalmers University of Technology, Fysikgränd 3, Göteborg, - 41296 Sweden; lars.hellberg@chalmers.se

Experimental physics is considered to be of fundamental importance in the engineering physics program at Chalmers University of Technology. The main experimental course package, lasting for the first three years, is based on problem-based learning and constitutes an attempt to apply a modern form of teaching experimental physics. Our ambition is to move away from the traditional (passive) laboratory work and apply something that better develops the students' ability to independently solve experimental problems. In particular, we want the students to take on the responsibility for their experimental work with the goal of becoming independent experimentalists. What is unusual with our program is the scale. We have about 120 physics majors, which makes the organization and the execution of the course a demanding task. In our presentation, we will elaborate on the organization and the execution of the courses. In addition, we will provide some highlights from our laboratory.

BD02 2:10-2:20 p.m. 3D Design for Labs

Contributed – Anne J. Cox, Eckerd College, 4200 54th Ave. S, St. Petersburg, FL 33711; coxaj@eckerd.edu

Incoming first-year students have the opportunity to take a half-credit course that teaches them CAD and electronics with Arduinos along with their traditional calculus, physics, computer science or chemistry classes. One of the projects for the course is to design (and then 3D print) an adaption or improvement for equipment used in physics labs. Students learn about how the equipment is used, the design constraints, and evaluate each other's designs. Some examples include: an adapter to attach a fan to a dynamics cart, a force probe holder and a fence for use with a motion detector.

BD03 2:20-2:30 p.m. 3D Printing and Scanning in Introductory College Physics and pre-Engineering Courses

Contributed – Jitendra B. Sharma, University of North Georgia, Dept. of Physics, 3820 Mundy Mill Rd., Oakwood, GA 30566; jb.sharma@ung.edu

Redaghn Sileshi, University of North Georgia

The maturing of 3D printing and scanning technologies has made it viable to integrate them in K12 and University level coursework and curricula. These technologies bring powerful digital design, 3D scanning, and fabrication to enable course projects in the introductory college physics course sequence and the pre-engineering courses. At the University of North Georgia students typically transfer to a baccalaureate program in engineering after two years of a pre-engineering curriculum. The 3D printing and scanning 'makerspace' has been integrated into course projects that are required of students in most of these courses. This talk will discuss the types of 3D scanners and 3D printers currently in use, the protocols developed for this facility usage and collaborative use with the art department. Future plans for a larger makerspace will be discussed along with planned cross listed courses between physics and art.

BD04 2:30-2:40 p.m. Design and Create Interactive Electronics with Programmable Sensors in Introductory Physics Lab

Contributed – Xin Du, Aquinas College, 1700 Fulton ST E, Grand Rapids, MI 49506; xd001@aquinas.edu

How can we blend science with art? How to enhance student's comprehension of the physics in circuit and electronics? We conducted a hands-on creative project in General Physics laboratory. In this project, the student will design and build up interactive electronic technologies involving LED lights, conductive stickers and programmable sensors. Each student is required to create his/her original interactive, functional and beautiful circuit within two lab periods. Our project explores the intersection of electric digital technology, traditional crafts, and art design. It also provides the students an opportunity to get started with coding and learn how to apply coding in a scientific project.

BD05 2:40-2:50 p.m. Undergraduate Physics Labs Deconstructed: Re-imagining Student Labs with the IOLab

Contributed – Brian Geislinger, Gadsden State Community College, 1001 George Wallace, Gadsden, AL 35902; bgeislinger@gadsdenstate.edu

Undergraduate labs in physics can be said to have three main goals – reinforcing conceptual ideas from lecture, teaching students analytical techniques, and allowing students self-exploration of physics concepts. Each goal has its own unique benefits and challenges. Many would argue that the third goal is the ultimate achievement for students yet also the hardest to attain. Most lab implementations feature an unsatisfying mix of the three, attempting to cater to both the struggling and advanced student. The IOLab device offers a possible new approach centered around one idea. With each students owning a very capable data collection device, lab doesn't have to be constrained to a weekly sanctioned event. We re-imagine lab as taking place on three different time scales – each catering separately to the three stated goals. Discovery activities reinforce concepts; longer labs teach analytical skills; and student-created lab projects allow them to explore using the IOLab.

BD06 2:50-3:00 p.m. Real:Digital – Integration of Physics Experiments and Interactive Digital Media Content

Contributed – Daniel Laumann, University of Münster, Wilhelm-Klemm-Straße 10, Münster, 48149 Germany daniel.laumann@wwu.de

Current physics education is caught between traditional approaches focusing real students experiments and an increasing impact of digital media content. The project "Real:Digital" aims to identify the potential benefit resulting from an integrative usage of these diametrically appearing representations. Physics experiments allow for tactile experiences being authentic and credible for students. Furthermore, experiments constitute a fundamental scientific method and should be considered as an important aspect of nature of science. Digital media content enable the consideration of visualizations representing physical models that help teachers as well as scientists to explain phenomena and to structure physics contents. How can these representations be used together to improve physics education? We present two examples illustrating fundamental principles for an integrative usage of physics experiments and interactive digital media content and demonstrating the potential benefits. The examples are related to the topics of magnetism (magnetic properties of matter) and acoustics (Doppler effect).

Session BE: PER: Student and Instructor Support and Professional Development, Program and Institutional Change

Location: Pacific Salon Two **Sponsor:** AAPT **Time:** 2:00-3:30 p.m. **Date:** Sunday, January 7 **Presider:** Daniel MacIsaac

BE01 2:00-2:210 p.m. Exploring LA-Faculty Partnerships: An introduction to the Preparation Session Observational Tool (PSOT)

Contributed – Fidel Amezcua, Chicago State University, Department of Chemistry and Physics, 9501 S. King Dr. - SCI 309, Chicago, IL 60628 famezcua@csu.edu

Felicia Davenport, Dontrell Cornelius, Andrea G. Van Duzor, Mel S. Sabella, Chicago State University

A successful LA Program effectively incorporates all essential elements of the LA Model. It is therefore important to create adequate support tools and resources to adopt and implement the model. One of the three essential elements of the LA model is the weekly preparation session in which faculty and their Learning Assistants (LAs) meet to discuss course objectives, content, pedagogical approaches, and student learning. Our previous research suggests that weekly preparation sessions also play a major role in forming LA-faculty partnerships. The Preparation Session Observational Tool (PSOT) was developed to categorize these partnerships by looking for specific interactions between the LA and faculty member. For this study, weekly preparation sessions were recorded and analyzed using the PSOT, to illustrate the types of partnerships that can develop between LAs and faculty.

*Supported by the National Science Foundation (DUE#1524829), the Department of Education, and the CSU Center for STEM Education and Research.

BE02 2:10-2:20 p.m. "I Can Learn a Lot from You, But You Can Learn a Lot from Me"– Exploring LA Faculty Partnerships Through the PSOT and Self Reflection*

Contributed – Felicia Davenport, Chicago State University, 9501 S. King Dr. - SCI 309, Chicago, IL 60628; frdavenport81@gmail.com

Fidel Amezcua, Dontrell Cornelius, Mel Sabella, Andrea G. Van Duzor, Chicago State University

One of the essential elements of the Learning Assistant (LA) Model is the weekly preparation session where Learning Assistants (LAs) and faculty members meet to discuss content understanding, student performance, and plan the course agenda. The weekly preparation session plays an important foundational role in how LAs are used in the classroom. Analysis of these sessions led to the development of the Preparation Session Observational Tool (PSOT). The PSOT was created to characterize different behaviors with specific codes to (1) assist researchers and LA Program coordinators to better understand the preparation session and (2) assist practitioners (LAs and instructors) to self reflect on their meetings and the type of partnership they have. This talk focuses on how PSOT might be used by practitioners as a tool to reflect on their preparation sessions and guide revisions to their focus during these meetings.

*Supported by the National Science Foundation (DUE#1524829), the Department of Education, and the CSU Center for STEM Education and Research.

BE03 2:20-2:30 p.m. Professional Development of Undergraduate Learning Assistants

Contributed –Ying Cao, 6300 Sw Grand Oaks Dr. Apt. E302, Corvallis, OR 97331-8507; caoyin@oregonstate.edu

Milo Koretsky, Oregon State University

The Oregon State University (OSU) Learning Assistant (LA) Program is modeled after the LA Alliance, according which an LA is an undergraduate

student who, through the guidance of course instructors and a special pedagogy course, facilitates discussions among groups of students in a variety of classroom settings that encourage student engagement and responsibility for learning. The OSU LA program began in spring 2014 in Integrative Biology and has propagated throughout science and engineering. Our research investigates the adapted LA programs and asks how it has helped the LAs grow both academically and professionally. A preliminary case study with OSU engineering LAs showed that the LAs perceived this program helping them solidify content knowledge, develop problem solving skills, understand other perspectives, and contribute in teamwork. The aspects seemed to build up engineering design ability, a high-quality achievement towards engineering professionals. This paper will present our research approaches and preliminary findings.

BE04 2:30-2:40 p.m. Powering an Informal Science Education Program with Undergraduate Facilitators**

Contributed – Debbie DeRoma, California State University San Marcos, 333 South Twin Oaks Valley Rd., San Marcos, CA 92096; dderoma@csusm.edu*
Edward Price,Charles J. De Leone, California State University San Marcos
James Marshall, San Diego State University

Undergraduate students are a potential resource for staffing university-community partnerships such as informal science education programs. This talk will describe issues in operating an undergraduate-powered informal science education program, based on our experience with the CSUSM Mobile Making program. In Mobile Making, teams of highly qualified and ethnically diverse undergraduate science and math majors facilitate weekly activities during after-school programs at 10 local schools, engaging middle school participants in authentic but low-cost Making activities. The undergraduate facilitators also serve as near-peer mentors and role models for the ethnically and socioeconomically diverse populations served by the program. Mobile Making includes a mix of undergraduate facilitators participating through community service learning and a smaller number who are paid. This talk will describe outcomes for the math and science majors, lessons learned about working with undergraduate facilitators, and suggestions for similar university-community partnerships.

*Sponsored by Edward Price**This work is supported by NSF DRL-1612775.

BE05 2:40-2:50 p.m. Project-based Educator Training through a Museum-University Partnership Program

Contributed – Danielle B. Harlow, UC-Santa Barbara, 6867 Buttonwood Ln., Goleta, CA 93117-5520 dharlow@education.ucsb.edu
Ron Skinner, Kaia Joye Moyer, MOXI, the Wolf Museum of Exploration + Innovation

We introduce a year-long museum apprentice and university certificate program that draws on physics education research and informal science education research. Participants complete project-based coursework while putting what they learn into practice as floor staff at MOXI, the Wolf Museum of Exploration + Innovation, a new interactive museum focused on science ideas aligned with the physics content in the Next Generation Science Standards (NGSS). In museums, visitors differ considerably in age, background, and interest and are free to move between exhibits depending on what appeals to them at the moment. This requires floor staff to consider how to initially engage visitors' interest and then sustain their interest through more productive interactions, differentiating for the different populations. Our goal is that program graduates will have the skills and knowledge to guide learners towards more productive science exploration and innovation, whether they work in informal environments or classrooms.

BE06 2:50-3:00 p.m. Lessons from Building an Online faculty Community: Establishing the NextGenPET FOLC*

Contributed – Edward Price, California State University San Marcos, 333 South Twin Oaks Valley Rd., San Marcos, CA 92096; eprice@csusm.edu
Fred Goldberg San Diego State University
Steve Robinson, Paula Engelhardt, Tennessee Technological University
Chandra Turpen, University of Maryland, College Park

Participation in a professional learning community can help faculty improve their instruction, conduct classroom research, and study student thinking. Faculty online learning communities (FOLCs) can bring together distant faculty with shared interests or circumstances. For the past 18 months, the authors have planned and established the Next Generation Physical Science and Everyday Thinking (NextGenPET) FOLC, a community of faculty teaching physics courses for preservice elementary teachers using the NextGenPET curriculum.[1] The FOLC's goal is supporting faculty development that will result in far-reaching, sustainable educational transformation. The community includes experts who serve as facilitators, an internal structure of faculty clusters, and supporting communication tools. This talk will describe lessons learned in establishing the NextGenPET FOLC, including key decisions about cluster size and structure, the value of initial in-person workshops, the significance of a shared curricular context, and generating support for project "requirements" such as assessment.

*This work is supported by the National Science Foundation DUE-1626496 ;(1) http://www.ngpfolc.org

BE07 3:00-3:10 p.m. When Research-based Introductory Physics Curriculum Change: A Case Study*

Contributed – Charles Joseph DeLeone, California State University San Marcos, 333 S. Twin Oaks Valley Rd., San Marcos, CA 92096; cdeleone@csusm.edu
Clarisa Bercovich Guelman California State University San Marcos

When a research-based physics curriculum is adopted at an institution, it is common for the implementers to make modifications to address the constraints and affordances of the new site. However, as time passes and new instructors are brought into the course, the curriculum can begin to see further modifications that are motivated by a variety of reasons. What elements of the original curriculum will persist and what elements undergo modifications is not always clear at the time of the original implementation. This talk reports on a case study that explores these questions in the context of UC Davis' introductory physics for the life sciences CLASP curriculum that was originally adopted 15 years ago at California State University, San Marcos.

*Supported in part by NSF-DUE #1068477

BE08: 3:10-3:20 p.m. Reasons Behind Sumter School District Students' Decisions to Take Physics

Contributed – Hui-Yiing Chang, University of South Carolina Sumter, 900 Tristan St., Sumter, SC 29154-7408; changhui@uscsumter.edu*
Jessica N. Kohler, Jordan Ard, University of South Carolina Sumter
Clausell Mathis, Florida State University

Enrollment in physics courses in the Sumter School District in Sumter, SC has been extremely low. Since physics is a requirement for most science and engineering degrees, not having enrolled in a physics course during high school could ultimately impede a student's pursuit of such majors during college. Furthermore, since physics provides the fundamental principles for science and engineering, unsuccessfulness in physics could hinder excellence in these disciplines. This project aims to explore the factors that may have been related to or may have influenced the SSD high school students' decisions to enroll in physics courses. This was achieved by conducting an electronic survey among voluntary participants from the seniors of SSD, then performing a quantitative analysis of the results. These results and the conclusions drawn are intended to help educators increase enrollment in physics courses in Sumter and other school districts.

*Sponsored by Clausell Mathis

BE09 3:20-3:30 pm. Examining Student and Faculty Perceptions of Physics Innovation and Entrepreneurship

Contributed – Anne E. Leak, Rochester Institute of Technology, 85 Lomb Memorial Dr., Rochester, NY 14586; aelsps@rit.edu

Elizabeth Sciaky ,University of California Santa Barbara

Christian Cammarota, University of Rochester

Benjamin M. Zwickl, Rochester Institute of Technology

Physics majors pursue a wide range of career paths, many in the private sector. The AAPT/APS PHYS21 report suggests that majors would benefit from learning how innovation and entrepreneurship (I&E) relate to physics. Yet, these are often unrecognized as part of physics by faculty and students. To support department initiatives, research is needed on I&E perceptions, including awareness of opportunities and barriers to implementation. We conducted semi-structured interviews with undergraduates and surveyed faculty and from physics departments around concepts related to I&E: technology, creativity, design, business, communication, leadership, and societal impact. Emergent and thematic coding was used to analyze responses. Faculty, while perceiving the value of physics I&E education, identified several barriers including limited resources, recognition, and low prioritization. Students viewed innovation as closely related to physics, especially in research, while design and business skills were seen as closer to engineering, distant from physics.

Session BF: Physics of Hobbies

Location: Royal Palm Three/Four **Sponsor:** Committee on Physics in Two-Year Colleges **Time:** 2:00-3:20 p.m. **Date:** Sunday, January 7
Presider: Paul Williams

BF01 2:00-2:10 p.m. The Physics in Phyre Phyting

Contributed – Stephen H. Irons, Yale University, 217 Prospect St., New Haven, CT 06511; stephen.irons@yale.edu

As a long time volunteer firefighter in my town, I have found that physics enters into just about every aspect of the job. Rich examples abound across many fields of physics, special relativity excepted perhaps. I will discuss some examples you could use in class from kinematics, dynamics, Newton's laws, friction momentum, impulse, kinetic and potential energy, energy and momentum conservation, torque and static equilibrium, behavior of solids, fluids and fluid flow, density and buoyancy, thermal conductivity, heat and energy transfer thermodynamics, combustion, the ideal gas law, wave properties, wireless communications, AND voltage, current and power. These are context rich examples that involve more than just replacing a generic car with a firetruck.

BF02: 2:10-2:20 p.m. The Physics of Guitar Building: The STEM Guitar Project

Contributed – Debbie A. French, Wilkes University, 84 W. South St., Wilkes-Barre, PA 18766; frenchd14@yahoo.com

Sean Hauze, San Diego State University

Richard M. French, Purdue University

Doug Hunt, Southern Wells High School

Thomas Singer, Sinclair Commuity College

Lutherie is a hobby many people enjoy, and the guitar is an engaging tool to teach physics. The STEM Guitar Project is an NSF-funded initiative capitalizing on this interest by using the electric guitar as a vehicle to teach integrated science, technology, engineering, and mathematics (STEM). Twelve lessons were created to teach integrated STEM concepts to K-16 students. Examples of physics topics within these lessons include intonation, wave behavior, simple machines, and electromagnetic induction of the pickups. This talk highlights examples of physics lessons using the guitar and learning outcomes measured by pre and post assessments from 769 students in 15 states. Through the Wilcoxon signed ranks test, there was a statistically significant ($p < 0.05$) increase in scores for each of the lessons analyzed. Additionally, a discussion of how to use the guitar as a vehicle to teach physics at a variety of levels will be presented.

BF03 2:20-2:30 p.m. Correlation of String/Body Resonances on a Cello

Contributed – Samantha Young, Loyola University Chicago, 326 Hambletonian Dr., Oak Brook, IL 60523; sam.quinzel@gmail.com

Gordon Ramsey, Loyola University Chicago

This undergraduate research project focuses on a full size acoustic cello, and investigates the correlation of the resonance properties between the strings and wooden body. The goals are to investigate the radiation patterns of the produced sound waves, to take high-speed video of a played string to physically observe the standing wave, and to simulate the body resonance of the cello. A mathematical model is formed to approach the situation where a musician plucks a string. Typical approaches assume the surface area of a finger to be a point source, but the surface area is actually parabolic, forming a bend in the string that is continuous to the following straight line. These same methods will be applied in an anechoic chamber to test ideal conditions. Results of this research can be used to teach waves and resonances.

BF04 2:30-2:40 p.m. Acoustics and Physics of Drum and Bugle Corps

Contributed – Jack A. Dostal, Wake Forest University, PO Box 7507, Winston Salem, NC 27109; dostalja@wfu.edu

One of my earliest experiences performing in drum and bugle corps was mind-expanding: the audibility of overtones. Sections of brass instruments playing in tune can produce strong, audible overtones above the note actually being played. In addition, the intelligibility of different instruments playing simultaneously must also be considered when designing a performance. Drums exhibit interesting physical and acoustical phenomena. Marching also involves some very interesting physics. While walking can be thought of as an act of controlled falling, marching demands that performers be on balance at all times and pivot on the ball of the foot to make a turn. Performers who spin flags and rifles add some of the most visual elements of physics to a performance. In this talk I will describe some of these acoustical and physical phenomena relevant to the performances of drum and bugle corps.

BF05 2:40-2:50 p.m. Thermodynamics and Barbeque

Contributed – Chuck Winrich, Babson College, 231 Forest St., Babson Park, MA 02457-0310; cwinrich@babson.edu

Cooking, by any means, is about heat transfer. There are many methods of cooking, and devices used to control the heat transfer in those methods. This presentation will focus on charcoal or wood-fired barbeque smokers. First will be a look at the design elements of a smoker with an eye towards how heat transfer into the meat being cooked is controlled. This will be followed by an examination of heat transfer within the meat itself. The combination of these aspects of heat transfer will be used to explain the results of low-temperature long-duration cooking that is common to barbeque-style cooking.

BF06 2:50-3:00 p.m. Some Science of Pottery Making

Contributed – Dean A. Zollman, Kansas State University, 116 Cardwell Hall, Manhattan, KS 66506-2601; dzollman@phys.ksu.edu

Functional pottery has a very long history. The first useful pots are thought to have been created around 10,000–9,000 BC. Glazed pots came about 1,000 years later, and the pottery wheel was invented between 6000 and 4000 BC. Further, pottery is truly multicultural and appeared in almost all ancient civilizations. Today, potters use many of the same techniques as those used for centuries except that electricity has made both throwing and firing pots much easier. The science involved in the process ranges from simple mechanics to complex molecular interactions. When using the wheel the potter must be constantly aware of the centrifugal effect. In the kiln a series of phase changes converts pottery from water-soluble clay to a rigid body covered by a glass. The science, which was unknown to the ancients, will be reviewed briefly.

BF07 3:00-3:10 p.m. Physics of Watercolors

Contributed – Tetyana Antimirova, Ryerson University, 350 Victoria Street, Toronto, ON M5B 2K3 Canada; antimiro@ryerson.ca

Creating a realistic painting requires an accurate transformation of three-dimensional objects onto a two dimensional surface. In addition to the need for drawing and painting skills, the properties and behavior of the art materials used play an important role. This talk describes the physics phenomena that are essential for watercolor techniques: the reflection and polarization of light, as well as the optical properties of the paper and pigments. The pigments used in watercolor paints vary in their transparency and opaqueness, size and their ability to bond to paper and stain it. Selecting a paper with smooth or rough finish will produce a totally different visual effect. The wet-on-wet technique is based on the capillary action of water. Different visual effects can be created by using salt, soap as well as special liquid materials designed to modify the interaction between paints and paper. Examples of these visual effects will be demonstrated.

BF08 3:10-3:20 p.m. Engineering a Bicycle Speedometer

Contributed – Shawn Reeves, EnergyTeachers.org, 220 Lexington Ave., Cambridge, MA 02138; shawn@energyteachers.org

When a student in the author's circuits class asked if they could build a speedometer, the author began to seek a simple circuit that would include a switch, a frequency meter, some way to convert that to a speed, and a display. Micro-controllers allow students to build inexpensive devices that can reliably monitor inputs, tell time, and compute things like speed based on those inputs. The fun begins when engineering the device to improve performance and features—to use the least amount of power; to allow for inputs like a changeable wheel diameter; to detect when a bike is in motion or being walked; etc. The author presents two designs and some design-considerations. Through EnergyTeachers.org the author helps educators around the world teach about energy and electronics, with lab materials, curricula, books, and other resources.

Session BG: Physics of Mars Exploration

Location: Sunset **Sponsor:** Committee on Space Science and Astronomy **Time:** 2:00-3:30 p.m. **Date:** Sunday, January 7
Presider: Matthew Perkins

BG01 2:00-2:30 p.m. Planetary Instrument for X-Ray Lithochemistry (PIXL) for the Mars 2020 Mission

Invited – Marc Foote, Jet Propulsion Laboratory, MS 306-431, 4800 Oak Grove Dr., Pasadena, CA 91109; mcfoote@jpl.nasa.gov

Abigail Allwood, Lawrence Wade, Jet Propulsion Laboratory

PIXL, the Planetary Instrument for X-Ray Lithochemistry, is one of two instruments slated to mount at the end of the Mars 2020 Rover arm for close-up analysis of natural and abraded rocks. PIXL produces an intense X-ray spot, focused to 120 microns. By measuring the spectrum of X-rays produced by fluorescence, the rock's elemental composition is determined. The X-ray spot is then mechanically scanned across the rock to map the composition spatially. Compared to previous Mars elemental composition instruments, PIXL's measurements are significantly more sensitive and orders of magnitude higher spatial resolution (120 microns compared to 2 cm). PIXL's science objectives are to evaluate the potential for past habitability, detect biosignature evidence of past life, and to provide a geochemical basis for sample selection for future return to Earth.

BG02 2:30-3:00 p.m. Physical Constraints of Landing Sites for the Mars 2020 Rover

Invited – Ken Brandt, Robeson Planetarium, 201 E. Livermore Dr., Pembroke, NC 28372; ken.starsabove@gmail.com

As of this submission, there are three candidate landing sites for the 2020 rover. Find out what sites, what the constraints are, and how you might use this to teach principles of space exploration, astronomy, and physics in your classroom.

BG03 3:00-3:30 p.m. SHERLOC on Mars 2020: From Physics to Engineering to Goebiology

Invited – Luther Beegle, Jet Propulsion Laboratory, 4800 Oak Grove Dr., Pasadena, CA 91109; Luther.Beegle@jpl.nasa.gov

The Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals (SHERLOC) instrument is part of the instrument payload for the next flagship mission to Mars. SHERLOC combines imagining with laser spectroscopy to characterize and physically map organic materials and astrobiology relevant materials. The results from SHERLOC will enable a better understanding of the aqueous history of a region on Mars and identify potential biosignatures in samples. Additionally, Mars 2020 has the ability to collect samples with high scientific value for potential return to Earth and analysis in terrestrial laboratories. This talk will focus on how a physicist navigates the worlds of engineering, geobiology, and chemistry in order to search for life on another planet. Finally, we will focus on how concepts taught in physics classes from high school to graduate school enable us to search for signs of life on Mars.

Session BH: Rocketry: Past and Future

Location: Royal Palm Five/Six **Sponsors:** Committee on Science Education for the Public, Committee on Space Science and Astronomy
Time: 2:00-3:20 p.m. **Date:** Sunday, January 7 **Presider:** Michael R. Gallis

BH01 2:00-2:30 p.m. Exploring the Wright Brothers with PBL

Invited – Nino Polizzi, Samueli Academy, 1901 N Fairview St., Santa Ana, CA 92706; npolizzi@samueliacademy.org

Project Based Learning (PBL)- a dynamic teaching approach where students explore real-world problems and challenges- is gaining momentum in education, particularly in STEM subjects. For an Engineer, PBL parallels what is done in the real world. From that perspective, this presentation details how the PBL process is used to excite high school students about the Wright Brothers and the Magic of Flight. The result is a "project recipe" that the audience can use on projects of their choosing. The brief intro to PBL includes specifics of the process in a way that can be utilized for any type project; Entry Documents, Know/Need To Know activities, contracts, worksheets etc. Ideas for integrating reading, writing and history across curriculum boundaries are explored. The Wright Brothers project is presented in detail: to learn the fundamentals of aeronautics, students are challenged to understand how the Wright Brothers achieved flight by building a scale model of the 1902 glider and testing it in a home-built wind tunnel. In addition to gathering data showing the relationships between lift, drag, angle of attack and wind speed, students experience the challenge of building a flight-worthy aircraft and a myriad of other skills-including the Engineering Process- that are transferrable. Through this project, students research the history of the Wright Brothers, discovering the elements that enabled the "Wright Miracle". Through the building of the model, they gain first-hand experience on the anatomy of a flying machine. Subjecting their models to the wind tunnel, they witness the interplay between the forces that make flight possible. Suggestions on how to "break out" sections of this project into smaller sections are provided. This presentation by Nino Polizzi- a 30-year aerospace engineer turned high school teacher- will use this project to provide a detailed example of using PBL to generate excitement and engagement in high school students.

BH02 2:30-3:00 p.m. From Theory to Practice: Bootstrapping Your Own Liquid Rocket Program

Invited – Michael Policelli, Aerospace Engineer (Speaking as an individual), 163 Ardmore Ave., Hermosa Beach, CA 90254-5230; mjpolicelli@gmail.com

The experience students can gain from amateur rocketry clubs is invaluable for many potential future careers in STEM well beyond exclusively aerospace. This talk will present a roadmap to overcome some common obstacles in starting your own program and the numerous educational benefits to students. Topics covered include sizing your system from a first principles approach, control systems and data collection, oxidizer compatibility and safety.

BH03 3:00-3:10 p.m. Using North Korean Missile Development to Enhance Student Interest in Kinematics and Newtonian Mechanics

Contributed – Kendall E. Mallory, Aims Community College, 5401 W 20th St., Greeley, CO 80634; kendall.mallory@aims.edu

The use of current events can enhance student interest in their studies of physics. The development of Intercontinental Ballistic Missiles in North Korea presents a strong opportunity for piquing student interest in kinematics, mechanics, error analysis, and the testing of hypothetical positions and strategies. Very early in their freshman courses, students can see the utility of physics including the analysis of international threats. In particular, I ask students to complete analysis of data from North Korean missile launches to determine the nature and seriousness of North Korean threats to the United States. This gives students an interesting motivation for working problems in ballistics. I can also ask students to evaluate the validity and accuracy of data associate with missile launches. This gives students an experience using physics and analytical techniques developing new concepts, models, designs, threats, and strategies.

BH04 3:10-3:20 p.m. 1-2-3-Escape! Using the Oberth Effect for Interplanetary and Interstellar Travel

Contributed – Devin Potratz, Grossmont College. 8800 Grossmont College Dr., El Cajon, CA 92020-1799; philip.blanco@gcccd.edu

Philip R. Blanco, Grossmont College

You have a spacecraft in a circular orbit around a central body (planet or Sun) that you want to send away on a (hyperbolic) escape path. Shortly after the dawn of the space age, Edelbaum (1959) showed that the spacecraft's asymptotic speed v_inf can be maximized (for a given amount of rocket fuel) by employing up to three separate impulse maneuvers, as opposed to expending all the fuel at once. This is due to the Oberth effect, which is distinct from the "gravity assist" that a planet can provide to a passing spacecraft. Here we use the software package Systems Tool Kit (STK) - freely available under an educational license - to simulate these maneuvers and animate the escape paths. This exercise can be used by students to demonstrate and appreciate the effects of orbital maneuvers on a spacecraft's angular momentum, mechanical energy, and its resulting trajectory.

Session CA: High School Teacher Certification and Qualifications Policy Discussion

Location: Tiki Pavilion **Sponsor:** Committee on Teacher Preparation **Time:** 4:00-6:00 p.m. **Date:** Sunday, January 7 **Presider:** John Stewart

The session will feature experts on teacher certification, qualifications, and science education policy from the American Association of Physics Teachers (Rebecca Vieyra) and the American Physical Society (Greg Mack). Gay Stewart will also discuss her experience in developing certification programs at two institutions. The panel will invite discussion of local issues of teacher certification and qualifications and how the disciplinary societies should be involved.

Panelists:
Greg Mack, APS
Rebecca Vieyra, AAPT
Gay Stewart, West Virginia University

Session CB: Physics MasterClass Nuts and Bolts (Panel)

Location: Royal Palm One/Two **Sponsor:** Committee on Physics in High Schools **Time:** 4:00-6:00 p.m. **Date:** Sunday, January 7
Presider: Marla Glover

Students analyzing experimental data from current experiments in particle physics. MasterClass is an effective way to energize and engage students in inquiry. This session will feature a panel of teachers that have organized and led MasterClasses. Participants will learn what is involved and activities to prepare students for this very useful program.

Panelists:
Shane Wood, Irondale High School, New Brighton, MN, swood5@nd.edu
Daniel Karmgard, University of Notre Dame, Notre Dame, IN, daniel.j.karmgard.1@nd.edu
Martin Shaffer, Cowley College, Arkansas City, KS, martin.shaffer@cowley.edu

Session CC: Aftermath of the Eclipse

Location: Pacific Salon Two **Sponsor:** Committee on Physics in Two-Year Colleges **Time:** 4:00-6:00 p.m. **Date:** Sunday, January 7
Presider: Todd Leif

CC01 4:00-4:30 p.m. NASA Nebraska High Altitude Ballooning Results from the Total Solar Eclipse

Invited – Kendra Sibbernsen, 287 Concord Circle, Papillion, NE 68046; ksibb@cox.net

As a part of the NASA Eclipse Ballooning project, the NASA Nebraska High Altitude Ballooning group launched three weather balloons with scientific payloads to stream images from altitude directly to the internet while in flight, take scientific measurements, and take photos of the moon's shadow on the Earth. The launch took place from the Stuhr Museum in Grand Island, NE, near the centerline of totality. Images, video, and data from the event will be shared.

CC02 4:30-5:00 p.m. Less than Seven Years Until the Next One

Invited – Bob Brazzle, Jefferson College, 2019 Brutus Ct., Fenton, MO 63026; bobbrazzle@yahoo.com

The Great American Eclipse of 2017 is now in the history books. Beginning in February of 2015, I joined a regional task force to help organizations and municipalities in the St. Louis region prepare for the eclipse. Among other things we organized sales of over 400,000 eclipse glasses through our task force. I also chaired a task force at Jefferson College, which is located about 9 km from the center line. I will describe the interactions between our regional task force and various organizations, city governments, and the media during the 30 months leading up to the eclipse. I will also describe the college's preparations for the event, and what we learned by hosting an estimated 2,000 visitors to our small campus that day. These observations should be useful to anyone in the path of the next American eclipse in 2024.

CC03 5:00-5:10 p.m. A Few Hours of Data Collection, a "Totality" of Wonder

Contributed – John P. Lewis, Glenbrook South High School (Retired), 1420 Magnolia St., Glenview, IL 60025; yesmoment1@yahoo.com

While preparing to travel to Missouri for totality, I thought, "Why not throw in some probes and an interface and measure a few things during the eclipse?" And I'm so glad I did. Armed with Vernier's LabQuest Mini, temperature, pressure and light sensors, and my laptop, my wife and I set off to collect data for the few hours that surrounded the big event. Watching the data unfold in realtime soon caught the interest of many of the people who were enjoying the eclipse at our location. Soon dozens of questions popped up as the equipment actually portrayed in an analytic form just what we were experiencing sensually. This talk will share some of the data, experiences, questions, and wonder that have resulted from a casual observation of this incredible phenomenon.

CC04 5:10-5:20 p.m. Eclipse Science from the Edge of Space

Contributed – Barbra M. Sobhani, Red Rocks Community College, 13300 W. Sixth Ave., Lakewood, CO 80228; barbra.sobhani@rrcc.edu

April Beal, Annie Strange, Red Rocks Community College

Our student team participated in a NASA project capturing data and images of the eclipse from the edge of space via high altitude balloon -- to help us understand where life could survive beyond Earth. The payload was launched in Guernsey, WY, during the eclipse to livestream the event from space across the path of totality. The team also sent up bacteria and seeds, to see how life reacts to a Mars-like environment. The students tested the viability of seeds exposed to high altitude conditions using a unique spherical cage design allowing for maximum exposure, while protecting during launch and landing. The exposed seeds have been grown in both Earth and Martian simulated soil and compared to seeds that were not flown. Three test launches were done prior to the eclipse. Preliminary results have shown that the exposed seeds sprout and grow more quickly than the control.

CC05 5:20-5:30 p.m. Measurements of Stratospheric Temperature Changes During the 2017 Solar Eclipse

Contributed – Kaye L. Smith, St. Catherine University, 2004 W Randolph Ave., St. Paul, MN 55105-1750; klsmith2@stkate.edu

Erick Agrimson, St. Catherine University

Gordon McIntosh, U of M, Morris

James Flaten, U of M, Twin Cities

The solar obscuration during the total solar eclipse of August 21, 2017, provided a unique opportunity to measure stratospheric temperature transitions using arrays of weather-balloon- borne temperature sensors. To measure these transitions, St. Catherine University and the University of Minnesota, Morris, flew over 40 temperature sensors suspended beneath weather balloons ascending within the path of totality. Past experience with day and night weather balloon flights have shown that the temperature beneath an ascending weather balloons is warmer than the surrounding ambient air during daytime flights, and cooler than the ambient air during nighttime flights. The total solar eclipse allowed us to study temperature transitions from daytime to eclipsed (pseudo-night) to daytime conditions at different altitudes in the stratosphere as the eclipse was occurring.

CC06 5:30-5:40 p.m. Modern Eddington Experiment Results

Contributed – William A. Dittrich, Portland Community College, PO Box 19000, Portland, OR 97280-0990; tdittric@pcc.edu

The Modern Eddington Experiment was undertaken by as many as 10 groups/individuals during the 2017 Total Solar Eclipse. Portland Community College fielded two teams in Oregon and achieved what appears at this early stage of analysis to be a success. This paper describes the PCC effort and results as well as the results from across the nation. It appears that the goal to have performed the experiment at a level of accuracy greater than ever before.

CC07 5:40-5:50 p.m. Off the Path: 83% Leads to More Involvement in Programs

Contributed – Thomas Herring, Western Nevada College / Jack C Davis Observatory, 2201 West, Carson City, NV 89703; thomas.herring@wnc.edu

A report on how an unexpectedly busy August 21, 2017 was has led to more participation in regular programs at the Jack C. Davis Observatory in Carson City, NV. Despite being well off the path of totality, this small observatory on campus at Western Nevada College attracted over 250 visitors on eclipse day and attendance at subsequent programs has increased by over 80%. Plans to capitalize on this increase will also be discussed.

CC08 5:50-6:00 p.m. Public Outreach for the 2017 Solar Eclipse

Contributed – Bob Powell, University of West Georgia, 1600 Maple St., Carrollton, GA 30118; bpowell@westga.edu

Ben Jenkins, University of West Georgia

Both authors gave PowerPoint presentations to local groups. Powell gave "Darkness in the Afternoon, the August 21 Solar Eclipse" at 27 locations, primarily during the period August 3-20, 2017. The locations included six civic clubs, four community groups, two church groups, and 15 schools. The attendance at his presentations was over 2400. Both authors gave radio and newspaper interviews. With funding from a grant (Sterling, Jenkins, Powell), the Department of Physics, and College of Science and Mathematics, 40,000 pairs of eclipse shades were distributed to students in the Carroll County and Carrollton Schools, the West Georgia community, and beyond. Jenkins estimates that over 5000 people came to the Observatory during the eclipse to look through telescopes equipped with safe solar filters or to collect a pair of eclipse shades; 3200 pairs of shades were distributed during the eclipse.

Session CD: Climate Change

Location: Pacific Salon One **Sponsor:** Committee on Physics in Two-Year Colleges **Time:** 4:00-5:50 p.m. **Date:** Sunday, January 7
Presider: Tom Carter

CD01 4:00-4:30 p.m. Clouds in a Changing Climate

Invited – Rachel Storer, Colorado State University, MS 233/300, 4800 Oak Grove Dr., Pasadena, CA 91109; Rachel.L.Storer@jpl.nasa.gov

One of the key ways that climate impacts our daily lives is through its effect on clouds and precipitation. As the climate changes, clouds will respond in complicated and uncertain ways. I will explain the central links between clouds and climate, and try to summarize what we know, and what we don't, about how these relationships might change in a warmer world.

CD02 4:30-5:00 p.m. Measuring the Ocean: Evidence for Global Temperature Change

Invited – Sarah T. Gille, University of California San Diego, 9500 Gilman Dr, Mail Code 9239, La Jolla, CA 92093-0230; sgille@ucsd.edu

The vast size of the ocean makes it difficult to measure. Electro-magnetic radiation does not penetrate long distances through water, so satellite-based observations are unable to probe the depths of the ocean. Decades of ocean research have relied on ship-based observations, obtained by lowering sensors down through the ocean. In the last 15 years, autonomous ocean profilers, called Argo floats, have transformed our ability to measure the ocean. Measurements from more than 3500 Argo floats deployed across the global ocean indicate that the ocean has warmed significantly relative to historic observations, and that it has continued to warm over the past decade. Observations indicate that warming is surface intensified but has penetrated through the entire

2000-m depth range sampled by Argo. Globally, the increase in ocean heat content represents a significant heat input to the Earth system. Since the density of water is temperature dependent, the warming is associated with global sea level rise.

CD03 5:00-5:30 p.m. The Navy, Climate Change, Risks, and Opportunities

Invited – Garth Nagel, Department of Navy, 1220 Pacific Highway, B127, San Diego, CA 92132-5190; garth.nagel@navy.mil

The U.S. Navy has major installations in the San Diego and Southern California region, which are at risk from rising sea levels, water scarcity, wildfires, and extreme weather due to climate change. Scientists predict that global sea levels will rise between 0.2 meters (8 inches) and 2.0 meters (6.6 feet) by 2100 thereby posing the most immediate threat to Navy installations. This session will provide a brief overview of the Navy's approach to addressing climate change and in particular sea level rise. Climate change poses one of the most challenging problems facing future generations, but it also provides opportunities for those with a background in physics, engineering and sciences to help mitigate and adapt to the impacts of climate change.

CD04 5:30-5:40 p.m. Cloud Physics II

Contributed – Celia Chung Chow, CSU, 9 Andrew Dr., Weatogue, CT 06089; cchungchow@comcast.net

This is a continuation of my research on cloud physics as a supplementary to physics teachers at all levels. (Part I was reported at AAPTSM17.)

CD05 5:40-5:50 p.m. Building Climate Intuition With Simple Classroom Demonstrations

Contributed – Sarah Gille, University of California San Diego, 9500 Gilman Dr., Mail Code 0230, La Jolla, CA 92093-0230; sgille@ucsd.edu

Why are cyclones counter-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere? What does it mean that the ocean is stratified? Students sometimes have a hard time with the key concepts that will help them understand the climate system. Simple classroom demonstrations can help them build their intuition. For example we use a beach ball globe to consider the rotation of the Earth and to illustrate the fact that the Earth's rotation is counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere.

Session CE: Integrating Computational Thinking into High School Physics

Location: Royal Palm Three/Four **Sponsors:** Committee on Educational Technologies, Committee on Physics in High Schools
Time: 4:00-5:40 p.m. **Date:** Sunday, January 7 **Presider:** Colleen Megowan-Romanowicz

CE01 4:00-4:30 p.m. Hackable Simulations: Deepening Student Understanding in the Physics Classroom

Invited – Steven W. Temple, San Rafael High School, 185 Mission Ave., San Rafael, CA 94901; stemple@srcs.org

Winston L. Wolff, Jeremy Yun, Stratolab

Tychos is a web-based, simple to adopt computational modeling tool for creating hackable simulations in the physics classroom. It opens up the black-box aspect of pre-constructed simulations while also simplifying and accelerating the acquisition of the skills needed to "code" the underlying physics. There are no virtual physics laws built into Tychos. Those rules must be defined and implemented by the students. Students can quickly define a hypothesis in code for anticipated behavior of a real experiment, then run the experiment and see if the simulation behavior matches the behavior of the physical world. Tychos can also be used as an assessment tool where teachers can create goals for the students, which Tychos will then automatically track and report progress. Attendees will be given a free account to Tychos and a set of resources for quickly integrating Tychos into their classroom.

CE02 4:30-5:00 p.m. Computation and Kinematics: Using Differential Form to Teach Motion

Invited – Joshua Rutberg, Rutgers University, 1 Richmond St., New Brunswick, NJ 08901; joshua.rutberg@rutgers.edu

Katie Martino, Blind Brook High School in Rye Brook

Algebraic expressions are one of the primary representations used to describe the physical laws and relationships under study in a physics class. This is done using closed-form, parametric equations with which every physics teacher should be infinitely familiar. These equations are used because they can be solved by students as young as eighth grade, often requiring nothing more complicated than a calculator. However, the reliance on these equations serves to limit the number of phenomena that can be reasonably studied by students who have yet to take calculus. High school physics must limit itself to, with only few exceptions, motion resulting from a constant net force. Trying to write the closed-form solution to describe the motion, however, the use of coding and other computational tools allows for a differential expression of motion that can describe phenomena which have long been considered toomathematically rigorous without the need for any calculus knowledge.

CE03 5:00-5:10 p.m. Using a Computational Model to Settle a Conceptual Debate: A Synthesis of Physics and Computation

Contributed – Luke D. Conlin, Salem State University, 352 Lafayette St., Salem, MA 01970; lconlin@salemstate.edu

What does it look like to learn physics through computational modeling? Recent attempts to synthesize the teaching of physics and computer science have focused on what the disciplines have in common, including various concepts (e.g., variables), or problem-solving strategies (e.g., decomposition of a problem into simpler parts). Another model of synthesis is to look for how the differences between the disciplines can complement each other. This kind of synthesis may be harder to predict, and harder to design for. In this preliminary study, we designed a block-based programming environment to help high school students learn physics, and analyzed their approach to learning with the system. Students spontaneously found moments of synthesis between physics and computational modeling, for instance, when they modified their simulation to settle a debate over a conceptual issue (i.e., the independence of x and y motion). This raises the question of how to design for such moments.

CE04 5:10-5:20 p.m. Programming Laws-of-Motion Simulations from First Principles

Contributed – Stewart Crawford, Hawai'i Pacific University, PO Box 37931, Honolulu, HI 96837; scrawford@hpu.edu*

A series of computational labs has been developed to create visual simulations that support the understanding of forces, momentum, and the laws of motion. Starting with simple linear motion, progressively enhanced simulations progress through single-body forces to multi-body orbital interactions. Students program the labs from first principles using the Python programming language with extensions that support vector mathematics. The lab series starts with basic programming constructs and gently builds the programming framework supporting key concepts of computational thinking. Students responded well to prototype efforts in the classroom, many self-reported a better understanding of the physics by seeing things in motion. Python presents a straightforward programming environment whose basics can be easily mastered by a teacher and picked up by the students. The computational labs are independent of any specific textbook, and have been mapped to several of the standards that guide the pedagogy of secondary schools.

*Sponsored by Wendy Adams

CE05 5:20-5:30 p.m. Black Hole Hunter: Computational Thinking in Physics/Astronomy

Contributed – Daniel DuBrow, Evanston Township High School & Northwestern University, 1600 Dodge Ave., Evanston, IL 60204; dubrowd@eths202.org

Jason Hwang, Northwestern University

In this computational thinking activity, we introduce students to the idea of using computer simulations to explore a physical system. Matching a known output by varying the inputs is a technique used very often in modern scientific research via simulation. In this example, students can see the effect of varying initial conditions such as the mass and location of the black hole at the center of the Milky Way galaxy on the orbit of a fictional star They match this orbit to an actual (observed) orbit, thus estimating where the galactic black hole is and its mass. Students then are able to dig into the computer model to not only see how the program is written but also to make their own changes in the code and to observe the effect of those changes on the output of the model, setting up additional opportunities to explore simulations and algorithms.

CE06 5:30-5:40 p.m. A Game-Centered, Interactive Approach for Using Programming Exercises in Introductory Physics*

Contributed – Chris Orban, Ohio State University, 191 W Woodruff Ave., Columbus, OH 43201; orban@physics.osu.edu

Richelle Teeling-Smith, University of Mount Union

Chris Porter, Ohio State University

Incorporating computer programming exercises in introductory physics is a delicate task that involves a number of choices that may have a strong affect on student learning, especially for absolute beginner programmers. We present a series of hour-long activities for classical mechanics that resemble well-known games such as “asteroids,” “lunar lander,” and “angry birds” as well as more sophisticated interactive visualizations. These activities use a browser-based programming framework called p5.js that provides a game-like environment to give students a feel for the physics. We discuss experiences from using these programming exercises in freshman physics classes at OSU’s Marion campus and in high school physics classes in Ohio. We are currently working to assess learning gains quantitatively using an animated version of the Force Concept Inventory originally developed by M. Dancy and other animated questions.

*Funds from the STEMcoding project (u.osu.edu/stemcoding) and the AIP Meggers Award

Session CF: Keeping it Real: Recognizing Physics Outside the Classroom

Location: Sunset **Sponsors:** Committee on Science Education for the Public, Committee on Physics in Pre-High School Education
Time: 4:00-6:00 p.m. **Date:** Sunday, January 7 **Presider:** Jim Hicks

CF01 4:00-4:30 p.m. Bringing Physics to Broadway

Invited – David Maiullo, Rutgers University/Department of Physics and Astronomy, 136 Frelinghuysen Rd., Piscataway, NJ 08854-8019; maiullo@physics.rutgers.edu

In the summer of 2015 I signed a contract to create, write and star in an Off Broadway version of my standard public physics demonstration show. Called “That Physics Show,” it was immediately successful and has been running since November 2015 with no end in sight. By July 2017 it had been performed over 300 times with over 34,000 attendees. In addition, I received the NYC Theater Drama Desk Award for “Most Unique Theatrical Production” for 2016. This talk will be the history and future of this effort to bring physics to the public in a special and highly visible way.

CF02 4:30-5:00 p.m. 30 Years of Outrageous Outreach

Invited – Gene Easter, Brushfire Science, 540 South Ridgecliff St., Tallmadge, OH 44278; gleaster@sbcglobal.net

Bill Reitz, happily retired

The Flying Bernoulli Brothers try to recollect their first 30 years beyond the classroom when they: Participated in an Emmy Award winning local TV show (as filler), starred in a video for the Ohio proficiency test (rerun in hundreds of school libraries), opened three science museums (ask us about water soluble packing pellets), headliner (substitutes) for Dick Minnix & Rae Carpenter,Tik Liem & a birthday pony ride, did spontaneous presentations during the bus ride to NSTA and in the food line at the picnic at an AAPT Summer Meeting, reached 80% of the state’s science teachers in a single session (Vermont), operated successfully Operation Physics for three decades, made light of themselves using Chemlume squirt guns, entertained students during science fair judging, and created McScience, Science“R”Us, Hans & Frans Sports Science, Light Pirates, The Bungling Brothers Circus, Carnival Knowledge and Ari and Flo Bernoulli.

CF03 5:00-5:10 p.m. City of Physics – Showcasing Physics Across Dublin, Ireland

Contributed – Shane Bergin, University College Dublin, Schools of Education & Physics, Dublin, NA1 Ireland; berginsd@tcd.ie

Aoibhinn Ni Shuilleabhain, Benjamin Cowan, University College Dublin

‘City of Physics’ was an informal physics outreach program, held over four weeks in Dublin, Ireland. Through a range of interventions, including physics displays on sidewalks, buses and trains, the program aimed to raise awareness of physics outside the classroom. Coordinating the program involved the challenge of engaging physicists, physics students, City Council, science communicators and advertising agencies in this collaborative work, but led to the success of a creative, colourful physics campaign. To investigate its impact, 130 people were surveyed on their opinions of ‘City of Physics’. We found that people’s age (? = .26, p>.001) and attitudes towards physics more generally (? =.42, p>.001) were significant positive predictors to their perceived impact of the initiative. While there are limitations to our study, analysis demonstrates that such a large-scale initiative has the potential to impact people’s opinions of physics and encourage them to further engage with outreach events.

CF04 5:10-5:20 p.m. Physics as a Street Art

Contributed – Tatiana Erukhimova, Texas A&M University, Department of Physics and Astronomy, College Station, TX 77843-4242; etanya@tamu.edu

The Texas A&M Department of Physics and Astronomy developed a new outreach program with support of the Science Festival Alliance. Our dedicated faculty and students “meet people where they are,” by adding exciting physics experiences to existing events and venues where people are already gathered: football games, First Fridays in Downtown, Heritage Festivals etc. These efforts truly engage with audience members who may never attend a science event on their own accord. Examples of our hands-on demonstrations that are always a big hit with the public include “magic bubbles” (soap bubbles floating in aquarium with dry ice), angular momentum (aka figure skater), gyroscopes, optical illusions, animal balloons and racquetballs frozen in liquid nitrogen, bike wheel generator, vacuum lifter, inseparable phone books (fight the friction!), sports physics and many more. Participation in the program brings our students together and teaches them valuable communication and leadership skills.

CF05 5:20-5:30 p.m. The DOH Program: Physics-Learning and Social Aspects of Dinner Office Hours

Contributed – Ameya S. Kolarkar, Auburn University, 206 Allison Lab, Auburn, AL 36849; kolarkar@auburn.edu

In the fall of 2016, we started “dinner office hours” for undergraduate students taking introductory physics courses at Auburn University. In the past three semesters of DOH, participating students have proclaimed it to be the top learning resource for them among various available resources in an active learning setting. Besides the physics-learning aspect of DOH, the social aspect is also one that keeps students coming back as they engage and discuss physics -- and more -- with each other, the instructor and the always-present Learning Assistants. We shall present quantitative improvements in students’ performance in physics and change in their attitudes towards physics.

CF06 5:30-5:40 p.m. What Did You See Out Your Window this Morning?

Contributed – Richard Gelderman, Western Kentucky University, 1906 College Heights Blvd., Bowling Green, KY 42101-1077; gelderman@wku.edu

Make use of all that time your students spend staring out the window of their bus/van/car/truck while going to and from school, extracurricular events, or while parents run errands. Challenge them to note the construction crane and ask how it can lift large loads to great heights. Maybe you are in a rural district and the student was watching a harvester separate grain from stalk. Maybe a quiet suburb has a water main being repaired and the student wonders how much water passes through the pipe and what make it move. Regardless of your setting, these observations and questions are a critical aspect of the practices of science, and should be thoughtfully and purposefully explored from the earliest grade levels.

CF07 5:40-5:50 p.m. Combining Engineering Studies with Sports

Contributed – Magnus Karlsteen, Chalmers University of Technology, Origovägen 6b, Gothenburg, SE SE-41296 Sweden; magnus.karlsteen@chalmers.se

Jonas Enger, University of Gothenburg

Jonathan Weidow Chalmers, University of Technology

The National Sport University in Gothenburg is a joint venture between Chalmers University of Technology and University of Gothenburg. It is an initiative from the Swedish National Sport Federation with the aim to support elite athlete students to combine their elite sport activities with higher education for dual careers. This could be achieved via individual study plans with allowances made to include training and event schedules. A part of this activity is the Sports and technology cluster at Chalmers, a facility where athletes, coaches, business and sports federations meet researchers, engineers and students to initiate advanced sports related research. The goal of this initiative, incorporating several scientific branches, is to enhance athlete's performance and security across a range of sports, including sailing, swimming and equestrian. An important part of the business is also to create interesting projects that motivate all interested engineering students in their studies.

CF08 5:50-6:00 p.m. Cross Fertilization of Physics and Math Instruction

Contributed – Mikhail Kagan, Penn State Abington, 1600 Woodland Rd., Abington, PA 19001-3918 mak411@psu.edu

The importance and utility of mathematics in physics is hardly ever questioned, but how do we get students excited when learning math? We know that students are best motivated to learn when they believe they are doing something meaningful, not just performing a mechanical calculation. Traditionally, math textbooks use "scientifically flavored" problems to illustrate "how math can be applied in the real world." Much less common, however, is the use of ideas from physics to inform mathematical methods and problem solving techniques. In my talk, I will highlight a few such physical ideas that would be suitable in a math class ranging from middle school to undergraduate curriculum. Why don't we help our math colleagues and their students?

Session CG: Physics for Life Sciences: Advanced Courses

Location: Pacific Salon Three **Sponsor:** Committee on Physics in Undergraduate Education **Time:** 4:00-5:20 p.m. **Date:** Sunday, January 7
Presider: Juan Burciaga

CG01 4:00-4:30 p.m. Using Interdisciplinary Research-based Curriculum to Bridge Physical and Life Sciences

Invited – Rae Anderson, 5998 Alcala Park, San Diego, CA 92110; randerson@sandiego.edu

Physics research is becoming increasingly interdisciplinary while quantitative skills are becoming increasingly critical for success in any life science career. To address these growing realities we have developed a biophysics major that provides students with the knowledge and skills necessary for successful careers in health professions, biotech, and interdisciplinary research. Upper-division physics coursework for the major focuses on integration and synthesis of physics and life science concepts and approaches, and development of scientific research and communication skills essential to all STEM-related advanced degree programs and careers. I will focus on our unique writing-intensive project-based laboratory course that engages students in conducting interdisciplinary research, reading scientific literature and writing journal articles. I will also describe our seminar series that focuses on communicating science, and exposure to and interaction with current cutting-edge research topics, physics researchers, and the research institute.

CG02 4:30-5:00 p.m. The Physics in Medical Physics

Invited – Usha Sinha, San Diego State University, 13360 Grandvia Pt., San Diego, CA 92130-1028; usinha@mail.sdsu.edu

Mauro Tambasco, San Diego State University

This talk will focus on the "physics" behind medical physics including the physics of diagnostic imaging and radiation therapy. Diagnostic imaging is ubiquitous and is the mainstay of modern diagnostic methods. The physics underlying these medical devices encompass the interaction of radiation with matter and span the electromagnetic spectrum. The physics of x-ray projection radiography, Computed Tomography, Magnetic Resonance, Ultrasound, nuclear medicine will be introduced while also highlighting clinical applications. The physics of radiation therapy treatment for cancer also focuses on interaction of radiation with matter and the talk will focus on understanding the physics and practical clinical applications of advanced radiation therapy technologies, including stereotactic radiotherapy, intensity-modulated radiation therapy, image-guided radiation therapy, and proton therapy. The learning objective is to emphasize how physics is being used to solve diagnostic and therapeutic problems in medicine while opening new avenues to explore the biology of normal and disease conditions in humans.

CG03 5:00-5:10 p.m. QBio: An Integrative Educational Program of Physics and Biology at UCSD

Invited – Philbert Tsai, University of California, San Diego, 9500 Gilman Dr., La Jolla, CA 92093-0374; ptsai@physics.ucsd.edu

The Quantiative Biology Program (QBio) is an integrative program consisting of both theory and experimental lab courses drawing students from multiple departments science departments. We will survey the program structure, but focus on the unique laboratory aspect of the program. The newly designed QBio Hacker lab serves as both classroom and shared resource. Students enroll in a first-quarter "boot-camp" lab course. Through a combination of lectures and hands-on experimental modules, students work together in interdisciplinary pairs to achieve a basic proficiency in experimental skills ranging from 3D fabrication for instrumentation to computer-electronics-hardware interfacing to optical design for modern microscopy to fundamentals of microfluidics. The students then enroll in a second-quarter "project/rotation" quarter in which the students utilize their newly developed experimental skills and resources to design and tackle a pilot research project under the guidance of individual QBio faculty.

CG04 5:10-5:20 p.m. Teaching Diffusion Using a Beach Ball*

Contributed – James Vesenka, University of New England, Department of Chemistry and Physics, 11 Hills Beach Rd., Biddeford, ME 04005 jvesenka@une.edu

Bradley Moser, David Grimm, 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 different sized cells modeled by different sized beach balls. The activity additionally requires a pair of tennis balls/student, metersticks 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.

*Supported by: NSF DUE grants 0737458 and 1044154

Session CH: SPS Undergraduate Oral Talks

Location: Royal Palm Five/Six **Sponsor:** SPS **Time:** 4:00-4:40 p.m. **Date:** Sunday, January 7 **Presider:** Brad Conrad

CH01: 4:00-4:10 p.m. A Classical Analogy for Defects in Quantum Band Structure

Contributed – Tadan M. Cobb, Berry College, 2277 Martha Berry Highway, NW, Mount Berry, GA 30149-1424; tadan.cobb@vikings.berry.edu

Parker J. Roberts, Shawn A. Hilbert, Berry College

Scott V. Carr, Coastal Carolina University

Conductivity in a solid is determined by the size of the band gap in the band structure of the solid. As the gap decreases, it takes less energy for an electron to jump the gap and the solid has a higher conductivity and vice versa. When a solid is introduced to an impurity, or defect, the band structure is altered and a miniature band can form in the formerly forbidden band gap leading to an increased conductivity in said solid. The concepts of band structure defects can be difficult for many undergraduate students to grasp. We developed an experimental analogy using an array of coupled harmonic oscillators. Previous work with this system has demonstrated band structure. Here we will extend it to demonstrate the effects of defects on the resonance structure.

CH02 4:10-4:20 p.m. A Classical Analogy for Quantum Band Formation

Contributed – Parker J. Roberts, Berry College, 2277 Martha Berry Highway, Mount Berry, GA 30149; parker.roberts@vikings.berry.edu

Tadan Cobb, Shawn A. Hilbert, Berry College

Scott Carr, Coastal Carolina University

Electrons in an atom are confined to distinct energy levels. When two atoms interact with each other, their electrons' energy levels split into two closely spaced levels. If a large number of atoms interact, they produce many split energy levels. In this case, the energy levels become so closely spaced that they overlap and form continuous bands. This paper demonstrates that an array of masses and springs, a visual and well-understood system, can mimic quantum band structure. The array's resonant frequencies play the role of energy levels, so that a system of coupled oscillators yields a spectrum of resonant frequencies, with as many frequencies as there are masses. Adjusting parameters of the system controls characteristics of the spectrum's band structure. This analogy is explored theoretically and then experimentally demonstrated.

CH03 4:20-4:30 p.m. Baseline Data Collection for Analysis of Muons Flux During a Solar Eclipse

Contributed – Michelle Matten, Ida Crown Jewish Academy, 6721 n Francisco, Chicago, IL 60645; mashamatten@gmail.com*

Tamar Dallal, Ezra Schur, Jacob Miller, Allen Sears Ida, Crown Jewish Academy

While it is true that scientists have been detecting muons for decades, trying to detect a change in muon counts during a total solar eclipse is more challenging. How and where should one arrange the muon counters in order to maximize results? What special conditions need to be taken into account? In this presentation we will discuss the approaches used to collect data before and during the solar eclipse of August 2017, the reasoning behind these methods, and how the data were used in order to help determine whether the eclipse had any effect on muon flux.

*Sponsored by Allen Sears

CH04 4:30-4:40 p.m. Baseline Studies for Cosmic Ray Solar Eclipse Experiment

Contributed – Tamar Dallal, Ida Crown Jewish Academy. 8829 Monticello Ave., Skokie, IL 60076-2345; tamar.dallal@icja.org*

Clarissa Carr, Jacob Rosenberg, Glenbrook North High School

A cosmic ray experiment was proposed to measure muon flux changes during a total solar eclipse. Before the eclipse, baseline studies of empty sky, lunar transit, and solar transit needed to be collected. In accumulating these baseline data, various methods of collection were implemented. Specific results of these investigations and reasons for each in preparation for the solar eclipse will be explored.

*Sponsored by Allen Sears, Ida Crown Jewish Academy; Nathan A. Unterman, Emeritus, Glenbrook North High School

Session CHB: Student Assessment through Lab Practicum

Location: Royal Palm Five/Six **Sponsor:** Committee on Physics in High Schools **Time:** 5:00-6:00 p.m. **Date:** Sunday, January 7
Presider: Katie Page

CHB01 5:00-5:30 p.m. Testing with Lab Summatives

Invited – Stephanie Hawkins, Barrington High School, 201 Lakewood Dr., Oakwood Hills, IL 60013-1123; scmarry11@yahoo.com

Shannon Feineis, Barrington High School

In light of aligning our curriculum to the NGSS standards, the physics teachers at Barrington High School decided to add one period lab summative assessments to our end of unit assessments. The students are given a situation where they must decide which equipment they will use, write a procedure explaining how they will collect data and perform the lab, create a model (graph, force diagram, electron flow chart, ect) and analyze their data. We will share sample lab summative assessments and share challenges we faced during our first year of implementing each assessment. Now that the kinks have been smoothed out, these lab summative assessments are successful and have a significant positive impact on student investment during learning labs and activities.

CHB02 5:30-5:40 p.m. Assessing Science Practice for the NGSS Through Laboratory-Based Exams

Contributed – James Christopher Moore, University of Nebraska Omaha, 510 Primrose Ct., Myrtle Beach, SC 29579-1734; jchristophm@gmail.com

Until recently, research into the assessment of physics learning has focused on content knowledge. However, within the actual practice of science, the dimensions of content knowledge, science practice, and reasoning are linked. The Next Generation Science Standards (NGSS) explicitly recognizes this link, where students demonstrate understanding of a topic by showing they can practice science within that domain. This shift in science standards prompts the following question: how do you assess practices? Unfortunately, there is no simple multiple-choice test we can deploy to measure practice abilities. Instead, I will describe how you can assess your students' growth as science practitioners by incorporating experiments into summative assessments. Specifically, I will describe two science practicums, one on magnets and the other on periodic motion, and discuss what indicators to look for in student work. I will show examples of assessment rubrics tied to the NGSS and applied to actual student responses.

CHB03 5:40-5:50 p.m. Data Matters: We Insist on Successful Results

Contributed – John Ball, Emma Willard School, 285 Pawling Ave., Troy, NY 12180; jball@emmawillard.org

The major reason we require that all 9th grade students take physics is to learn the importance of lab to understanding science. Since accurate results best illuminate major laws, we evaluate students during lab practicums on the quality of their results. As a consequence, we have found that students "sweat the details" more in lab, repeat labs on their own time to gain confidence, and talk more to us and each other about the quality of their work. Our focus on

results has increased interest in science as measured by (among other things) larger enrollments and AP science scores. Of special interest may be the fact that we are an all-girls school.

CHB04 5:50-6:00 p.m. Understanding Optical Concepts through Various Optical Phenomena in Convex Lenses

Contributed – Ji Seon Cha, Physics education/Graduate school of Korea National University of Education, 101-1611, 31, Osongsaengmyeong 3-ro, Osong-eup, Heungdeok-gu, Chungcheongbuk-do, Cheongju-si, 28160; jjangu1219@gmail.com*

Sang Min Jeong, Physics education/Korea National University of Education

Jung Bog Kim, Physics education professor/Graduate school of Korea National University of Education

In the school, we try to find the position of the image according to the position of the object to learn the path of the light through the convex lens. However, in this experiment, two images of the object seen through the lens occur. This phenomenon represents a slightly different result than what we know well, so there is a gap between theory and actual phenomena.Therefore, this study aims to investigate the optical concepts that students can learn in the course of explaining the causes of these phenomena.*Sponsored by Jung Bog Kim

Session CI: 30 Demos in 60 Minutes

Location: California Room **Sponsors:** Committee on Physics in High Schools, Committee on Teacher Preparation
Time: 4:00-5:00 p.m. **Date:** Sunday, January 7 **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 CJ: K-12 PER

Location: California Room **Sponsors:** Committee on Physics in High Schools, Committee on Research in Physics Education
Time: 5:00-6:00 p.m. **Date:** Sunday, January 7 **Presider:** Dan Crowe

CJ01 5:00-5:30 p.m. Exploring the Role of Content Knowledge in Responsive Teaching

Invited – Lisa Goodhew, University of Washington, 3910 15th Ave NE, Seattle, WA 98195; goodhewl@uw.edu

Amy D. Robertson, Seattle Pacific University

Responsive teaching is an instructional approach that (1) foregrounds the substance of students' ideas, (2) recognizes disciplinary connections within students' ideas, and (3) takes up and pursues the substance of students' ideas. In responsive classrooms, the curriculum emerges (at least in part) from these ideas and from students' generative engagement and questions. We use in situ data from three K-12 classrooms—one elementary, one middle school, and one high school—to draw out and speak to the role of content knowledge in responsive teaching. We show that one role that content knowledge plays in responsive teaching is to support teachers in eliciting, seeing, and then pursuing disciplinary connections within their students' thinking.

CJ02 5:30-6:00 p.m. High School Students' Representations and Understandings of Electric Fields

Invited – Ying Cao Oregon State University, 6300 Sw Grand Oaks Dr. Apt. E302, Corvallis, OR 97333; caoyin@oregonstate.edu

Barbara Brizuela Tufts University

This study investigates the representations and understandings of electric fields expressed by Chinese high school students 15 to 16 years old who have not received high school level physics instruction. Physics education research has reported students' conceptions of electric fields post-instruction as indicated by students' performance on textbook-style questions. It has, however, inadequately captured student ideas expressed in other situations informative to educational research. In this study, we explore students' ideas of electric fields pre-instruction shown by students' representations produced in open-ended activities. 92 participant students completed a worksheet drawing comic strips about electric charges as characters of a cartoon series. Three students who spontaneously produced arrow diagrams were interviewed individually after class. As most research has understood students as having fixed conceptions divergent from canonical targets, this study shows students' reasoning to be variable in moments, and that variability includes common-sense resources that can be productive for learning.

Session TOP01: Graduate Student Topical Discussion

Location: Pacific Salon One **Sponsors:** Committee on Research in Physics Education, Committee on Graduate Education in Physics
Time: 6:00-7:30 p.m. **Date:** Sunday, January 7 **Presider:** Eric Williams

This session is the primary opportunity for student members of the PER community to meet and discuss common issues. While this session is aimed toward graduate students, we welcome undergraduates who are interested in studying PER or curious about life as a graduate student!

Session TOP02: Celestial Navigation in the Pacific: Polynesian Insights into Old Traditions

Location: San Diego Room **Sponsor:** Committee on Space Science and Astronomy **Time:** 6:00-7:30 p.m. **Date:** Sunday, January 7
Presider: Stephanie Slater

Forty years ago, in one manifestation of the Hawaiian Renaissance, wayfinders demonstrated that ancient Hawaiians were capable of traversing the wide Pacific to settle and trade on islands separated by thousands of miles without modern navigational instrumentation, making Hawaiian voyaging a living, evolving, sustainable endeavor. Na Ohana Hoku, the Hawaiian Star Families constitute the basic units of the Hawaiian sky. In contrast to the Western system of 88 constellations, Na Ohana Hoku divides the sky into four sections that each run from the northern to the southern poles. This configuration reduces cognitive load, allowing the navigator to preserve working memory for other complex tasks. In addition, these configurations of stars support the navigator in finding and generatively using hundreds of individual, and navigationally important pairs of stars. The Hawaiian Star Compass divides the celestial sphere into a directional system that uses 32 rather than eight cardinal points. Within the tropics, the rising and setting of celestial objects are consistent within the Hawaiian Star Compass, providing for extremely reliable direction finding. Together, Na Ohana Hoku and the Hawaiian Star Compass provide the tropical navigator with astronomical assistance that is not available to, and would have been unknown to Western navigators trained at higher latitudes.

Special Session: JD Jackson Award awarded to Mehran Kardar

Location: Golden Ballroom **Time:** 7:30–8:30 p.m. **Date:** Sunday, January 7
Presider: Janelle M. Bailey

Mehran Kardar

Force from Non-equilibrium Fluctuations in QED and Active Matter

by Mehran Kardar, Massachusetts Institute of Technology

The pressure of a gas, the van der Waals attraction between molecules, and the Casimir force in quantum electrodynamic (QED) are classical examples of forces resulting from equilibrium (thermal or quantum) fluctuations. Current research on “Active Matter” studies the collective behaviors of large groups of self-driven entities (living or artificial), whose random motions superficially resemble thermally fluctuating particles. However, the absence of time reversal symmetry leads to unusual phenomena such as directed (ratchet) forces, and a pressure that depends on the shape and structure of the confining wall. I discuss if long-range forces are generated due to conservation laws in such non-equilibrium particulate matter.

Some manifestations of QED fluctuations out of thermal equilibrium are well-known, as in the Stefan-Boltzmann laws of radiation pressure and heat transfer. These laws, however, acquire non-trivial twists in the near-field regime of sub-micron separations, and in the proximity of moving surfaces. I will discuss surprising consequences for heat transfer, and for dissipation in vacuum.

Session PST1 Poster Session

Location: San Diego Room **Time:** 8:00-9:30 a.m. **Date:** Monday, January 8

Persons with odd-numbered posters will present their posters from 8 to 8:45 a.m.; those with even-numbered posters will present from 8:45 to 9:30 a.m. Posters will be available until 3 p.m.

Labs/Apparatus

PST1A01 8:00-8:45 a.m. Quadcopter Yaw Control: Conservation of Angular Momentum or Atmospheric Drag?

Poster – Kirk M. Williams, California State University, Chico, Physics Department, Campus Box 202, Chico, CA 95929-0202; kwilliams10@mail.csuchico.edu*

Tori A. Goff, Eric J. Ayars, California State University, Chico

Quadcopters (AKA "drones") do not fly in vacuum. This is obvious enough that experimenting on one in a vacuum chamber would seem rather uninteresting, but there is one question that may be usefully addressed by such an experiment: the mechanism for yaw control. Quadcopters control yaw (rotation about the vertical axis) by differential rotor speed, and the question of whether those changes in rotor speed create yaw torque via conservation of angular momentum or via atmospheric drag can be addressed by "flying" a quadcopter in a vacuum where there is effectively zero atmospheric drag.

*Sponsored by Eric Ayars

PST1A02 8:45-9:30 a.m. Science in the Shadow

Poster – Irene Guerinot, Maryville College, 502 E. Lamar Alexander Pkwy., Maryville, TN 37804; irene.guerinot@maryvillecollege.edu

Planetary events provide a rich opportunity to engage students in science. The 2017 (total) solar eclipse lends itself to studies of lunar and solar science as well as celestial mechanics and Sun-Earth-Moon dynamics. I will be presenting undergraduate student designed experiments that will have a basis on the amazing experience the students had on August 21, 2017. These experiments will keep the momentum generated during the eclipse and will be constantly improved and redesigned for the 2024 total solar eclipse experience.

PST1A03 8:00-8:45 a.m. Step Away from the Arduino!

Poster – Eric Ayars, California State University, Chico, Campus Box 202, Physics, Chico, CA 95929-0202; eayars@csuchico.edu

The Arduino development board has revolutionized the use of microcontrollers in the laboratory, the classroom, and the maker community in general. Arduino has been around for a dozen years, and for many applications there are now much better options. Some options are upgrades from the Arduino and offer improved speed, better performance, or hardware advantages such as D/A outputs or higher-resolution A/D converters. Others are still-capable downgrades that allow useful capability at much-lower cost. Alternately there are some devices that offer completely different architectures and development environments with potentially powerful applications for physics teaching and lab use.

PST1A04 8:45-9:30 a.m. Using Arduinos to Collect Data

Poster – Marc 'Zeke' Kossover, Exploratorium, 17 Pier Ste 100, San Francisco, CA 94111; zeke_kossover@yahoo.com

Through shop instruction, the Exploratorium's Teacher Institute has been helping teachers make their own classroom equipment for decades. Two years ago we ventured into adding Arduinos to the mix. We learned that teachers learn best and are most likely to implement the tools in their classroom if they see novel experiments that can be better done with Arduinos, have some well-defined initial examples to copy, spend time learning the programming skills themselves, and get lots of feedback from more experienced instructors. See and play with some of the designs that we have developed.

PST1A05 8:00-8:45 a.m. 4-F Fourier Optics System Using Two Spatial Light Modulators

Poster – Romulo Ochoa, The College of New Jersey 2000 Pennington Rd, Department of Physics, Ewing, NJ 08628; OCHOA@TCNJ.EDU

Jaylond Cotten-Martin, Corrado Ballaera, Chris Sweet, The College of New Jersey

We present a 4-F Fourier optical system with two spatial light modulators (SLM). It allows for an efficient and improved method of observing the effects of optical filtering. We refined a technique that we previously developed to apply filtering to various types of images. The original 4-F system involved only one spatial light modulator, but was later enhanced to contain two in order to improve the quality of our results and produce them with greater ease. The experimental data gathered from our modified 4-F system is compared to both the computer modeling results, obtained using MATLAB and Mathematica, and the experimental data gathered from our one SLM setup. We were successful in improving our system and technique in order to consistently obtain high quality results.The system also allows for demonstrations of basic image recognition.

PST1A06 8:45-9:30 a.m. A Cylindrical Grating Spectrograph

Poster – Mark F. Masters, Purdue University Fort Wayne, Department of Physics, Fort Wayne, IN 46805; masters@ipfw.edu

Jacob Millspaw, Purdue University Fort Wayne

We present our work on a small, low-cost cylindrical grating spectrograph. The grating itself is made from a CD or DVD fragment. The grating is held in a 3d printed housing. The linear array detector is controlled by a PSoC mixed signal processor that provides timing signals to read out the array and control exposure. It collects the signal in either analog or digital form (depending on which array is used) and then sends this data through the USB port to a Raspberry Pi or another computer. A Python program provides the interface to control the detector.

PST1A07 8:00-8:45 a.m. A Demonstration of Constructive Interference Using an Ultrasonic Rangefinder

Poster – Jose L Baranda, California State University, Chico, Physics Department, Campus Box 202, Chico, CA 95929-0202; jbaranda1@mail.csuchico.edu*

Eric J. Ayars ,California State University, Chico

When a spring is uniformly stretched in the beam of an ultrasonic rangefinder, there are lengths of spring stretch for which the spring coil spacing is an integer half-wavelength of the rangefinder's ultrasonic carrier wavelength. Reflections from successive coils then add constructively, creating erroneous distance measurement which can be used to determine the wavelength of the ultrasonic signal.

*Sponsored by Eric Ayars

PST1A08 8:45-9:30 a.m. Synthetic Aperture Imaging Using Shallow Water Waves with Cylindrical Targets

Poster – Sarah Kwon, United States Naval Academy, Physics Dept. 572 C Holloway Rd., Chauvenet Hall 040 Annapolis, MD 21402; korman@usna.edu

Murray Korman, United States Naval Academy

The fundamental principles of a stripmap synthetic aperture radar SAR or synthetic aperture sonar SAS 2-dimensional imaging experiment can be demonstrated using a shallow water ripple tank as the wave medium along with several short cylindrical rods (or disks) as targets -- just protruding above the surface. At N discrete evenly spaced locations along a straight track, a single point-like spherical pulse is generated by a typical ripple tank pod dipping into the water and returning -- just once. Target echoes are received (near the source) by a linear capacitance-to-voltage needle-like probe [McGoldrick, Rev. Sci. Inst. Vol. 42, 359 (1971)]. Using a time correlation backprojection algorithm the echoes vs. time at N locations are used to predict an image of the targets – called the two-dimensional reflectance, f(x,y) [Ulander, Hellsten and Stenson, IEEE Trans. Aero. Elec. Sys. Vol. 39, No. 3, 760 (2003)].

PST1A09 8:00-8:45 a.m. Classroom Activities Using a Local Positioning System

Poster – Cora Siebert, Portland State University, 1719 SW 10th Ave., Room 134, Portland, OR 97201; cora@pdx.edu*

Thomas Allen, Gabriel Mukobi, Ralf Widenhorn, Portland State University

The use of commercially available local positioning devices and their applications in the physics classroom will be presented. Using these positioning devices, students have a hands-on way of engaging with the relationships between position, velocity, and acceleration in 1-dimensional, 3-dimensional, and rotational systems. Students will be able to connect these concepts with their graphical and mathematical representations by completing various kinesthetic activities that include walking, running, jumping, spinning, and tossing objects.

*Sponsored by Ralf Widenhorn

PST1A10 8:45-9:30 a.m. Earth's Magnetic Field, Cosmic Rays and the 2017 Solar Eclipse

Poster – Martin Shaffer, Cowley College, 125 S 2nd St., Arkansas City, KS 67005; martin.shaffer@cowley.edu

Zachary Mavis, Alexandra Randell, Cowley College

Measurements of the Earth's magnetic field from Spaceweather.com and cosmic ray muon flux rates collected with a Quarknet detector over several weeks suggest an inverse relationship. This proposed relationship was tested during the August 21, 2017 solar eclipse using data collected by the Quarknet's Solar Eclipse Muon Flux Experiment at a variety of locations.

PST1A11 8:00-8:45 a.m. Electromagnetic Levitation as a Demonstration and Lab Project

Poster – Eli T. Owens, Presbyterian College, 503 S. Broad St., Clinton, SC 29325; etowens@presby.edu

Electromagnetic levitation of small objects provides an ideal medium to illustrate several important physics principles related to electricity, magnetism, and circuits. Additionally, it provides a visually striking demonstration. As a demonstration, electromagnetic levitation is suitable for illustrating a range of topics including Earnshaw's theorem, force balance, electromagnets, circuits, feedback, and Newton's laws for rotation. Electromagnetic levitation also makes a suitable advanced lab or circuits project for undergraduate students. The setup I will be presenting consists of an electromagnet below which a small iron object is suspended. The position of the object is kept stable via a feedback loop consisting of an LED and photodiode pair that monitors the position of the iron object and then adjusts the current through the electromagnet accordingly. A synchronous detection system further provides a high degree of noise immunity, promoting advanced lab skills when used as a student project.

PST1A12 8:45-9:30 a.m. Introductory Experiments in Sound-Source Localization

Poster – Stephen Eric Hill, University of Redlands, 1200 E. Colton Ave., Redlands, CA 92373-0999; eric_hill@redlands.edu

Sound Localization connects physics to biological systems and everyday experience, as well as the simulation of everyday experience in video games and musical recordings, while it also synthesizes and reinforces basic waves principles – phase, wave speed, diffraction, reflection, and spectrum. This poster presents a sequence of introductory-level experiments students can perform using the free sound processing program, Audacity, to explore the fundamental wave physics responsible for sound localization cues: Interaural Time Difference (delays in sound's arrival at one ear vs. the other), Interaural Level Difference (variations in sound intensity at one ear vs. the other), and the effect of Anatomical Transfer (differences in a sound's spectrum due to reflection from and diffraction around the head and upper torso).

Astronomy

PST1B01 8:00-8:45 a.m. New Resources from AAPT/Temple NASA Heliophysics Education Consortium

Poster – Ramon Lopez, University of Texas at Arlington, 701 South Nedderman Dr., Arlington, TX 76019; cosmicrel@gmail.com

Bradley S. Ambrose, Grand Valley State University

Janelle M. Bailey, Temple University

Ximena C. Cid, Cal. State Dominguez Hills

Rebecca Vieyra, American Association of Physics Teachers

Shannon D. Willoughby, Montana State, Bozeman

Learn about new research-based astrophysics teaching resources produced by the AAPT/Temple University team. These resources include a collection of hands-on activities, lecture tutorials, concept tests, and diagnostic tools that strategically fill in gaps in existing astrophysics content. This team is funded by the NASA Heliophysics Education Consortium, and in early 2017 produced a collection of resources about eclipse science for the Great American Eclipse: http://aapt.org/resources/eclipse2017.

PST1B02 8:45-9:30 a.m. The Eclipse on Campus and Along the Path of Totality

Poster – Bob Powell, University of West Georgia, 1600 Maple St., Carrollton, GA 30118; bpowell@westga.edu

Ben Jenkins, Ben Team, University of West Georgia

Faculty, staff, and students of the University of West Georgia studied the solar eclipse on August 21, 2017 at two locations. The West Georgia Observatory (95% coverage) was one site, primarily for outreach. Jenkins and observatory assistants hosted over 5000 people who came to campus during the eclipse to look through telescopes equipped with safe solar filters; 3200 pairs of solar eclipse shades were distributed during the eclipse. The second location was 500 meters from the centerline of the path of totality near Lexington, SC. Powell and Team led a group of 20 people to study the eclipse. Both groups photographed the eclipse; studied photosensitive plants; measured air temperature, atmospheric pressure, and brightness of the Sun; and studied the Sun with a small radio telescope. Some of the photosensitive plants began to close as totality approached. A small decrease in radio emissions from the Sun was detected.

PST1B03 8:00-8:45 a.m. A Short Course in Astrophysics

Poster – John E. Popp, Moraine Valley CC, retired, 4080 Hancock St Apt 2810, San Diego, CA 92110; johnepopp44@att.net

Our knowledge about the universe, like the universe itself, is expanding an an accelerating rate, and yet the answers that an Astrophysicist might give to some deceptively simple questions are more inegmatic than ever. This very brief article is meant for possible use by teachers in introductory HS or college physics or astronomy courses. It is meant to be both amusing, somewhat controversial, and to refer to ideas that may or may not be expressed by some astrophysicists. It could provoke a lengthier discussion of how these ideas might be justified by experts or students.

PST1B04 8:45-9:30 a.m. Citizen CATE: Bridging the Citizen-Science Divide

Poster – Margaret P. Hill, Southeast Missouri State University, Dept. of Physics & Engineering Physics, 1 University Plaza, MS6600, Cape Girardeau, MO 63701; phill@semo.edu

The Great American Eclipse brought together professional astronomers, university faculty, K-12 science teachers, students, and community members to share in scientific discovery. Students and faculty at Southeast Missouri State University fielded Citizen CATE Team-040, one of the 68 sites across the United States that collected data on the time evolution of the solar corona. As part of this project we performed public outreach to help our community understand this rare astronomical event. This poster presents the impact that being involved in this cutting-edge citizen science activity has had on undergraduate research, outreach to local community groups and schools, and citizen interest in science.

PST1B06 8:45-9:30 a.m. College Students' Understanding of Eclipses*

Poster – Janelle M. Bailey, Temple University, 1301 Cecil B Moore Ave., Philadelphia, PA 19122; janelle.bailey@temple.edu

Timothy G. Klavon, Temple University

Shannon D. Willoughby, Montana State University

A recent total solar eclipse visible in the U.S. prompted an exploratory study into college students' understanding of eclipses. Students in an introductory astronomy course (n = 151) and a physical science course for preservice teachers (n = 25) were asked to complete one of two parallel open-ended surveys, including questions about the view of a total eclipse (solar or lunar) from three locations, the time the eclipse would be visible, and the cause of the eclipse. Three researchers created and used a rubric to score each question. Frequency of scores shows that students have incomplete understandings or alternative conceptions. Some students scored high on explaining their eclipse but could not predict the approximate time of day or night that it would be visible. Results suggest that students may not have coherent ideas about eclipses, and that more robust instruction including construction of Sun-Earth-Moon system models may be needed.

*This work is supported in part by NASA grant number NNX16AR36A.

Other Posters

PST1C01 8:00-8:45 a.m. Normalization of Cosmic Ray Data for High School QuarkNet Experiments

Poster – Allen J. Sears, Ida Crown Jewish Academy, 8233 Central Park Ave., Skokie, IL 60076-2908; searsphysics@gmail.com

Nathan A Unterman, Emeritus, Glenbrook North High School

Anthony Valsamis, Glenbrook North High School

A large collaboration of data collection was conducted during the August 21st 2017 solar eclipse investigating cosmic ray flux using QuarkNet muon counters. Some of the muon counters had varying levels of count efficiency due to environmental and equipment conditions. Normalization of data on these counters was necessary to combine their readings with other counters to look for a signal. The methods of data normalization and pedagogical strategies are presented by a group of high school teachers.

PST1C02 8:45-9:30 a.m. Total Solar Eclipse at Charleston, SC

Poster – Joel C. Berlinghieri, The Citadel, 171 Moultrie St., Charleston, SC 29409; berlinghieri@citadel.edu

Jim Near, The Citadel

On August 21st at 2:47 p.m. EDT the North American Total Solar Eclipse passed over the Charleston, SC area. The Citadel Physics Department sponsored two events during the eclipse. The student body (The Corps of Cadets), faculty, staff, and guests were supplied with protective glasses and guidance for the proper and safe viewing and photographing of this event. Special guests included the national office of Sigma Xi, local college and industry officials. This viewing was proceeded by a seminar explaining the reasons why total solar eclipses are so rare at any particular location, the properties of the Sun and what measurements or observations might be of interest during a total eclipse, and the safe viewing and photographing of the Sun during partiality and totality. Two physics student teams used portable weather stations and high altitude balloons to measure meteorological properties of the atmosphere and rates of cosmic radiation before and during the eclipse. A 360 degree camera was also placed aboard one of the launched balloons.

PST1C03 8:00-8:45 a.m. A New Kind of Photography to Connect Art With Physics

Poster – John E. Beaver, University of Wisconsin – Fox Valley, 1478 Midway Rd., Menasha, WI 54952; john.beaver@uwc.edu

We describe a unique photographic process that is both inexpensive and accessible to students, but allows for artistic control in ways that ordinary digital and film-based photography does not. Furthermore, its use highlights in an active way many important physical principles that underly photography. And we argue that it can provide a useful bridge to students who are more comfortable with art than science. What we call Ephemeral Process photography uses ordinary photographic gelatin silver paper in a printing-out mode, with no chemical developer or fixer, but with a simple non-hazardous chemical accelerator applied by hand. No darkroom is needed, and the paper responds directly and visibly to exposure to light. The sensitivity is much less than that of ordinary photographic detectors, but still fast enough for in-camera photography. We describe the process, its basic chemistry, and relate several interesting uses in the classroom.

PST1C04 8:45-9:30 a.m. Community College STEM Honors Program: Increasing Diversity, Developing STEM Leaders

Poster – Barbra M. Sobhani, Red Rocks Community College, 13300 W. Sixth Ave., Lakewood, CO 80228; barbra.sobhani@rrcc.edu

To support diverse students in STEM, we developed a comprehensive STEM Honors Program. The mission is to provide exceptional learning opportunities through interdisciplinary education and problem-solving experiences for a community of scholars in order to prepare them to be leaders in a global community. Each student cohort will tackle a wicked problem theme integrating classes, field trips and capstone projects. Students participate in service learning, internships, and travel opportunities; providing a competitive edge in careers and transfer. Program learning outcomes include intellectual inquiry, research skill, interdisciplinary problem solving, leadership, civic and global learning. We have involved our four year partners in the development of the program in order to facilitate honor to honors transfer. Honors faculty recruited across disciplines are immersed in the wicked problem and incorporate the theme into their courses. The Honors student/faculty cohort advising and mentoring will promote identity as a scholar and increase persistence and retention.

PST1C06 8:45-9:30 a.m. Examining Physics Education in Taiwan

Poster – Hui-Yiing Chang, University of South Carolina Sumter, 900 Tristan St., Sumter, SC 29154-7408; changhui@uscsumter.edu*

Clausell Mathis, Florida State University

Taiwan is one of the top performing countries at the annual International Physics Olympiad for high school students. Interviews were conducted with three professors from the premier science education university in Taiwan, and school authorities, teachers and students from the top boys' school and the top girls' school in the country. Classroom observations of these two schools were also done. The interviews and observations are compiled and analyzed to investigate factors that may have contributed to the success of the Taiwanese. This is done with the intention of providing ideas for improving physics education in the United States.

*Sponsored by Clausell Mathis

PST1C07 8:00-8:45 a.m. Fostering Student Abilities to Synthesize Information in Scientific Inquiry*

Poster – Kathleen M. Koenig, University of Cincinnati, 2600 Clifton Ave., Cincinnati, OH 45221; kathy.koenig@uc.edu

Janet Zydney, Casey Hord, University of Cincinnati

Lei Bao, The Ohio State University

A windmill engineering design project, implemented in an 8th grade classroom, was designed to lead students through activities focused on the cyclic process of scientific inquiry. Experiments built upon one another and results of initial experiments were to inform the design of subsequent experiments; enabling students practice in the scientific thinking and decision making promoted in 21st Century Learning. Preliminary research, however, found that most students treated the inquiry explorations as fragmented steps and struggled in synthesizing information to guide necessary decisions in the experimental process. Students often resorted to "trial and error," with narrow vision for addressing only those questions on the page rather than stepping back and focusing on the larger task. This presentation will include what was learned about student habits as well as their deficiencies in scientific thinking, and how the curriculum was redesigned to better support student learning and performance.

*Supported by NSF DRK-12 Grant #1417983.

PST1C08 8:45-9:30 a.m. A Novel Approach for Teaching Electromagnetism Concepts Using Coding Activities in Algebra-based Physics*

Poster – Chris Orban, 191 W Woodruff Ave., Columbus, OH 43210; orban@physics.osu.edu

Richelle Teeling-Smith, University of Mount Union

Chris Porter, Ohio State University

Building off of a set of carefully designed classical mechanics programming exercises that were constructed for introductory algebra-based physics classes, we present a series of electromagnetism programming exercises in a browser-based framework called p5.js. Importantly, this framework can be used to highlight the physics aspects of an interactive simulation code while obscuring other details. We describe efforts to probe the impact of these coding activities on student conceptual learning using a series of animated questions that we developed with inspiration from the Brief Electricity and Magnetism Assessment. These activities and assessments are used in freshman physics classes at OSU's Marion campus and in a number of high school physics classes in Ohio. *Funding from the STEMcoding project (u.osu.edu/stemcoding) and the AIP Meggers Award

Physics Education Research

PST1D01 8:00-8:45 a.m. Student Perceptions of a Computer-based Role Playing Game

Poster – Eric S. Mandell, Bowling Green State University, 3206 Penrose Ave., Toledo, OH 43614-5338; meric@bgsu.edu

Michael A. Greene, Bowling Green State University

Looking to adapt to harness the advantages of Exploratory Learning (EL), Game-Based Learning (GBL) and Story-Based Learning (StoBL), and hoping to improve student engagement outside of class, we are developing a computer-based Role-Playing Game (RPG), where students encounter aspects of the College Physics curriculum as they play. In this work, we discuss early results in measuring student attitudes towards the first chapter of game content, and towards GBL in the College Physics class. Information gathered from these early surveys explore the level of student engagement and will allow us to tweak aspects of the game before the project is completed. Knowledge of potential trouble points for students can also help inform the choice of in-class activities that will help students proceed in the RPG, further integrating the story into the course.

PST1D02 8:45-9:30 a.m. Exploring Engineering Course Enrollment Trends in High School

Poster – Marie C. Pink, San Jose State, 1 Washington Square, San Jose, CA 95192; mariecpink@yahoo.com

Cassandra A. Paul, San Jose State

Engineering practices are an important element of the Next Generation Science Standards implementation. Recently, more high schools have begun offering engineering courses. Yet, despite expanding offerings and rising enrollment, few females enroll. For example, at one high school in Silicon Valley, males outnumbered females by a ratio greater than 5:1 in the 2016-17 academic year. To better understand the influence of prior coursework and student demographics on program enrollment, specific enrollment trends are evaluated in a single high school district and the five partner elementary districts to identify factors influencing student enrollment in high school engineering courses.

PST1D03 8:00-8:45 a.m. Gender Fairness in the Force and Motion Conceptual Evaluation

Poster – Rachel Henderson, West Virginia University, 135 Willey St., Morgantown, WV 26505; rjhenderson@mix.wvu.edu

John Stewart, Paul Miller, West Virginia University

Adrienne Traxler, Wright State University

Rebecca Lindell, Tiliadal STEM Education

Gender gaps on the various physics concept inventories have been extensively studied. It has been shown that on average, men score 12% higher than women on mechanics concept inventories and 8.5% higher than women on electricity and magnetism concept inventories. Classical Test Theory and Differential Item Functioning has been used to show that multiple items of the FCI are unfair to women. In the current study, Classical Test Theory (CTT) and Differential Item Functioning (DIF) analysis will be used to explore gender biases in the Force and Motion Conceptual Evaluation (FMCE). The difficulty and the discrimination of the 43 items will be examined and gender fairness will be explored in two different instructional environments.

PST1D05 8:00-8:45 a.m. Hands-on & Minds-on Particle Physics in S'Cool LAB at CERN

Poster – Julia Woithe, CERN, Geneve 23, Geneva, Geneva 1211; Julia.woithe@cern.ch

Alex Brown, Alexandra Feistmantl, Oliver Keller, Sascha Schmeling, CERN

S'Cool LAB is a new Physics Education Research facility at CERN, the world's largest particle physics laboratory in Geneva, Switzerland. High-school students and their teachers are invited to contribute to research projects by taking part in hands-on & minds-on particle physics experiments on-site at CERN. Participating in S'Cool LAB research enables teachers to give their students a glimpse of life and work in a world-leading international research institute. By getting hands-on with physics in S'Cool LAB, students can make discoveries independently, learn to work scientifically, and apply their knowledge in a new setting. In 2017, almost 7000 high-school students and their teachers from more than 30 different countries took part in hands-on workshops in S'Cool LAB. In this contribution, we will present S'Cool LAB, the concept of our learning activities, and selected research results on the impact of visits to S'Cool LAB. S'Cool LAB Website: cern.ch/s-cool-lab

PST1D06 8:45-9:30 a.m. Effects of Summer Camp on Participants' Affective Views of Science

Poster – Iliana E. De La Cruz, St. Mary's University, 935 Cottonwood Ave., San Antonio, TX 78225-1918; idelacruz1@mail.stmarytx.edu

Micha Kilburn, University of Notre Dame

There exists a movement to draw more diverse groups of students to science, technology, engineering, and math (STEM) careers. There is limited research on the effect of informal education on K-12 students' views of science, but recent data suggests children decide on STEM as early as grade school. This research quantitatively examines the effect of a STEAM summer camp had on its participants' affective views of science. Using pre-post surveys, the participants were asked to rate their interest in science, list career aspirations, and associate words they thought describe science or art. Researchers analyzed four years of these programmatic surveys for correlations between words associated with science, and age or gender. This summer, researchers also interviewed camp participants to better understand the reasoning behind word associations and to evaluate the survey instrument. Preliminary analysis suggests camp affects participant word associations, and interviews highlighted points of confusion in participant survey understanding.

PST1D07 8:00-8:45 a.m. Examining Laboratory Notebook Practices in the Introductory Lab

Poster – Michael T. Zwartz, Department of Physics, Lewis University, 1 University Pkwy., Romeoville, IL 60446; michaelzwartz@lewisu.edu

Joseph F. Kozminski, Lewis University

Laboratory notebooks are significant records of research to show what a researcher did, how they did it, and what data were collected from the experiment. The AAPT Laboratory Recommendations emphasize the importance of helping students develop good laboratory notebook practices throughout the undergraduate curriculum. This study tracks students' progression in developing the necessary notebook practices for success in the laboratory. This research was conducted through a series of student surveys given in undergraduate physics classes. A pre-survey and a post-survey were given covering topics of how students use lab notebooks and how they learned those practices. This study allows us to see the changes in laboratory notebook beliefs and practices of students through two semesters of introductory lab work. The research is beginning to uncover what methods of training are most beneficial to students' beliefs and practices when using a laboratory notebook.

PST1D08 8:45-9:30 a.m. Identifying Students' Productive Conceptual Resources for Wave Superposition

Poster – Lisa Goodhew, University of Washington, 3910 15th Ave. NE, Seattle, WA 98195; goodhewl@uw.edu

Amy D. Robertson, Rachel E. Scherr, Seattle Pacific University

Paula R. L. Heron, University of Washington

In a resources theory of knowledge, students' intuitive ideas are viewed as potentially productive and as a basis for instruction. Instruction grounded in a resources theory of knowledge has the potential to promote learner agency, support students from diverse backgrounds, and enhance conceptual understanding. We present a preliminary resource-based analysis of students' written responses to conceptual questions about mechanical waves – one that focuses on the common, productive ideas that students use to reason about mechanical waves, with an eye toward how they can inform instruction. We discuss what students' common, productive ideas are, how they are productive, and in what ways they might be taken up in instruction.

PST1D09 8:00-8:45 a.m. Implantation and Assessment of High Impact Practices in Calculus-based Introductory Physics*

Poster Pei-Chun Ho, California State University, Fresno, Department of Physics, 2345 E. San Ramon Ave., M/S MH37, Fresno, CA 93740-8031; pcho@csufresno.edu

Daqing Zhang, Raymond Hall, Gerardo Munoz, Mihai Gherase, California State University, Fresno, Department of Physics

Traditional lecturing strategy tends to deliver knowledge by an instructor in class time. The learning environment for students is quite passive and results in a high DFW rate in the introductory-level physics. Starting from the spring of 2014, the calculus-based introductory Physics PHYS 4A (Mechanics and Wave Motion) and PHYS 4B (Electricity, Magnetism, and Heat) at Fresno State have undergone a redesign to adopt high impact practices to improve student success rate. Five practices are used as impact parameters: (1) pre-lecture activities (FlipIt Physics), (2) interactive demonstrations, (3) class practice, (4) iClicker pop quizzes, (5) peer coaching (i.e., SI leader), along with FCI (PHYS 4A), CSEM (PHYS 4B), and instructor-designed common final exams to assess the student learning outcome. As a result, the instructors incorporated the high impact practices intensively showed significant improvement in student learning (grade average improved ~ 8%).

*Faculty learning for outcome and knowledge (FLOCK) at California State University, Fresno is supported by NSF WIDER 1347822.

PST1D10 08:45-9:30 a.m. Investigating Learning and Mathematization of Introductory Electricity and Magnetism Concepts*

Poster – Christopher B. Colborn, Cal Poly, 885 Leff St Apt 16, San Luis Obispo, CA 93401; cbcolbor@calpoly.edu

Stamatis Vokos, Cal Poly

Over three quarters we sought to develop a better understanding of the connections between conceptual and mathematical models of electricity and magnetism concepts that students generate in the introductory calculus-based course. Student understanding was assessed in part through weekly assessments in which explanations of reasoning were required. A focus was student understanding of resistor-capacitor circuits and the exponential functions associated with charging or discharging, as well as students' ability to construct integral expressions for electric and magnetic fields of extended distributions. We found common modes of reasoning through analysis of written student responses. Our results indicate a disparity between conceptual understanding of the physics principles of interest and applications of the knowledge of the associated mathematical expressions, extending prior work in this area. We anticipate using our research results to modify our instructional materials to help students engage with these issues at a deeper level than is currently the case.

*We gratefully acknowledge the Cal Poly Frost Summer Research Program.

PST1D11 8:00-8:45 a.m. K-12 Mathematics Course Progression in Northwest Florida: Pipelines and Bottlenecks

Poster– Bethany N. Campbell San Diego State University / University of West Florida, 1415 2nd St. Apt. E209, Coronado, CA 92118-1571; bnwcampbell@gmail.com

Christopher N. Varney, Aaron Wade, University of West Florida

The mathematics and science courses that students take in high school have correlations with the likelihood of obtaining not just a STEM degree, but also a college degree in general.[1] While there has been a push for students to take more science and mathematics in high school, there has been seemingly less of a focus in elementary and middle schools. We explore the possibility of a pipeline that exists as early as elementary school and investigate potential bottlenecks that may influence whether students remain in the pipeline, if they can get in at all.

1. Tyson W., et al.; Science, Technology, Engineering, and Mathematics (STEM) Pathways: High School Science and Math Coursework and Postsecondary Degree Attainment. Journal of Education for Students Placed at Risk (JESPAR), 12(3), 243-270 (2007)

PST1D12 8:45-9:30 a.m. Lessons Learned from an Interactive Online Course in Contemporary Physics*

Poster – Dean A. Zollman, Kansas State University, 116 Cardwell Hall, Manhattan, KS 66506-2601; dzollman@phys.ksu.edu

Raiya Ebini, Kansas State University

For the past three years we have delivered an online course on quantum physics and its applications, which was aimed at students who were not majoring in physics. This course, Contemporary Physics, includes hands-on activities, computer visualizations, conceptual development and very little mathematics. Students enrolling in the course are studying disciplines ranging from philosophy to business. The online version of this course takes advantage of the vast body of physics education research that shows that students learn significantly better when they are actively involved in the teaching-learning process. To provide active learning the core materials were supplemented by concept maps, other visualizations, particularly from the PhET project and videos posted by others on YouTube. We have used PER techniques to assess students' learning and attitudes toward the learning environment. We will report on results so far and some lessons learned from the assessment.

*Supported by the KSU Global Campus

PST1D13 8:00-8:45 a.m. Math Skills Triage and Concurrent Remediation in Introductory Physics

Poster – Miriam T. Simpson, Cuyamaca College, 900 Rancho San Diego Pkwy., El Cajon, CA 92019; miriam.simpson@gcccd.edu

Valorie Glasser, Cuyamaca College

Analysis of preliminary data on the math background and skills of beginning physics students and its impact on their performance in an introductory physics series designed for scientists and engineers. Methods: Over three years, 183 students in an introductory mechanics course were given a basic math skills assessment test and a survey on their math background. These students were then monitored through the rest of the physics series, comparing performance on a number of key physics skills looking for correlations with mathematical skill. During the second and third year of the study, students with poorer math skills were given some basic math refreshers as companion module to the physics course. Results: Students who scored poorly on the assessment had a higher attrition and failure rate in the course series, but with review in relevant math topics, that rate could be reduced by up to 50%.

PST1D14 8:45-9:30 a.m. Models Problem Solving by Engineering Students: Analysis of Three Cases

Poster – Oscar Jardey OJS Suarez, Fundación Universidad Autónoma de Colombia calle 12 B No 4 - 20, Bogotá, AA 11001 Colombia; oscar.jardey.suarez@gmail.com

The purpose of this paper is to present three models, each corresponding to a case, of how students solve a problem in an initial engineering physics course (Bogota - Colombia) from the perspective of cognitive strategies and metacognitive strategies. The research methodology was qualitative and based on verbal protocols. To state the three cases, fictitious names are used so that the identity of the students who participated in the research protects is known. The three cases constitute empirical evidence that contributes to understand the reality of the student population of the first engineering courses, indicating reasons that go beyond the epistemological obstacles of learning physics. The main conclusion is that academic anxiety is a factor that affects inversely, obtaining academic achievement.

PST1D15 8:00-8:45 a.m. p-prims Activation Through Turning the Hand-cranked Generator*

Poster – Yoshihide Yamada, University of Fukui, Bunkyo 3-9-1, Fukui, pref 910-8507 Japan; yamada.heart@gmail.com

Kyoko Ishii, Tamagawa University

Kazuo Kobayashi, Syuhei Yamamoto, University of Fukui

The situation of turning the hand-cranked generator activates students' p-prims (phenomenological primitives) of "Ohm" and "Working Harder." Students say that "When hand-cranked generator is connected to some resistor, the effort is needed to overcome its resistance." A lot of students (estimated over 60%) make wrong judgement about the effort needed to maintain constant speed of turning the crank when connected to different kind of elements. Their reasoning is like "The larger the resistance, the harder you have to push the crank." These answering patterns are shown in multiple problem contexts. One is the context in which a hand-cranked generator is connected to light bulb, insulator, or short circuit, another is connected to incandescent light bulb versus light-emitting diode. In both cases, students' responses suggest the activation of Ohm's and Working Harder p-prims.

* Supported by the KAKENHI Grant 15H02913, 16K01033 and 16K16306.

PST1D16 8:45-9:30 a.m. Rise of Management Skills in STEM Occupations

Poster – Hyewon Jang, Harvard/KNUE, 29 Oxford St., Cambridge, MA 02138; hwjang@seas.harvard.edu

The development of technology has changed the skills demanded in the labor market. IT technology developed rapidly since the 2000s, however, there is no analysis of how this technology has changed the skills required for STEM occupations. This study explored trends in required skills by comparing the major skills of 2002 and 2016 using O*NET managed by the Department of Labor. We find that high-level cognitive and resource management skills were integrated in the early 2000s, but resource management sciences have fallen into a new one. We discuss the reason why these changes occurred in light of network economy, and STEM education for promoting competencies required for STEM jobs.

PST1D17 8:00-8:45 a.m. Supporting Students in Online Courses by Leveraging the Skills and Expertise of LAs*

Poster – Dontrell Cornelius, Chicago State University, 9501 S. King Dr. - SCI 309, Chicago, IL 60628; dcorne20@csu.edu

Fidel Amezcua, Felicia Davenport, Andrea G. Van Duzor, Mel S. Sabella, Chicago State University

Involving Learning Assistants (LAs) in online STEM courses is in its early stages. In these settings, LAs have the opportunity to utilize their expertise in STEM, as well as leverage their own unique experiences as students to aid in the creation of effective online instructional material. Collaborative relationships between LAs and instructors provide opportunities for LAs to engage students in various aspects of the online classroom, such as development of modules, facilitating online discussions, engaging in peer-editing/review, and holding online "office hours." This poster describes how LAs can support online learning environments and analyzes how online courses might be structured in order to leverage LA expertise and support students in these classes.

*Supported by the National Science Foundation (DUE#1524829), the Department of Education, and the CSU Center for STEM Education and Research.

Lecture/Classroom

PST1E01 8:00-8:45 a.m. Progression of Student Feedback and Computational Skills in P-Cubed

Poster – Daryl McPadden, Michigan State University, Florida International University, 567 Wilson Rd., East Lansing, MI 48824; dmcpadden621@gmail.com

Paul Irving, Michigan State University

Marcos D. Caballero, Michigan State University, University of Oslo

Projects and Practices in Physics is a sequence of two introductory, calculus-based physics courses, covering mechanics (P-Cubed) and electricity and magnetism (EMP-Cubed). Both P-Cubed and EMP-Cubed are flipped classrooms, where students read online notes and complete homework assignments at home and spend class time working on complex problems (or projects) in small groups. The projects are designed to be intricate and challenging, often asking students to model the situation using minimally working VPython code. This requires students to work together to create a plan, make simplifying assumptions, and make choices as work through their solution. In addition to incorporating basic computational modeling, a key feature of P-Cubed and EMP-Cubed are that students get individualized feedback from an instructor on how well they understood the material and how they functioned in the group. We present the progression of the student feedback and development of computational skills through the P-Cubed and EMP-Cubed curricula.

PST1E02 8:45-9:30 a.m. Raising Physics to the Surface

Poster – Elizabeth Gire, Oregon State University, 367 Weniger Hall, Corvallis, OR 97331; giree@oregonstate.edu

Aaron Wangberg, Winona State University

Robyn Wangberg, St. Mary's University of Minnesota

The Raising Physics to the Surface project is to develop student-centered activities with carefully engineered tools to help students develop rich, geometric understandings of physics. The tools include 3D, transparent, dry-erasable surfaces that represent functions of two variables, corresponding contours maps and gradient maps, and inclinometers for measuring slopes on a surface. At this early stage of the project, we are prototyping activities and tools for topics in mechanics, E&M and thermal physics courses. We present some of this preliminary work, including examples of activities and tools that represent physical systems that are relevant to physics instruction.

PST1E03 8:00-8:45 a.m. The Ranking Task as Interactive Lecture Demonstration

Poster – Nathan A. Quarderer, Northeast Iowa Community College/The University of Iowa, 1625 Hwy 150 South, Calmar, IA 52132; quarderern@nicc.edu

In my short career as a physics instructor, I have grown to rely heavily on ranking tasks as a means of introducing concepts, providing opportunities for class discussion, and assessing student understanding. Many of the scenarios described in Ranking Task Exercises in Physics (Okuma, Maloney, Hieggelke) can be carried out in the classroom with the help of equipment found in a typical physics lab, or demonstration stock room. Using a technique modeled after the Interactive Lecture Demonstration procedure (Sokoloff & Thornton), I have adapted my original approach to teaching with ranking tasks to include time for students to recreate their task of interest as a way of testing their predicted outcomes.

PST1E04 8:45-9:30 a.m. Wave vs. Particle: Classroom Revisiting of a Historical Controversy

Poster – Scott Bonham, Western Kentucky University, 1906 College Heights Blvd., Bowling Green, KY 42101; Scott.Bonham@wku.edu

Is light a particle or a wave? Important scientist of 17th and 18th century took opposing views on this question, including Isaac Newton and Robert Hooke in a sharp exchange of papers to the Royal Society that got their relationship off to a bad start, gave us ROYGBIV, and prepared the way for an iconic Pink Floyd album cover. I use these texts with my students to introduce physics topics of refraction, the nature of color, and wave and particle models. I also use them for discussion of nature of science, including models and evidence, scientific law vs. scientific theory, and valid scientific arguments. This presentation will share how I help my non-science students process the texts and to make connections with the various topics through discussions and hands-on activities.

PST1E05 8:00-8:45 a.m. Building a Rigid Body Simulator for Courses in Computational Physics

Poster – John Walker, University of St. Thomas, 14804 Judicial Rd., Burnsville, MN 55306-4817; john.walker@stthomas.edu

Gerry Ruch, University of St. Thomas

Many courses in computational physics, in order to cover a breadth of topics, use a variety of computational techniques to solve a set of unconnected physics problems. We propose a focus on a single complex problem that emphasizes system building. With this approach, students will learn to use many computational techniques together inside of a larger software system. Because many physics students are excited by video games, we have chosen to build a rigid body physics simulator from the ground up during the course of our one- semester class. Using an object-oriented approach in Python, students learn the principals of good software engineering, the requisite computational techniques, and how to translate their existing knowledge of Newtonian physics into a working code. The resulting physics engine is also useful in a research environment to model physical systems like the solar system, toppling chimneys, billiards, or the dynamics of a collection of interacting rigid objects.

PST1E06 8:45-9:30 a.m. Classical Physics and Personal Experience: Two Contemplative Practices

Poster – Zosia Krusberg, Northwestern University, 2145 Sheridan Rd., Evanston, IL 60208-3112; zosia.krusberg@northwestern.edu

Meredith Jane Ward, Vassar College

One of the primary objectives of the introductory physics curriculum is for students to become aware of the connections between the fundamental principles of classical physics and their personal experience. However, numerous studies have shown that students' awareness of such connections tends to deteriorate, sometimes substantially, following instruction. In this work, we present two contemplative practices aimed at deepening students' experiential engagement with the connection between physics concepts and the physical world by heightening their awareness of their sensory experiences as well as by continually directing their attention to visual manifestations of physical principles in nature and in the public and private spaces they inhabit. Additionally, we report on the written assessments of these practices, and find that students express, among other things, a heightened awareness of their physical embodiment, the applicability of physics concepts to their personal experience, and the natural emergence of questions in response to observations of the physical world.

NSHP Plenary Speaker – Gabríela González, Louisiana State University, for the LIGO Scientific Collaboration and the Virgo Collaboration

Location: Golden Ballroom **Date:** Monday, January 8 **Time:** 9:30–10:30 a.m. **Presider:** Mel Sabella

Gabríela González

Gravitational-wave Astronomy

by Gabríela González, Louisiana State University, for the LIGO Scientific Collaboration and the Virgo Collaboration

The recent discoveries of gravitational waves from mergers of black holes and neutron stars have opened a new era of astronomy, with very bright prospects for the future. We will describe the details of the latest discoveries of mergers of binary black hole systems, and the observation of a merger of neutron stars by LIGO and Virgo detectors that was followed up by many electromagnetic observations.

Special Session – AIP Science Communications Awards

Location: Golden Ballroom **Date:** Monday, January 8 **Time:** 10:30–11:00 a.m.

The Science Communication Awards of the American Institute of Physics were established in the 1960s to recognize some of the best science writing of the previous year. Entries aim to improve the general public's appreciation of the physical sciences, astronomy, math and related science fields. Entries are judged by a committee of scientists and journalists, and winning authors receive a prize of $3,000, an engraved Windsor chair, and a certificate of recognition. Paula Ayer is the winner of the Writing for Children Award. Paula Ayer is an editor at Greystone Books and an accomplished translator and award-winning author of four books for both teens and children. She grew up in Calgary, Alberta, and studied at the University of Calgary and Simon Fraser University. Ayer now resides in Vancouver with her husband and daughter. Noah Baker is the winner of the Broadcast and New Media Award.

Session DA: A Classroom Activity That Engages Your Students

Location: Royal Palm One/Two **Sponsor:** Committee on Physics in Two-Year Colleges **Time:** 11:00 a.m.-12:20 p.m. **Date:** Monday, January 8
Presider: Dwain Desbien

DA01 11:00-11:10 a.m. A Fun Card Game for Teaching Scientific Reasoning and Vocabulary

Contributed – John R. Walkup, California State University, Fresno, 2345 E. San Ramon Ave., Fresno, CA 93740; jwalkup@standardsco.com

Roger Key, 2345 E. San Ramon Ave.

The Next Generation of Science Standards compel science educators to scale up the rigor of their curriculum and instruction while transferring more ownership of the learning process onto their students. To help meet this challenge, the presenter has significantly modified a card game called Eleusis to teach students the process of scientific discovery, how scientists work collaboratively, and even how science teams compete against each other. While playing the game, participants in this session will learn a fun, engaging way to teach students to distinguish among many of the most important scientific terms including facts, models, hypotheses, theories, and laws. This presentation will also describe the concept of Cognitive Rigor, a superposition of Bloom's Taxonomy and Webb's Depth of Knowledge, and how teachers can use Cognitive Rigor during Eleusis sessions to generate student questions and lesson activities that deepen critical thinking.

DA02 11:10-11:20 a.m. Lab Idea: How Many Calories in a Heat Pack?!!

Contributed – James J. Lincoln, PhysicsVideos.com, PO Box 11032, Newport Beach, CA 92658; LincolnPhysics@gmail.com

As an alternative or follow up to the well-known "How many calories in a peanut" lab, I present the "How many calories in a hot pack" lab. Hand warmers of supersaturated sodium acetate solution are broken to release heat during a phase change. This dramatic process can be used to heat up water and measure calorie output. But, if you are not careful, you can miss many of the calories. In this talk I discuss how to perform this engaging lab effectively and explain the creative nuances that can be explored by students again and again...because...THE PACKS ARE REUSABLE!

DA04 11:30-11:40 a.m. STEAMy Side of Feezya [TinkerVention + PhysArt]

Contributed – Taoufik Nadji, Interlochen Arts Academy, 3552 Faculty Ln., Interlochen, MI 49643; NADJIT@INTERLOCHEN.org

The presenter will share his new STEAM implementations of project-oriented set of activities in his physics classes. The activities involve students tinkering and inventing gadgets (called TinkerVentions), creating art pieces (referred to as PhysArt), or coding that reflects their deep understanding of the physics concepts they have just learned. These projects have elevated the students' physics learning experience to new levels that require creativity, ingenuity, and self-expression.

DA05 11:40-11:50 a.m. Experience the Magic of Science First Hand

Contributed – John Banks, St. Joseph Catholic School, 308 New Mannsdale Rd., Madison, MS 39110 jbks54@gmail.com

In the last 10 years I have developed an action hero, Super B (Banks). In this persona I introduce science concepts and interactive demonstrations. I have a PVC wand embedded with neon lights that flash. When I wave it over students' heads, it dispels ignorance. Among the first hand activities are a bed of nails, elephant toothpaste, magnet and a wood block in a copper tube, ruler break, paper tear, and disappearing glass. I also do a warm up exercise with drama shapes and a take home model for informal assessment with DeBono Thinking Hats.

DA06 11:50-12:00 p.m. Assignments for Developing Science Literacy for Non-Majors

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

I'll talk about several things I do in my "Hamline Mythbusters" class: ten-hundred word essays, What If blog posts, estimation days, debate days, and lateral thinking puzzles. Most work well. Some took a few iterations to get right. I'll also describe my philosophy for such classes where I focus much more on process than content.

DA07 12:00-12:10 p.m. Games and Demos for Elementary Science in the Mayan Highlands

Contributed – Jean-Francois Van Huele, Brigham Young University, N151 ESC BYU, Provo, UT 84602-4681; vanhuele@byu.edu

In this talk I will relate my experience visiting elementary schools in isolated villages during a recent trip to Guatemala. What impact can a single visit have on students, teachers, and visitor? How can one extend the usefulness of the exchange? More generally, what science conversations and demonstrations can we bring and share with young people in developing nations? The purpose of this contribution is to exchange ideas and information on what resources are available to help individual efforts in this area.

DA08 12:10-12:20 p.m. Dr. Seuss', buiLT Bunnies; exCePT i buiLD rabbiTS 4 caTS oN 2 HaTS

Contributed – Shannon A. Schunicht, Mnemonicwriting.com, 370 Cyprus Dr., Cocoa Beach, FL 32931-3040; mnemonicwriting@gmail.com

Complicated equations are forgotten after test recollection, whereas simple acronyms, like FOIL (First, Outside, Inside & Last) are always remembered. Physics instruction is intimidating to ANYONE, without such aspirations, i.e. Biologist/Microbiologist! It now becomes second, if not discarded all together. A mid-air collision rendered three weeks unconsciousness. Pragmatic discoveries were made to compensate for the residual memory deficits. The most valuable was having vowels represent mathematical operations, i.e. "a" multiplication to imply "@", "o" for division to mean "over", "i" for subtraction to signify "minus", "u" for addition to symbolize "plus", and "e" for equals. Most constants and variables are indeed consonants, i.e. "c" ="speed of light", and "z" = "altitude". ADDITION CONSONANTS may be inserted for intelligibility. An acronym for The Quadratic Equation: =>exCePT i buiLD rabbiTS 4 caTS oN 2 HaTS<= (Remember Dr. Seuss?). The possibilities of this mnemonic technique are limitless as Delta X approaches 0!

***Note how this mnemonic's technique {vowels:mathematical operations} application to Western languages is remarkable; however its application to EASTERN characters has yet to be explored?

Special: Conducting Outreach – Best Practices for Undergraduate Students

Location: Sunset **Time:** 11:00 a.m.-12 p.m. **Date:** Monday, January 8

James Merrick (SPS Education Programs Manager) and Danielle Weiland (SPS Programs Coordinator)

Communicating science to the general public is pivotal for scientific literacy and can help promote public understanding of physics education and research. Undergraduate students have a unique position to foster a curiosity and passion for the physical sciences within the next generation. In this session, participants will learn the ins and outs of planning and implementing quality outreach programs while exploring a variety of interesting outreach demonstrations. Hosted by the Society of Physics Students, this session will provide undergraduates the tools necessary to help students of all ages explore physics and astronomy concepts.

Session DB: Astronomy Papers and Aftermath of the Eclipse II

Location: Tiki Pavilion **Sponsor:** AAPT **Time:** 11:00 a.m. -12:10 p.m. **Date:** Monday, January 8 **Presider:** Janelle Bailey

DB01 11:00-11:10 a.m. Public Outreach in Astronomy and Service Learning at Blinn College

Contributed – James A. Freeman, Blinn College, 3001 Bluebonnet Blvd., Brenham, TX 77833; jim.freeman@blinn.edu

Service Learning is a teaching and learning approach that integrates community service with academic study to enrich learning, teach civic responsibility, and strengthen communities. The Night Sky Network is a NASA-sponsored national organization of Astronomy Clubs with the goal of promoting public education in astronomy. At Blinn College, we have merged these two concepts to provide students with a unique opportunity to participate in self-directed public outreach activities in astronomy. In this presentation, I describe our approach of allowing students to borrow telescopes, locate them in a public venue, and show visitors some of the night-sky wonders while explaining what they are seeing. I also discusses benefits, both tangible and intangible, that accrue to students, the college, and the community.

DB02 11:10-11:20 a.m. The Sight of a Lifetime! Solar Eclipse 2017: Preparing for and Studying the Big Event – A Public Engagement Project

Contributed – Irene Guerinot, Maryville College, 502 E. Lamar Alexander Pkwy., Maryville, TN 37804; irene.guerinot@maryvillecollege.edu

Discussion of an ORAU funded project for public engagement and data collection as it relates to the total solar eclipse of 2017. I will describe the project's goals, funding, expected benefits, and timeline as well the results of our experiments.

DB03 11:20-11:30 a.m. Study of Muon Flux During a Solar Eclipse Results

Contributed – Jacob M. Miller, Ida Crown Jewish Academy, 3837 Greenwood St., Skokie, IL 60076-1939; jacobm613@live.com

Ezra Schur, Allen Sears, Ida Crown Jewish Academy

Nathan A. Unterman, Emeritus Glenbrook North High School

Using QuarkNet cosmic ray muon detectors during the recent August 2017 solar eclipse, experiments were conducted to measure the change of muon flux during the eclipse. Using a fixed array of counters, data on muon flux was captured from a 30 degree cone of acceptance centered at the point of totality of the eclipse. Additionally, a tracking telescope of counters was used to capture a 22 degree angle of acceptance, following the Sun throughout the day. Finally, a small stack of counters was used to establish a control measure of muon flux. Pre-eclipse team discussions included the Sun as a significant source of cosmic rays showing changes during the occultation, a decrease in cosmic rays due to the blocking of rays by the Sun and Moon, and an increase in cosmic rays due to atmospheric changes unique to an eclipse. Specific methods and findings will be presented.

DB04 11:30-11:40 a.m. Filming the Eclipse with Antiquarian Photography: Art Meets Astronomy

Contributed – John E. Beaver, University of Wisconsin - Fox Valley, 1478 Midway Rd., Menasha, WI 54952; john.beaver@uwc.edu

Anne Haydock, Department of Film Studies, Lawrence University

We describe a unique experimental documentary and photography project that uses the August 21, 2017 solar eclipse as source material. An interdisciplinary collaboration between a professor of film studies and a professor of physics and astronomy, we incorporate alternative photographic processes and stop animation, including some techniques that were newly developed for this project. So that the final product would respect our different backgrounds, we documented the eclipse from our own local (coincidentally neighboring) spaces, rather than traveling to the path of totality. The work (completion expected April, 2018) will include animated and live-action film accompanied by still photography, in an installation setting. The process is a learning experience for both collaborators, and as such, it has already proven relevant for the teaching of our respective courses. We present some preliminary results, and describe some of the practical benefits for the teaching of our courses.

DB05 11:40-11:50 a.m. Identifying Unsafe Solar Eclipse Shades

Contributed – Benjamin G. Jenkins, University of West Georgia, 1601 Maple St., Carrollton, GA 30118-0001; bjenkins@westga.edu

Stephen Ramsden, Charlie Bates Solar Astronomy Project

Bob E. Powell, University of West Georgia

During the lead-up to the solar eclipse, a number of unsafe solar shades were being imported into the U.S. Testing was undertaken to find methods to identify unsafe shades using more accessible probes then expensive spectrophotometers. Using a Vernier LabQuest2, a pynometer probe, cellphone camera, and extensive personal experience; several unsafe viewing shades were found. These shades transmitted light levels of over 2-3x the light levels of known, safe shades under various broad spectrum light sources. Typical irradiance using the pynometer was in the range of 1100 w/m^2. Known safe shades reduced levels to 5-6 w/m^2. Unsafe shades had levels from 8-13 w/m^2 or more. Additional shared traits of unsafe shades were noted. Information was posted on social media and shared with amateur astronomy groups to aid in finding any unsafe glasses. Using these data a minimum of 400 unsafe solar eclipse shades were removed from local school stocks.

DB06 11:50 a.m.-12:00 p.m. Studying the Regener-Pfotzer Cosmic Radiation Maximum During a Solar Eclipse

Contributed – Erick Agrimson, St. Catherine University, 2004 Randolph Ave, #4105, Saint Paul, MN 55105; epagrimson@stkate.edu

Gordon McIntosh, U of M, Morris

Kaye Smith, St. Catherine University

James Flaten, U of M, Twin Cities

The University of Minnesota, Morris, and St. Catherine University used Geiger counters suspended beneath high altitude balloons (HAB), to study altitude-dependent changes in the cosmic ray flux within the path of totality during the solar eclipse on August 21, 2017. It is known that cosmic ray fluxes grow with increasing altitude until the Regener-Pfotzer (R-P) maximum, above which fluxes decrease. In our work, we measured the omnidirectional cosmic ray flux plus cosmic-ray-induced coincidences between pairs of Geiger counters mounted both vertically and horizontally. Pressure and temperature were also logged. To characterize possible eclipse-induced changes to the Regener-Pfotzer maximum, we measured cosmic ray flux as a function of altitude in the days leading up to the eclipse, as well as during the total solar eclipse itself.

DB07 12:00-12:10 p.m. Instruction Material for Solar Eclipse Using Desmos Program

Contributed – Jo Mi-Sun, Korea National University of Education, Dept of Physics Education, Cheongju, CG 28173 S Korea bundggi@naver.com

Kim Jung Bog, Korea National University of Education

Eclipses such as solar eclipse or lunar eclipse were fears for people in the past. On the other hand, it is a natural phenomenon that attracts a great deal of interest to us living in modern times as well as students learning science. In particular, on August 21, 2017, people could see total eclipses all over the United States from the west to the east. In this study, we developed educational materials by integrating both the content of light ray in the physics and eclipse phenomenon in earth science. Educational materials were developed by using the Desmos program (http://teacher.desmos.com), which can draw graphs,

figures, or pictures using mathematical languages such as equations, functions, and vectors. These educational materials can explain followings including eclipses: 1) The distance of the sun, earth and moon (absolute distance, relative distance), 2) In the case of light coming from afar, reaching with parallel rays to observers, 3) The earth looks flat to us living on the surface and so on.

Session DC: Gender Bias in Teaching Evaluations, Recommendations and Recognition

Location: Royal Palm Three/Four **Sponsors:** Committee on Women in Physics, Committee on Professional Concerns
Time: 11:00 a.m.-12:30 p.m. **Date:** Monday, January 8 **Presider:** Sathya Guruswamy

DC01 11:00-11:30 a.m. Student Evaluations (mostly) Don't Measure Teaching Effectiveness

Invited – Philip B. Stark, University of California, Berkeley, Department of Statistics, #3860, Berkeley, CA 94720; stark@stat.berkeley.edu

Student evaluations of teaching (SET) are widely used in academic personnel decisions as a measure of teaching effectiveness. Observational evidence shows that student ratings vary with instructors' gender, ethnicity, and attractiveness; with course rigor, mathematical content, and format; and with students' grade expectations. Randomized experiments show that SET are negatively associated with objective measures of instructor "value-added" and biased against female instructors by a large, statistically significant amount. Bias affects how students rate even putatively objective aspects of teaching, such as how promptly assignments are graded. It is not possible to adjust for the bias, because it depends on many factors, including course topic and student gender. Biases can be large enough to cause more effective instructors to get lower SET than less effective instructors. SET are more sensitive to students' gender bias and grade expectations than they are to teaching effectiveness.

DC02 11:30 a.m.-12 p.m. Are there Gender Differences in Interruptions of Academic Job Talk?

Invited – Mary Blair-Loy

Laura E. Rogers, Daniela Glaser, Y. L. Anne Wong, Danielle Abraham and Pamela C. Cosman

We use a case study of job talks in five engineering departments to analyze the under-studied area of gendered barriers to finalists for faculty positions. We focus on one segment of the interview day of short-listed candidates invited to campus: the "job talk", when candidates present their original research to the academic department. We analyze video recordings of 119 job talks across five engineering departments at two Research 1 universities. Specifically, we analyze whether there are differences by gender or by years of post-Ph.D. experience in the number of interruptions, follow-up questions, and total questions that job candidates receive. We find that, compared to men, women receive more follow-up questions and more total questions. Moreover, a higher proportion of women's talk time is taken up by the audience asking questions. Further, the number of questions is correlated with the job candidate's statements and actions that reveal he or she is rushing to present their slides and complete the talk. Finally, departments with a higher proportion of women ask fewer questions of all candidates. We argue that women candidates face more interruptions and often have less time to bring their talk to a compelling conclusion, which is connected to the phenomenon of "stricter standards" of competence demanded by evaluators of short-listed women applying for a masculine-typed job.

DC03 12:00-12:30 p.m. Race, Gender and His/Her/Their Qualifications: Disparities in the Attribution of Achievement in Letters of Recommendation

Invited – Kimberlee Shauman, Department of Sociology, University of California, Davis

This paper presents the results of an analysis of race and gender differences in the letters of recommendation (LORs) written for scholars who applied for STEM faculty positions at research-intensive universities. Methods for computational text analysis are applied to a large corpus of LORs to test for bias by race and gender in the evaluation of the job applicants' achievements and professional characteristics. The design of this study improves upon prior LOR analyses in four ways that are intended to increase the reliability of the estimated disparities in LOR content and their validity as indicators of evaluation bias. First, we use a sample of LORs that spans multiple disciplines and is sufficiently large to test for disparities by race, gender, and their interaction. Second, we focus on disparities in possessive phrases, i.e., possessive nouns or pronouns and the words coupled with them. We measure three ways in which variation in the use of possessive phrases may indicate evaluation bias: their frequency of use, whether singular or plural forms are used, and the types of words with which they are coupled. Third, we measure the substantive context of the possessive phrases, in order to differentiate the language used in LOR text describing, for example, an applicant's research agenda and teaching experience. Fourth, we include robust measures of the characteristics of the applicants' scholarship (e.g., whether their work is co-authored) and scholarly productivity to test if disparities in LOR language reflect gender and race differences in applicant quality or bias in evaluation.

Session DD: Introductory Labs/Apparatus

Location: Royal Palm Five/Six **Sponsor:** AAPT **Time:** 11:00 a.m.-12:10 p.m. **Date:** Monday, January 8 **Presider:** Sam Sampere

DD01 11:00-11:10 a.m. Pivot Interactives for Lab Skills Assessment

Contributed – Peter H. Bohacek, Henry Sibley High School, 1897 Delaware Ave., Mendota Heights, MN 55118; peter.bohacek@isd197.org

Authentic assessment of students' science process skills presents challenges to teachers. Pivot Interactives allows teachers to create online activities that can teach and assess skills such as experimental design, measurement and uncertainty, graphing and data analysis, and error analysis.

DD02 11:10-11:20 a.m. Determining Young's Modulus by Measuring Guitar String Frequency*

Contributed – Adam Davenport, Loyola University Chicago, 1032 W Sheridan Rd., Chicago, IL 60626; adavenport1@luc.edu

Robert R. Polak, Andrew Fischer, Jared Rafferty, Loyola University Chicago

In an attempt to present Young's Modulus as a testable quantity rather than a textbook-given constant, we have designed a simple laboratory exploring the phenomena associated with it—namely, the frequency of a plucked guitar string in relation to a change in its length. This serves to begin building intuition of physical constants, presenting them as quantities with significance beyond their inclusion on the inside covers of textbooks. The ready availability of all involved materials makes this laboratory ideal for high school and introductory college classrooms.

*This paper has been accepted for inclusion in *The Physics Teacher.*

DD03 11:20-11:30 a.m. A Novel, Simple, Friendly, Cousin of the Double-Cone System

Contributed – Constantin Rasinariu, Loyola University Chicago, 1032 W. Sheridan Rd., Chicago, IL 60660; crasinariu@luc.edu

Asim Gangopadhyaya, Loyola University Chicago

We introduce a novel, two-mass system that slides up an inclined plane while its center of mass moves down. The system consists of two identical masses connected by an ideal string symmetrically placed over a corner-shaped support. On a horizontal table, the string moves towards the corner for any value of the corner angle. If the table is tilted upward, we find that the string still moves towards the corner provided that the tilting angle is less than a critical value. This system is reminiscent of a double-cone rolling up a set of inclined V-shaped rails. The double-cone's motion, while relatively easy to demonstrate, is rather difficult to analyze. The example considered here is straightforward to understand, and it does not involve the subtleties of the three-dimensional geometry required for the involved analysis of the double-cone problem.

DD04 11:30-11:40 a.m. Using Introductory Physics Labs to Promote Scientific Reasoning: Implementation and Dissemination*

Contributed – Kathleen Koenig, University of Cincinnati, 2600 Clifton Ave., Cincinnati, OH 45221; kathy.koenig@uc.edu

Larry Bortner, Krista E. Wood, Lindsay Owens, University of Cincinnati

Lei Bao, The Ohio State University

Students enter college with wide variations in reasoning abilities. Research indicates that students with formal reasoning patterns are more proficient learners, and these abilities are also important for informed citizens living in the information age. Unfortunately, the typical college course does not address these skills. In an effort to better target students' development of scientific reasoning, including the ability to critically review "scientific" postings on the web, we have revised the structure of the activities in our introductory physics labs, required of all STEM majors. Students engage in experimental design and emphasis is placed on student use of evidence-based reasoning in making decisions in the lab and in report writing. This presentation will describe the revised lab curriculum as well as present data that demonstrate significant shifts in student development of scientific reasoning both locally and at a dissemination site. The authors are seeking additional dissemination sites for those interested.

*Partially supported by NSF IUSE DUE 1431908

DD05 11:40-11:50 a.m. Setting Up Physics Laboratories in the Developing World: Holding Up in the Maelstrom

Contributed– Muhammad Sabieh Anwar, Lahore University of Management Sciences, Department of Physics, Syed Babar Ali School of Science and Engineering, Opposite Sector U, DHA, Lahore, Punjab 54792 Pakistan; sabieh@lums.edu.pk

I would like to discuss the various aspects of establishing a new low-cost university physics laboratory that strives to emulate the world's best practices. I will use as an example the Physics Lab in our own university which has now been replicated in five other national universities. This exercise brings to light special challenges as well as unique opportunities, especially when performed in a developing country such as Pakistan. In particular, the process requires various fine balancing acts. First, indigenization based on locally available resources is to be balanced with the importation of technology. This is not only costly but one has to also face tedious import rules and the unwillingness of foreign companies to deal with particular developing countries. Second, there is a cultural philosophy of considering experiments a handmaiden to theory. Third, development of laboratory is considered to be inferior or unworthy as compared to classroom teaching or doing "elite" physics. The constant pressure of publication in the clamor of promotions or rankings, further dampens the spirit of lab development.

DD06 11:50 a.m.-12:00 p.m. In-depth Optical Experiment Design on the One Platform*

Contributed – Raohui Feng, Sun Yat-Sen University, No. 135, Xingang Xi Rd., Guangzhou, Guangdong 510275 P. R. China fengrhui@mail.sysu.edu.cn

Fuli Zhao, Han Shen, Yizhong Fang, Xintu Cui,Sun Yat-Sen University

We have constructed a comprehensive experimental platform based on Spatial Light Modulator(SLM). This platform includes many experimental projects, and these projects are designed based on the principle of "Core Device Combining With Accessories." The core device of the platform is SLM, which can be used flexibly as many optical elements. Till now we have achieved the construction of geometrical optics, physical optics, information optics, and other hierarchical optics experiment projects on our platform. This talk will show how to use SLM to set up the course experiments in Lab and the demo ones in lectures for undergraduate students by adding different accessories.

*This project is supported by J1210034 & J1110094

DD07 12:00-12:10 p.m Atom Trap Using a Pyramidal Mirror

Contributed – Sun Young Seo, Korea National University of Education, Dept of Physics Education, Cheongju, CB 28173 S Korea; ssyoung0425@gmail.com*

Eun Kang Kim; Ashish Kumar Sharma, Jung Bog Kim, Korea National University of Education

Uniform velocity low-speed atomic beams can be applied to atomic optics such as atomic clock or atomic interferometer. In order to generate a slow atom beam, we use the Magneto Optical Trap (MOT) method to create atomic gas that is kept very close to absolute zero. Magneto optical trap is achieved with pairs of three orthogonal laser beams and a magnetic quadrupole field. In the case of using a pyramidal mirror, three orthogonal laser beams can be performed by a single beam, which is a relatively simple structure. In this study, the pyramidal mirror was used to generate magneto optical trap and atomic beams of Rb atomic gases. The cooling beam for the magneto optical trap consists of three pairs by a pyramidal mirror out of a circularly polarized single incident light. Both a quarter wavelength plate and a mirror are installed to form a pair of light pressure for the light passing through the hole of 6X6 mm2 made at the apex of the pyramidal mirror. After the magneto optical trap was formed, a circular mask of less than 1mm diameter was attached on the quarter wavelength plate to form a donut-shaped retro-reflected light. Therefore, in the region where there is no reflected light through the mask, the atoms are subjected to the light pressure in the direction of gravity by the incident cooling beam to form an atomic beam eventually.

*Sponsored by Jung Bog Kim

Session DE: PER: Assessment, Grading and Feedback

Location: Pacific Salon One **Sponsor:** AAPT **Time:** 11:00 a.m.-12:20 p.m. **Date:** Monday, January 8 **Presider:** Alexandru Maries

DE01 11:00-11:10 a.m. Assessing Thinking Skills in Traditional and Non-Traditional Sections

Contributed – Beth Thacker, Texas Tech University, Department of Physics and Astronomy, MS 41051, Lubbock, TX 79409-1051; beth.thacker@ttu.edu

We examined the results of free-response questions as part of a large-scale assessment of our introductory courses, including an analysis of thinking skills both qualitatively and with a rubric based on Bloom's taxonomy. We report on a subset of the data comparing two sections of the same course taught by the same instructor the same semester, one traditionally and one non-traditionally. The non-traditionally taught students were enrolled in a hands-on, laboratory-based physics section taught without a lecture and without a text. Students worked through the evidence-based materials developed for the course[1,2], doing experiments to explore the world around them and developing qualitative and quantitative models based on their experimentation. We report on the thinking skills demonstrated on homework and exam problems in the traditionally and non-traditionally taught sections as evidenced by the rubric based on Bloom's taxonomy.

1. National Science Foundation - Course, Curriculum and Laboratory Improvement grant CCLI-EMD #0088780, "Humanized Physics – Reforming Physics Using Multimedia and Mathematical Modeling". 2. National Science Foundation - Course, Curriculum and Laboratory Improvement grant CCLI #9981031 for "Workshop Physics with Health Science Applications"

DE02 11:10-11:20 a.m. Evaluating Critical Thinking and Experimentation in Intro Physics Labs

Contributed – Natasha G. Holmes, Cornell University, 406 Physical Sciences Building, 245 East Ave., Ithaca, NY 14853 ngholmes@cornell.edu

Many instructors and education researchers are developing new curricula and pedagogies for teaching scientific practices such as critical thinking and experimentation skills. As we develop ways of teaching these skills, we must also consider ways of evaluating them. I will present some of the work our group has done to develop ways of assessing students' critical thinking and experimentation skills in the context of an introductory physics lab course. Time permitting, I will include both formative and summative methods, including the Physics Lab Inventory of Critical thinking, a new diagnostic assessment currently undergoing tests of reliability and validity.

DE03 11:20-11:30 a.m. In-class vs. Online Administration of Low-stakes Research-based Assessments

Contributed – Manher Jariwala, Boston University, 590 Commonwealth Avenue, Department of Physics, Boston, MA 02215; manher@bu.edu

Jayson Nissen, Ben Van Dusen, California State University Chico

Eleanor W. Close, Texas State University

Research-based assessments (RBAs), such as the Force Concept Inventory, have played central roles in transforming courses from traditional lecture-based instruction to research-based teaching methods. To support instructors in assessing their courses, the online Learning About STEM Student Outcomes (LASSO) platform simplifies administering, scoring, and interpreting RBAs. Reducing the barriers to using RBAs will support more instructors in objectively assessing the efficacy of their courses and transforming their courses to improve student outcomes. We investigate the extent to which RBAs administered outside of class with the online LASSO platform provided equivalent data to traditional paper and pencil tests administered in class. We used an experimental design to investigate the differences between these two test modes with 1,310 students in 3 college physics courses. Analysis conducted with Hierarchical Linear Models indicates that the online LASSO platform can provide equivalent data to paper and pencil tests in terms of student participation and performance.

DE04 11:30-11:40 a.m. Assessing Learning by Observing Engagement in an Interactive Physics Exhibit

Contributed – Ron K. Skinner, MOXI, The Wolf Museum of Exploration + Innovation, 125 State St., Santa Barbara, CA 93101; ron.skinner@moxi.org

Danielle B. Harlow, UC-Santa Barbara

How do we assess learning when curriculum involves more open-ended, multiple-outcome learning experiences? Can observable evidence made available through students' actions and words be used to determine whether and how students meet learning standards? We introduce a framework to describe student engagement at an interactive science museum exhibit where students build and test ball roller coasters. Our framework consists of two dimensions: (1) levels of engagement, which describe what students are doing and how they are interacting with the exhibit, and (2) practices of learning, which are derived from the Next Generation Science Standards (NGSS). Plotting the levels of engagement against practices of learning allows us to characterize which practices of learning students might be engaged in based on our observation of their behavior. Our initial findings suggest this framework can be used to assess engagement in NGSS science and engineering practices in classroom-based open-ended learning experiences.

DE05 11:40-11:50 a.m. Can Assessments Tell Us if Students Engage in Scientific Practices?

Contributed – James T. Laverty, Kansas State University, 1228 N. 17th St., Manhattan, KS 66502; laverty@ksu.edu

Katherine C. Ventura, Amali P. Jambuge, Kansas State University

The science education community is currently shifting from whether or not students have expert-like understandings of concepts to thinking about what students can do with those concepts. The idea of students engaging in the process of science ("scientific practices") with scientific ideas holds significant promise for improving student learning, but how do we assess if students can engage in scientific practices with their physics knowledge? We are working to develop questions that assess if students can do science with their scientific knowledge but how can we know if they are actually assessing what we want? In this talk, I will discuss the development of these assessment items, interviews we've done with students working on them, and the evidence we have that the students do (or do not) engage in the practices of science. This work will inform the development of future classroom and standardized assessments.

DE06 11:50 a.m.-12:00 p.m. Are All Grade-Scales Created Equal?

Contributed – Cassandra Paul, San Jose State University, Department of Physics & Astronomy, One Washington Square, San Jose, CA 95192; cassandra.paul@sjsu.edu

David Webb, Mary Chessey, University of California - Davis

There are lots of different ways that professors can choose to assign grades in their classroom. If you ask a professor about the principles involved in their grading scheme, many will tell you that 'fairness' is an important design element. However, achieving 'fairness' between students does not necessarily imply that 'equity' is also achieved. While all students might have the same opportunities and course expectations, some populations of students may be more negatively affected by specific grading practices than students of other populations. In this study we share findings from examining a decade's worth of course grades in introductory physics courses. We find that even something as simple as changing from a 100 point scale to a 4.0 scale can have major implications for equity in course grades.

DE07 12:00-12:10 p.m. Addressing Student Retention with Bi-Weekly Computerized Quizzes

Contributed – Brianne N. Gutmann, University of Illinois at Urbana-Champaign, 1110 W. Green St., Urbana, IL 61801; bgutman2@illinois.edu

Tim Stelzer, Morten Lundsgaard, Gary Gladding, University of Illinois at Urbana-Champaign

Prior to the main physics classes, the University of Illinois offers a preparatory physics course for students who feel underprepared for the calculus-based engineers' sequence. After taking this preparatory course, only about half of the students continue and then pass the target course. This drop includes students who do not enroll in the main sequence following the initial class and students who do not pass after enrolling. To address this issue, we implemented bi-weekly quizzes with re-tests offered on off weeks to encourage students to confront difficult topics and continue to work on them, while also providing students regular feedback. Ongoing results from the quiz performance and student enrollment will be shown.

DE08 12:10-12:20 p.m. Creative Ways Students Interpret Experiences as Physics Majors

Contributed – Mary K. Chessey, University of California, Davis, One Shields Ave., Davis, CA 95616-5270; mkchessey@ucdavis.edu

David J. Webb, University of California, Davis

Performance feedback offers a valuable opportunity to guide students' development of knowledge and skills. Undergraduate physics majors in upper division classes dedicate many hours to coursework, yet the feedback for their effort often takes the form of numeric scores with uncertain meaning, especially for students who recently transferred to the university from a community college. This year-long study focuses on the experiences transfer students within a large cohort of physics majors and reveals the creative work that students do to fill in the gaps in the assessment of their performance. Findings from observations, interviews, and participation in the student community indicate that students use many indirect means to guess how they're really doing in their major, such as informal conversations with classmates and instructors, and time spent solving problems. These findings have useful implications for instructors working towards creating an inclusive physics classroom by centering students' perspectives.

Session DF: PER: Diversity, Equity & Inclusion

Location: Pacific Salon Two **Sponsor:** AAPT **Time:** 11:00 a.m.-12:20 p.m. **Date:** Monday, January 8 **Presider:** Jacquelyn Chini

DF01 11:00-11:10 a.m. A Study of Select Physics Teachers Beliefs on Diversity, Equity, and Multiculturalism in Physics and Implementing Culturally Relevant Practices in the Classroom

Contributed – Clausell Mathis, Florida State University, 1130 High Meadow Dr., Tallahassee, FL 32306-9936; cm15j@my.fsu.edu

Mark Akubo, Sherry Southerland, Florida State University

The goal of this qualitative study is to investigate physics instructors' beliefs about diversity equity, and multiculturalism in physics and implementing culturally responsive practices in the classroom. The study focuses on how physics teachers' beliefs impact practice, and data collection was guided by the Teacher Centered Reform Model by Gess-Newsome et al. (2003) and Brown-Jeffry and Cooper's (2011) description of culturally relevant pedagogy. Data collection included class observation and interviews of physics teachers. Data analysis was guided by the culturally responsive observation protocol (CITE), and interview coding scheme focusing on cultural responsiveness as described by Powell & Rightmyer (2011). Beliefs domains were categorized as: student characteristics, identity and achievement, equity and excellence, teaching the whole student, and developmental appropriateness. The themes of the coding scheme were: cultural awareness, teaching accommodations, familiarity, color blindness, and no change.

DF02 11:10-11:20 a.m. Taking Scientific Inquiry Practices into Social Justice Discussions

Contributed Carolina Alvarado, California State University Chico, Science Education 0535, 940 W 1st St., Chico, CA 95929-1001; calvaradoleyva@csuchico.edu

Dicha Perez-Montalvo, California State University Chico

In a physical science course designed for future k-8 science teachers, students are involved in an open-ended scientific inquiry course where they develop ownership of designing their own experiments and constructing the concepts around the light. We present how we can use these venues to explore the power dynamics embedded in education and science by employing Critical Race Praxis for Educational Research. In this presentation, we present different strategies employed to engage students in challenging the dominant cultural discourse in STEM as well as preliminary results of student's work. We will explore how students participating in such activities are using scientific argumentation to address inequity in society and the awareness level of such issues. We argue that the approach of Critical Race Praxis can be embedded in a physical science course in order to problematized the current practices in physics to foster a change in our practice.

DF03 11:20-11:30 a.m. Evaluating the Performance and Participation Gap Between Male and Female Students in Physics Lab Courses

Contributed – Kathryn L. McGill, Cornell University, 245 East Ave., Ithaca, NY 14853; klm274@cornell.edu

Katherine N. Quinn, Michelle M. Kelley, Emily M. Smith, N. G. Holmes, Cornell University

Recent work has identified many instances of performance gaps between male and female students in physics, with no clear mechanisms for these gaps. In a previous study on physics lab courses, gaps were found both in student scores on a data analysis diagnostic, the Concise Data Processing Assessment (CDPA), and in student behaviors in a lab course. Surprisingly, while male students, as compared with their female peers, scored higher on the CDPA and spent more time on the computer (where data analysis was performed), these gaps were not correlated. We present our initial findings on whether these gender performance gaps arise in two different types of physics lab courses at Cornell University. We also report on whether gender gaps arise in two other measures of student performance in laboratory courses: the Physics Lab Inventory of Critical Thinking (PLIC) and the Colorado Learning Attitudes About Science Survey for Experimental Physics (E-CLASS).

DF04 11:30-11:40 a.m. Gender Fairness in the Conceptual Survey of Electricity and Magnetism

Contributed – Rachel Henderson, West Virginia University, 135 Willey St., Morgantown, WV 26505; rjhenderson@mix.wvu.edu

John Stewart, Adrienne Traxler, West Virginia University

Wright State University

Rebecca Lindell, Tiliadal STEM Education

Gender gaps on the various physics concept inventories have been extensively studied. It has been shown that on average, men score 12% higher than women on mechanics concept inventories and 8.5% higher than women on electricity and magnetism concept inventories. There have been multiple items identified in the Force Concept Inventory that are unfair to women and removing those item reduces the overall gender gap. In the current study, Classical Test Theory (CTT) and Differential Item Functioning (DIF) analysis will be used to explore gender biases in the Conceptual Survey of Electricity and Magnetism (CSEM). The difficulty and the discrimination of the 32 items will be examined and DIF analysis will employ the Mantel-Haenszel statistic to identify any gender biases.

DF05 11:40-11:50 a.m. Identifying Women's Success in Physics: Theoretically Framing a Feminist Study

Contributed – Brian Zamarripa Roman, University of Central Florida, 4000 Central Florida Blvd., Physics Department, Orlando, FL 32816; b.zamarripa@knights.ucf.edu

Jacquelyn J. Chini, University of Central Florida

Researchers' characterization of the underrepresentation of women in physics has led to an understanding of the ways that a seemingly masculine field leads to underperformance and attrition of women pursuing a career in physics. This qualitative pilot study paves the way for an attempt at reshaping the perception of physics as masculine field by identifying the ways women find themselves successful in different stages of academic and industry related careers in physics. Participants were interviewed following a semi-structured laddering technique that was progressively tailored to minimize the intrusion of the interviewer's perspectives of success. Data was analyzed thematically to identify patterns and preserve the voice of the interviewees. Since this study is designed by a man with the intention of supporting women pursuing physics, it is necessary to explicitly state the theoretical frameworks that aid in justifying the study and guide the methodology.

DF06 11:50 a.m.-12:00 p.m. Optimizing Group Composition with Respect to Gender and Ability Level

Contributed – Kristine E. Callan, Colorado School of Mines, 1232 West Campus Rd., Golden, CO 80401; kcallan@mines.edu

Bethany R. Wilcox, Wendy K. Adams, Colorado School of Mines

Rich learning can take place in small peer group settings with appropriately designed activities, but it is unclear to what extent group composition in terms of ability impacts physics learning. Furthermore, many research studies in physics classrooms have shown that single gender groups positively affect women, and have no effect on men. However, it can be difficult to implement single-gender groups without student backlash. To explore the question of how to optimally form groups, we first asked our students whether they strongly preferred single gender or mixed gender groups, and incorporated any strong preferences for mixed gender groups into our grouping assignments. We then assigned half of the students to groups with large differences in incoming physics ability (using FMCE pre-scores), and half to groups with smaller differences in incoming physics ability. We will report on students' grouping preferences and performance in the large-range ability and narrow-range ability groups.

DF07 12:00-12:10 p.m. Supporting Teachers to Encourage Pursuit of Undergraduate Physics for Women

Contributed – Theodore Hodapp, American Physical Society, One Physics Ellipse, College Park, MD 20740; hodapp@aps.org

Join a new national campaign to increase the number of young women who pursue a degree in physics. While the percentage of women graduating with a bachelor's degree in physics has declined over the last decade, this gender inequity could be off-set if each high school physics teacher was able to recruit one young woman to physics every three years. This campaign aims to mobilize and support high school physics teachers to encourage young women to go into physics through the use of effective strategies, carefully structured lessons, and community supports. This work is supported by NSF #1720869 and led by Florida International University, the APS, AAPT, and Texas A&M-Commerce.

DF08 12:10-12:20 p.m. Being WISE

Contributed – Shahida Dar, Mohawk Valley Community College, 1101 Sherman Dr., Utica, NY 13501; sdar@mvcc.edu

This session aims at discussing why there are so few female students in Science Technology & Engineering majors. The presenter will talk about how to increase the number of female students in STEM-related fields. Proven practices of WISE (Women in Science and Engineering) group at Mohawk Valley Community College will be discussed.

Session DG: The Flipped Classroom

Location: Pacific Salon Three **Sponsors:** Committee on Women in Physics, Committee on Educational Technologies
Time: 11:00 a.m.- 12:20 p.m. **Date:** Monday, January 8 **Presider:** Kathleen Falconer

DG01 11:00-11:10 a.m. Flipping the Large-Enrollment Introductory Physics Classroom

Contributed – Chad Kishimoto, University of San Diego, 5998 Alcala Park, San Diego, CA 92110-2492; ckishimoto@sandiego.edu

Michael Anderson, University of California, Riverside

Joe Salamon, MiraCosta College

Most STEM students experience the introductory physics sequence in large-enrollment classrooms led by one lecturer and supported by a few teaching assistants. This work describes methods and principles we used to create an effective flipped classroom in large-enrollment introductory physics courses by replacing a majority of traditional lecture time with in-class student-driven activity worksheets. We compare student learning in courses taught by the authors with the flipped classroom pedagogy versus a more traditional pedagogy. By comparing identical questions on exams, we find significant learning gains for students in the student-centered flipped classroom to students in the lecturer-centered traditional classroom. Furthermore, we find that the gender gap typically seen in the introductory physics sequence is significantly reduced in the flipped classroom.

DG02 11:10-11:20 a.m. Introducing SCALE-UP to Switzerland – Collaborative Group Learning for Swiss Students

Contributed – Gerald Feldman, George Washington University, Department of Physics, Washington, DC 20052; feldman@gwu.edu

Guillaume Schiltz, Andreas Vaterlaus, ETH Zürich

In spring 2017, we offered a pilot section of an introductory physics class at ETH Zürich that was taught using the SCALE-UP collaborative group-learning approach. We reconfigured a classroom with nine hexagonal tables (two groups per table), accommodating 54 students. Lecture was reduced to a minimum, which was a significant departure from the typical environment of a Swiss university class. To enable class preparation and problem-solving practice, the online MasteringPhysics system was used for pre-class "Warmups" and post-class homework assignments. To evaluate the effectiveness of this active-learning pedagogy at ETH, we compared student performance in the SCALE-UP section with a parallel lecture section, based on the FCI and a common mid-term exam, as well as a survey soliciting student feedback about their experience. We will summarize details of our project at ETH and present data from the two concurrent class sections to demonstrate that the SCALE-UP students outperformed their lecture counterparts on the common assessments.

DG03 11:20-11:30 a.m. Are Incentives Essential in a Flipped Classroom Setting?

Contributed – Guillaume Schiltz, ETH Zurich (Swiss Federal Institute of Technology), LFKP, HPF G 3.2, Zurich, CH 8093 Switzerland schiltz@phys.ethz.ch

Gerald Feldman, George Washington University

Andreas Vaterlaus, ETH Zurich (Swiss Federal Institute of Technology)

In a Swiss research university, we have divided an undergraduate student cohort into two parallel teaching settings. We offered a highly interactive flipped class (SCALE-UP) to one group of 52 students and a traditional lecture to the remaining 318 students. According to university regulations, we were not allowed to use grading as an incentive to control the students' learning behavior or to administer different grading schemes to the separate groups. Grades for both groups are determined by a comprehensive final exam in January 2018. We measured the performance of both groups by using an optional mid-term exam and FCI pre-/post-tests. A survey provided feedback about the students' learning experience and about their time effort. The flipped class group showed higher performance and engagement than the lecture group. Interestingly, both groups spent about the same time for out-of-class preparation. At least in a European context, flipping the class seems to work well without additional incentives.

DG04 11:30-11:40 a.m. Using Textbooks in a Flipped Classroom

Contributed – Thomas A. Moore, Pomona College, Department of Physics and Astronomy, Claremont, CA 91711; tmoore@pomona.edu

One approach to flipping the classroom involves using the textbook to deliver content outside the classroom. This approach is often overlooked because most textbooks are not designed to be used this way and do not always do well at being the primary source of content. In this talk, I will outline three different ways that I have used appropriately designed textbooks to create a flipped classroom environment in both introductory and higher-level classes, and describe how to recognize textbooks that work.

DG05 11:40-11:50 a.m. The Thayer Method – 19th Century Flipped Classrooms at USMA

Contributed – Corey Gerving, United States Military Academy, 753 Cullum Rd., West Point, NY 10996; corey.gerving@usma.edu

Jacob Capps, Gabriel Lucero, United States Military Academy

Jill Rahon

In 1828, COL Sylvanus Thayer, then the superintendent of the United States Military Academy, outlined his philosophy of instruction for the cadets attending West Point. His ideas centered on placing more emphasis on outside preparation for class, with in-class application by cadets with their instructors. This model became known as "The Thayer Method," and has been in use (to varying degrees) at the United States Military Academy ever since.
In modern pedagogical terms, this was the 19th century equivalent of the Flipped Classroom. Here we present our preliminary work towards updating Thayer's methods with modern techniques and technology.

DG06 11:50-12:00 p.m. Using Apps for Teaching Circuits in Introductory Physics

Contributed – Kathy Shan, University of Toledo, 2801 W. Bancroft St., Toledo, OH 43606; Kathy.Shan@utoledo.edu

I discuss a case study on the use of a circuit building application in an interactively taught (partially flipped) class for teaching direct current resistor circuits in a small honors section of the calculus based, introductory physics class (Phys 2140) for science and engineering majors at an open enrollment, public university. Student understanding was evaluated using a pre-post test model before and after a unit on direct current resistor circuits, using a subset of questions from the Electric Circuits Concept Evaluation. For comparison, the same pre-post test was given to students in a lecture-based, large enrollment section of the course that did not use the circuits application. Preliminary results suggest that the use of the app greatly improves student understanding of DC resistor circuits and plans are being made to scale up the design for further study.

DG07 12:00-12:10 p.m. Flipped Experimentation Using Smartphones

Contributed – Sebastian Staacks, RWTH Aachen University, 2nd Institute of Physics A, Templergraben 55, Aachen, 52062 Germany; staacks@physik.rwth-aachen.de

Simon Hütz, Heidrun Heinke, Christoph Stampfer, RWTH Aachen University

Typically, a flipped classroom means that instructional learning is moved out of the classroom and into the individual learning space. But in physics there is another aspect in class, that can be flipped: experimentation. Usually, this is not done because of technical limitations. Students are not equipped with appropriate experimental tools and hence limited to experimentation in class or they might not even have possibilities to experiment at all. Especially large courses at universities only use demonstration experiments on stage for illustration. In this talk we will show how we flipped the experimentation aspect of a large university-level physics course at the RWTH Aachen University using smartphones and our free app "phyphox" (Android and iOS, see http://phyphox.org). In fact, we first instructed students to do experiments at home, gathered their results online and then discussed their collective result in class while introducing the physical background for their data.

DG08 12:20-12:20 p.m. Best Practices for Significant Learning in the Flipped Classroom

Contributed – Sarah Formica, University of North Georgia, 82 College Circle, Dahlonega, GA 30597; sarah.formica@ung.edu

The flipped classroom is an environment where instructional content is delivered from instructor to student outside the classroom and activities and problem solving are done during class time. I began to partially flip my classroom 10 years ago by implementing Just-in-Time Teaching and Peer Instruction, and over the years my teaching methods and classroom environment have evolved. I will present effective strategies that enhance student engagement and learning both in and out of the classroom. These best practices have effectively improved student learning in my calculus-based Physics I course. In the last 5 years, the average gain on the Force Concept Inventory for students in my flipped, active-learning classroom was approximately 40%, a factor of 2 higher than the national average. This year, after I implemented a social learning platform that enables students to collaboratively read and annotate the textbook, this cohort's average gain on the FCI was 55%.

AIP Panel on Communicating Science to the Public

Location: Golden Ballroom **Sponsor:** AIP **Time:** 12:30-2:00 p.m. **Date:** Monday, January 8 **Presider:** Jason Bardi

A panel discussion focused on challenges and tips for communicating science to the public: Come hear stories from the field, tips on breaking into the publishing industry, and what can happen behind the book or camera.

Panelists:

Paula Ayer, Greystone Books
Noah Baker, Nature and Scientific American
Antonia Banyard, Author
Don Lincoln, Fermi National Accelerator Laboratory in Chicago

Plenary – Lynne Talley, Scripps Institution of Oceanography, Univ. of Calif., San Diego

Location: Golden Ballroom **Time:** 2–3 p.m. **Date:** Monday, January 8 **Presider:** Mel Sabella

Lynne Talley

Physics and the Changing Climate of the Southern Ocean and Antarctica

The ocean and atmosphere are fluids with scales of motion from 10,000s of kilometers down to millimeters, studied by physical oceanographers and atmospheric scientists using traditional fluid dynamics in the Earth's rotating coordinate system. They interact with other environmental systems to create the Earth's climate system. We study them using theory, complex computer modeling, observations, and combined modeling/observations.

The topic here is how the Southern Ocean, which broadly surrounds Antarctica, fits into the overturning circulation of the global ocean, and how it affects and is affected by global climate. Our interest in this region stems from interaction of the ocean and atmosphere with the Antarctic ice sheet, which is losing mass, leading to potentially major global sea level rise; from the Southern Ocean's major role in sequestering additional heat in the deep ocean; and from its role in taking up a sizeable fraction of anthropogenic CO_2. It is also a region of climate change surprises, where sea ice cover has been slightly advancing rather than retreating, surface waters are not necessarily warming, and carbon may be outgassing from the deep ocean at greater rates than hitherto expected.

The ocean circulation is wind- and buoyancy-driven, with wind creating most of the momentum but buoyancy central to the overturn. For a few decades, community focus has been on the Southern Ocean circulation's dynamical similarity to the atmosphere, which has no lateral boundaries and is therefore dominated by east-west (zonal) flow, which is driven by zonal winds. Our focus is shifting to the asymmetries in this zonal flow, which result from wind forcing and interaction with large-scale topographic features. The regional climate surprises can largely be attributed to strengthened winds, which enhance upwelling of deep waters to the sea surface. Southeastward and upward spiraling of northern, non-freezing, deep waters into the Southern Ocean and through the Antarctic Circumpolar Current (ACC) brings them to the Antarctic margins, where the ice shelves are losing the most mass. This spiraling pathway is not uniformly southeastward nor is upwelling along the pathway uniform: the location of the fronts where carbon-rich upwelled water reaches the surface is strongly steered by topography and by the subpolar Ross and Weddell gyres, while upwelling itself is enhanced by strongly localized eddy fields where the ACC crosses major topography.

Session EA: Developing and Measuring Content Knowledge for Teaching

Location: Pacific Salon One **Sponsors:** Committee on Research in Physics Education, Committee on Physics in High Schools
Time: 3:30-5:30 p.m. **Date:** Monday, January 8 **Presider:** Stamatis Vokos

EA01 3:30-4:00 p.m. Defining and Studying Physics Teacher Content Knowledge for Teaching Energy*

Invited – Eugenia Etkina, Rutgers, The State University of New Jersey, 10 Seminary Place, New Brunswick, NJ 08901-1183; eugenia.etkina@gse.rutgers.edu
Lane Seeley, Seattle Pacific University
Stamatis Vokos, Cal Poly

If you are engaged in teacher preparation and teacher professional development, you know that it is vitally important to (a) clarify the construct that underlies specialized content knowledge; (b) operationalize it in some domain; (c) measure it in both static contexts and also in the classroom; and (d) correlate it with classroom instruction and its effect on student learning. This talk describes a piece of a multi-year, multi-institutional effort to investigate (a) through (d) in the domain of energy in a high school physics course. In particular, we describe the framework that we developed to clarify Content Knowledge for Teaching (CKT) in the context of high school energy learning. We then outline the process through which we developed, tested, and refined a "paper-and-pencil" assessment administered on a computer, and discuss the substantive and psychometric features of several items based on a field test of the final form of the assessment.

*This work was supported by NSF grant DRL-122273 and DRL-8211.

EA02 4:00-4:30 p.m. The Role of Disciplinary Knowledge and Scientific Practices in Productively Responding to Learner Thinking*

Invited – Lane Seeley, Seattle Pacific University, 3307 Third Ave. W., Seattle, WA 98119; seelel@spu.edu
Eugenia Etkina, Rutgers University
Stamatis Vokos, California Polytechnic University

The Next Generation Science Standards has provided a compelling vision for the role of both disciplinary knowledge and scientific practices as integral to the pursuit of scientific understanding. How then do disciplinary knowledge and scientific practices support the daily work of a science teacher? How might an expert teacher utilize both knowledge and practices to respond productively to learner thinking? We will share a video case study where instructors and fellow students make use of both disciplinary knowledge and science practices in responding to learner thinking. We will also describe a set of assessment items that we have created to probe the disciplinary knowledge and knowledge of scientific practices that is relevant for recognizing and responsively engaging with the energy ideas of HS physics students. We will share results from pilot studies of over 500 H.S. physics teachers and analyze responses to both multiple choice and constructed response items.

*This work is supported in part by NSF grant DRL-122273 and DRL-8211.

EA03 4:30-5:00 p.m. Modeling Different Components and Scales of Content Knowledge for Teaching*

Invited – Michael C. Wittmann. University of Maine. 5709 Bennett Hall. Orono, ME 04469-5709; mwittmann@maine.edu
Carolina Alvarado, California State University Chico

We have investigated teacher knowledge for teaching the topic of energy along three dimensions: teacher content knowledge, their knowledge of common student ideas when learning energy, and their pedagogical strategies for helping students learn most effectively. Using data from surveys asked on an annual basis, we observe growth in teacher understanding of all three topics. Their content knowledge becomes more nuanced, they are more aware of student's ideas, and their teaching strategies are more constructivist in nature. Using data from discussions during professional development meetings, we observe that teachers can describe students' most common difficulties when answering a given question, but do not discuss the valuable physics content that is leading to these incorrect answers. This suggests a complex relationship between teachers' subject matter knowledge and knowledge of students' ideas, underscoring the importance of studying knowledge for teaching as a whole and across multiple grain sizes.

*Supported in part by NSF grants 0962805 and 1222580.

EA04 5:00-5:30 p.m. Developing Content Knowledge for Teaching Through Course Reforms and Research

Invited – Gorazd Planinsic, University of Ljubljana, Physics Department, Jadranska 19, Ljubljana, 1000 Slovenia gorazd.planinsic@fmf.uni-lj.si

In my talk, I will describe a master's program for preservice high school physics teachers in the Physics Department, University of Ljubljana. In particular, I will focus on student Master's thesis that represents 20% of total credit points in the second cycle of the study and typically requires six months to complete. The students working on the theses participate in reforms in undergraduate physics courses and conduct research on the effectiveness of these reforms. Both activities contribute to the development of their content knowledge for teaching of specific physics topics and science practices.

Session EB: Introductory Courses

Location: Pacific Salon Three **Sponsor:** AAPT **Time:** 3:30-5:20 p.m. **Date:** Monday, January 8 **Presider:** Shahida Dar

EB01 3:30-3:40 p.m. Backward Reaction Force on a Fire Hose, Myth or Reality?

Contributed – Rodrigo Rivera, Pontificia Universidad Catolica de Valparaiso, av valparaiso 230, depto 911, Viña Del Mar, 2571527 Chile; rodrigo.rivera@pucv.cl
Francisco Vera

The widely accepted explanation for the backward force produced by a firehose on firefighters uses Newton's third law in a way that is conceptually wrong. We provide empirical evidence that a backwards reaction force does not exist on a straight hose, and show the mechanism behind the backwards force that appears when water flows inside a curved hose. The correct application of Newton's laws makes it possible to devise new solutions to efficiently fight a fire without having to diminish the water flow to lower the reaction forces in the nozzle.

EB02 3:40-3:50 p.m. Fluid Dynamics of the Cardiovascular System for Introductory Physics

Contributed – Bradley S. Moser, University of New England, 11 Hills Beach Rd, Dept. of Chemistry and Physics, Biddeford, ME 04005; bmoser@une.edu

The fluid dynamics of real biological systems demand deeper layers of physics than the typical introductory physics teacher has previously encountered. As the Introductory Physics for Life Sciences (IPLS) community continues to grow and evolve, it remains vital to talk with professionals and colleagues in the fields of biology and medicine. In this talk, the author revisits old and presents new context rich physics problems and demonstrations developed from conversations with cardiologists, cardiovascular nurses, and professors of anatomy and physiology. These include a model human circulatory system that exemplifies the equation of continuity and Poiseuille's law, the application of Bernoulli's Principle to the diagnosis of aortic stenosis (blocked heart valves), and the physics of stress tests. The author also contends that Poiseuille's law is the more appropriate choice for most biological fluid flow applications and encourages a Poiseuille-first approach to teaching fluid dynamics.

EB03 3:50-4:00 p.m. IPLS Students Defining and Solving their Own Problems

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

Defining and solving problems, including determining needed information, is a skill that life and health science students need and that can be developed and practiced in the IPLS course. At Mercy College students pose their own questions within their own scenarios and answer their own questions – all within guidelines. The process and examples will be presented.

EB04 4:00-4:10 p.m. The Impossible Siphon

Contributed – Francisco Vera, Av Brasil 2950, Valparaiso, Quinta Region 2374631 Chile francisco.vera.ucv@gmail.com

Rodrigo Rivera, Pontificia Universidad Catolica de Valparaiso

A siphon is a device that is used to drain a container, with water rising inside a hose in the form of an inverted U and then going down towards a discharge point placed below the initial water level. The siphon is the first of a number of inventions of the ancients documented about 2000 years ago by Hero of Alexandria in his treatise Pneumatics, and although the explanation given by Hero was essentially correct, there is nowadays a controversy about the underlying mechanism that explains the working of this device. Discussions concerning the physics of a siphon are plagued with inconclusive experiments and biased interpretations of the role played by concepts like absolute negative pressures, the strength of liquid's cohesion and the possibility of a siphon working in vacuum or in the presence of bubbles. Torricelli understood the working principle of the barometer and the impossibility of pumping water out of wells deeper than 10.33 m. Following Torricelli's ideas it would be also impossible to build a siphon that drives water to ascend higher than 10.33 m. In this work, we report the first siphon that drives water to ascend higher than the Torricellian limit. Motivated by the rising of sap in trees, we built a 15.4 m water siphon that shows that absolute negative pressures are not prohibited, that cohesion plays an important role in transmitting forces through a fluid, and that surfactants can help to the transport of water in a metastable regime of negative pressures.

EB05 4:10-4:20 p.m. Class Size in an Introductory Active-Learning based Physics Course

Contributed – Connor Gorman, University of California, Davis, 1100 Olive Dr., Davis, CA 95616-4791; cogorman@ucdavis.edu

The effect of class size on student learning has been a topic of conversation and research in the education community for some time now but relatively few studies have been done on this issue in the context of university classrooms or physics courses. This study uses multiple regression and other techniques to analyze the role that class size plays in the learning outcomes for students taking an introductory university physics course based on active-learning principles.

EB06 4:20-4:30 p.m. Quantitative Reasoning and Mathematics in Introductory Physics

Contributed – Andrew D. Cahoon, 32 Trent Rd., Hooksett, NH 03106; acahoon@colby-sawyer.edu

Quantitative reasoning (QR) and mathematics are distinct, but interdependent, and so the distinction is often ill-defined. Introductory physics is a natural setting for students to develop both sets of skills and for instructors to investigate how QR and math are individually applied in problem solving. Which QR and math skills are lacking? How well does the traditional curriculum address them? We distinguish QR and math skills and discuss current research on QR assessment. Then, we discuss pre- and post-assessment results from an algebra-based introductory physics course taken by life science students at Colby-Sawyer College.

EB07 4:30-4:40 p.m. Tutorial-style Problem Sessions for a Large Enrollment Physics Class

Contributed – Sathya Guruswamy, University of California, Santa Barbara, Department of Physics, Santa Barbara, CA 93106; sathya.guruswamy@ccs.ucsb.edu

This talk will detail our experience of bringing small-group teaching to a large enrollment second-year class for physics majors in our department. While the lecture session is in traditional style, we use Learning Assistants to implement small-group teaching and active-learning in the Discussion Sections by converting them into tutorial style problem-solving sessions conducted in a specialized collaborative Teaching Studio environment. We provide individual attention and engage the students as they think through concepts and solve problems, by stimulating discussion, and asking them probing questions, thus helping them not only arrive at answers, but to learn to think like physicists.

EB08 4:40-4:50 p.m. Momentum, Impulse, the Future, and the Past

Contributed – Ruth W. Chabay, High Point University, 2712 Edenridge Dr., High Point, NC 27265; rchabay@highpoint.edu

Formulating the Momentum Principle in a way suitable for iterative applications changes the nature of discourse about force and momentum change. In particular, it offers a different way of talking about situations that frequently trigger conceptual struggles (for example, students' inclination to include the force exerted by a hand even after a ball has been thrown).

EB09 4:50-5:00 p.m. Initial Deployment Results of New Video Resource for Introductory Physics

Contributed – Jonathan D. Perry, Texas A&M University, 4242 TAMU, College Station, TX 77843-0001; JPerry@physics.tamu.edu

Tatiana L. Erukhimova, William H. Bassichis, Texas A&M University

Results from initial deployments of a new video resource designed as supplemental instruction for calculus-based introductory physics are presented. The growth of multimedia resources in recent years may be attributed to the increased ease of production and benefit to students of video engagement as an instructional technique. Exploiting this potential benefit, a new resource, called Freshman Physics Classroom (FPC), targeted towards calculus-based introductory physics, was developed by a team at the Department of Physics & Astronomy at Texas A&M University (TAMU). Impact of this resource is analyzed through student surveys, comparative performance on examinations, and gains exhibited on relevant conceptual assessments. Results from an Electricity & Magnetism course (spring 2017) show high student approval, increased performance on mid-term exams, and improved gains on the Brief Electricity & Magnetism Assessment (BEMA). Further results for Mechanics (fall 2017) will also be presented, utilizing the Force Concept Inventory (FCI) instead of the BEMA.

EB10 5:00-5:10 p.m. EMF and Field Inside a Solenoid

Contributed – Bruce A. Sherwood, NCSU Emeritus, 2712 Edenridge Dr., High Point, NC 27265; bruce.sherwood@gmail.com

Inside a long solenoid whose spatially uniform magnet field is changing, there is a curly electric field that is tangent to circles centered on the solenoid. A conducting circular ring that is centered on the solenoid will carry a current proportional to the emf that is equal to the rate of change of the magnetic field times the area of the ring. Place an identical ring just to the right of the first ring, and the second ring will experience the same emf and carry the same current, yet where the two rings nearly touch, the currents run in opposite directions. However, the curly electric field must have a unique direction at that location. Understanding this puzzle requires recognizing the additional electric field contributions from surface charges that build up on the second ring. See brucesherwood.net/?p=138.

EB11 5:10-5:20 p.m. It's About Time: Teaching Correct Intuition for General Relativity*

Contributed – Jonathan M. Clark University of Tennessee, Knoxville, 7238 Austin Park Lane, Knoxville, TN 37920; jclar121@vols.utk.edu*

When teaching relativity, many famous analogies and simplifications are called upon to aid students' intuitions. The phrase "gravity bends space" and the visual of a bowling ball on a trampoline are two such examples. However, mathematical considerations of the theory necessitate a more rigorous explanation. Particularly, time's role in relativity is central to the theory's ability to model our world. We present several key connections to the real world which include: the coordinate transformation in Einstein's original thought experiment, a weak field approximation showing that Newtonian gravity can be completely recovered from perturbing the time component in the metric, and the theorem of geometry that a three-dimensional manifold cannot have Einstein gravity in a vacuum with vanishing cosmological constant. These considerations are simple enough to include in an advanced high-school or undergraduate-level lesson plan.

*Sponsored by Lauren Jeneva Clark

Session EC: PER: Student Content Understanding, Problem-Solving and Reasoning

Location: Royal Palm Three/Four **Sponsor:** AAPT **Time:** 3:30-5:20 p.m. **Date:** Monday, January 8 **Presider:** Andrew Gavrin

EC01 3:30-3:40 p.m. A Computer-based Role-Playing Game for College Physics

Contributed – Eric S. Mandell, Bowling Green State University, 3206 Penrose Ave., Toledo, OH 43614-5338; meric@bgsu.edu

Michael A. Greene, Bowling Green State University

Looking to adapt to harness the advantages of Exploratory Learning (EL), Game-Based Learning (GBL) and Story-Based Learning (StoBL), and hoping to improve student engagement outside of class, we are developing a computer-based Role-Playing Game (RPG), where students encounter aspects of the College Physics curriculum as they play. The story-aspect of the game is used as a vehicle for introducing physics concepts in the game-world, more or less, synchronously with those in the course. Our model would have the instructor referring to events and problems in the game while in class, which can help augment a flipped classroom model. Here, we present a first look at the early content of the game, and describe its scope and intended learning outcomes. Our associated poster presentation will describe early results in measuring student attitudes towards the first chapter of game content, and towards GBL in the College Physics class.

EC02 3:40-3:50 p.m. A Physical Science Phenomena-based Lecture Approach for K-8 Teacher Preparation*

Contributed – Roger A. Key, Fresno State Physics, 2345 E San Ramon Ave MS/MH37, Fresno, CA 93740; rogerk@csufresno.edu

Anthony Hinde, Dermot Donnelly, Fresno State Chemistry

The Next Generation Science Standards (NGSS) call for a three-dimensional view of science learning and scientific phenomena that includes disciplinary core ideas, science and engineering practices, and cross-cutting concepts. Given such shifts, teacher educators need to decide whether to revise, replace, or reform their existing courses for science education. Such decisions require critiques of existing curriculum, instruction, and assessment, and of new approaches. Using knowledge integration items and rubrics, this study evaluates pre/post student learning outcomes in an existing Physical Science class for future K-8 teachers (n = 94; Semester 1) and compares it with a pilot phenomena-based lecture approach (n = 74; Semester 2). Findings across both semesters show that overall students enter these classes with mostly non-normative ideas and leave with predominantly partial ideas. However, the pilot phenomena-based lecture approach suggests greater student connection of science concepts to scientific phenomena. Implications for science education will be discussed.

*We wish to acknowledge the support of NSF for this project through IUSE Project ID 1712279

EC03 3:50-4:00 p.m. Examining Concurrent Representation Choices Using Network Analysis

Contributed – Daryl McPadden, Florida International University, Michigan State University, 567 Wilson Rd., East Lansing, MI 48824; dmcpadden621@gmail.com

Eric Brewe, Drexel University

As part of a larger study of students' representation choices in Modeling Instruction (MI), this work focuses on what representations students use concurrently during problem solving. MI is a set of active learning curricula for introductory physics with explicit class time devoted to understanding, interpreting, and using multiple representations as part of the model building process. In this study, 120 students from two sections of the electricity and magnetism course (MI–E&M) in spring 2016 completed a survey of 25 physics problem statements pre- and post-instruction, covering both Mechanics and E&M content. Rather than asking students to solve every problem, students were asked to simply list which representations they would use. Using network analysis, we determined what representations students frequently rely on together, what representations feed into others, and what representations serve as "connectors" between the various representations. Ultimately, these results have implications for further curriculum development and refinement.

EC04 4:00-4:10 p.m. Improving Student Understanding of Air Resistance Through a Lab Activity*

Contributed – Andrew Hood, Western Washington University, 516 High St., Bellingham, WA 98225; andrewh6307@gmail.com

Andrew Boudreaux, Brian Stephanik, Western Washington University

The topic of air resistance has received relatively little attention in terms of research-based curriculum development. Even though students demonstrate an awareness of air resistance, they struggle to answer basic qualitative questions. For example, they sometimes believe that, because mass does not appear in the air resistance force formula, it does not need to be considered. This is not the case for an object falling at terminal velocity, where the air resistance force is balanced by the weight force. At Western Washington University, a 2-hour lab activity was created to strengthen student understanding of air resistance and terminal velocity principles. Preliminary data was collected during use in an introductory calculus-based physics course. The talk will describe the initial creation of the lab, an analysis of its effectiveness, as well as recent improvements to the lab activity.

*Work supported by Washington NASA Space Grant

EC05 4:10-4:20 p.m. Same Data, Different Conclusions: A Tale of Two Approaches

Contributed – Katherine Ansell, University of Illinois at Urbana-Champaign, 1110 West Green St., Urbana, IL 61801; crimmin1@illinois.edu

Mats Selen University of Illinois at Urbana-Champaign

Physics experimentation involves a progression through multiple decisions, ranging from the design of the experiment itself to different ways that the results can be interpreted. In our introductory physics lab reform efforts, we have considered scientific skills and practices as tools which support the decision-making process. A recent lab practical exam probed how students in skill-focused lab instruction consider data samples, compared to their peers in concept-focused labs. While it was unsurprising that students with different instruction behaved differently at the end of the semester, a consistent pattern arose between the way that students thought about their data and the conclusions that they made. This talk will describe these patterns, using framing of student data analysis into "point" and "set" methods, and discuss the implications of promoting specific data analysis practices on the reliability of student decisions.

EC06 4:20-4:30 p.m. Interactions During Peer Instruction – The Influence of Previous Subject Experience

Contributed – Judy Vondruska, South Dakota State University, Box 2222, SDEA 263, Brookings, SD 57007; judy.vondruska@sdstate.edu

While students with previous subject experience are more likely to have the correct answer on clicker questions prior to peer discussion, their familiarity with the content does not necessarily benefit an inexperienced discussion partner. This session will relate the results of a mixed methods analysis in which the quantitative influence of peer instruction is more deeply explored through focus group interviews and participant surveys.

EC07 4:30-4:40 p.m. Productive Physical Intuitions about Patterns of Motion

Contributed – Benedikt W. Harrer, San Jose State University, One Washington Square, San Jose, CA 95192-0106; benedikt.harrer@sjsu.edu

Virginia J. Flood University of California, Berkeley

In this exploratory study, we identify and characterize productive physical intuitions undergraduate pre-service STEM teachers used to investigate and make sense of the curious behavior of a weighted wheel. Relying on everyday experience and ideas generated through their ongoing study of various scientific disciplines, students were able to make sense of balance, oscillation, and threshold – important concepts for a wide range of scientific contexts, from simple mechanics to complex dynamical systems.

EC08 4:40-4:50 p.m. Supporting Sense Making in Sophomore Mechanics

Contributed – Elizabeth Gire, Oregon State University, 367 Weniger Hall, Corvallis, OR 97331; giree@oregonstate.edu

Paul Emigh Oregon State University

MacKenzie Lenz, Kelby Hahn, Oregon State University

How can we better support students in adopting some of the physics sense-making strategies that professionals find useful? We have developed a new course for our physics majors that has an explicit and prominent emphasis on physics sense-making. Our goal is for the students to develop sense-making skills that will help them be successful in the major and impress their upper division physics instructors, research advisors, and future employers. In our first offering of this sophomore mechanics course, which immediately follows the introductory sequence, we went a bit bananas. Sense-making was supported in all aspects of the course - during in-class activities, on augmented homework assignments, and on exams - and treated on nearly equal footing as the physics content. In this talk, I will discuss some of the instructional strategies we used, some results of students' performance and practices, and challenges.

EC09 4:50-5:00 p.m. A Concept Inventory for Momentum, Energy, and Rotational Dynamics

Contributed – Alex Chediak, California Baptist University, 8432 Magnolia Avenue, Riverside, CA 92504; achediak@calbaptist.edu

Kyle Stewart, California Baptist University

Jennifer L. Esswein, Education Northwest

For over 20 years, David Hestenes' diagnostic, the Force Concept Inventory (FCI), has been used in college physics courses to gauge student understanding of Newtonian concepts. While the FCI has proven invaluable for this purpose, semester-long physics courses generally cover topics that go beyond the scope of the test. In order to broaden coverage, 15 test items addressing energy, momentum and rotational dynamics have been created to fit seamlessly with the FCI. An Item Response Theory (IRT) analysis reveals that our new test items compliment the FCI items in terms of difficulty, and allow for a more complete picture of student ability to master concepts in the semester-long course. In addition to the Rasch model results, we will present utility of the new items for inquiry-based physics courses.

EC10 5:00-5:10 p.m. Student Ability to Apply Superposition to Interference of Light

Contributed – Tong Wan, University of Washington, Department of Physics, Box 351560, Seattle, WA 98195-1560; tongwan@uw.edu

Peter S. Shaffer University of Washington

The Physics Education Group at the University of Washington has been investigating introductory students' understanding of interference of light for many years. A sequence of tutorials has been developed and has proven to be effective at addressing several difficulties that students encounter while applying superposition to interference of light. However, we have found that some errors persist even after lecture and tutorial instruction. We present preliminary results from an introductory optics course to demonstrate some of these errors.

EC11 5:10-5:20 p.m. Inquiry-based PD: Influence on Self-efficacy in Teaching Math through Physics

Contributed – L. J. Clark, University of Tennessee, 7238 Austin Park Lane, Knoxville, TN 37920; dr.jenevaclark@utk.edu

Peggy Bertrand, Jonathan M. Clark, University of Tennessee

In this study, when mathematics teachers (n=20) were provided professional development pertaining to physics content, their physics content knowledge improved, as did their self-efficacy in teaching mathematics through physics. However, this analysis reveals these two gains were not significantly correlated. Also, this study examines what components of self-efficacy. For example, technology and equipment concerns were somewhat alleviated by the training, and teachers gained confidence to anticipate, detect, and remediate student physics-related errors. These results have practically significant implications for cross-curricular STEM professional development design and implementation, while revealing theoretically significant nuances in the development of teacher knowledge.

Session ED: Professional Skills for Graduate Students (Panel)

Location: Royal Palm One/Two **Sponsors:** Committee on Research in Physics Education, Committee on Graduate Education in Physics
Time: 3:30-5:30 p.m. **Date:** Monday, January 8 **Presider:** Lisa Goodhew

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 Graduate Student Topical Discussions. Topics covered may include: preparing for careers after graduate school, becoming integrated with the community, developing research skills, and disseminating your work. While this session is aimed toward graduate students, we welcome undergraduates who are interested this professional development opportunity or curious about life as a graduate student!

Panelists:

Mel Sabella, Chicago State University, Chicago, IL

Homeyra Sadaghiani, California State Polytechnic University, Pomona

Session EE: Putting It All Together: Supporting Young Physics Learners (Panel)

Location: Tiki Pavilion **Sponsors:** Committee on Physics in Pre-High School Education, Committee on Diversity in Physics
Time: 3:30-5:30 p.m. **Date:** Monday, January 8 **Presider:** Shane Wood

EE01 3:30-3:50 p.m. Supporting Underrepresented Elementary Students in Science: Overcoming the Challenges

Panel – Sharon G. Fargason, Baker Elementary School, 4041 T St., San Diego, CA 92113; sharonfargason@gmail.com*

Diversity in STEM fields continues to be an issue of great concern to the scientific community. While many current efforts attempt to entice older students into studying science, the elementary classroom is often overlooked as a rich and valuable place where success among diverse learners can occur. However, work in two urban elementary schools serving students who are historically underrepresented in scientific fields reveals that quality science instruction not only builds students' knowledge and skills, but also develops perseverance, self-efficacy, and agency in young students. Additionally this work with students who were largely English Language Learners showed that creating a rich environment for authentic inquiry increased talk and critical thinking, often helping students to strengthen their linguistic skills. This talk, given by an elementary school teacher, will focus on how scientific inquiry enhanced the opportunities for diverse learners in an elementary science classroom.

*Sponsored by Fred Goldberg

EE02 3:50-4:10 p.m. Phun with Physics – Graphing Motion with Toy Cars

Panel – David B. Warner, Rancho Santa Fe School District, P.O. Box 1772, Rancho Santa Fe, CA 92067-1772; dwarner@rsf.k12.ca.us

Using battery-powered toy cars or carts and tracks with a PASCO motion sensor, middle school students can graph position and velocity graphs and make a physical connection with topics in their math classes. Most MS students are exposed to linear equations and some to quadratics, but don't make a physical connection to the mathematics until HS physics. However, they are perfectly capable of understanding these concepts when exposed to them in a fun way.

EE03 4:10-4:30 p.m. Physics in Elementary School: Professional Development Models for K-5 Teachers and Principals

Panel – Katya Denisova, Baltimore City Public Schools, 200 E North Ave., Baltimore, MD 21202; kdenisova@gmail.com

STEM Achievement in Baltimore Elementary Schools (SABES) is a six-year partnership between Johns Hopkins University and Baltimore City Public Schools district (Maryland), funded by NSF. SABES' goal is to increase instructional time spent on Physics (within the scope of NGSS Science curriculum) in early grades, and significantly raise the quality of teaching and learning by providing job-embedded professional development opportunities and instructional support in schools servicing low income students. I will share our successes and challenges with curriculum design, instructional mentoring, and Professional Development with an emphasis on the course we have designed for school principals.

EE04 4:30-4:50 p.m. Supporting Young Learners and their Teachers

Panel – Sharon F. Kirby, University of West Georgia, 1857 Burfordi Dr., Marietta, GA 30008; sfkirby@bellsouth.net

Shane Wood QuarkNet

Physics learning should begin at the earliest possible age and continue throughout the students' educational career. Elementary teachers are our best hope. I have helped lead workshops for elementary teachers over the past 12 years and taught pre-education students for four years. All workshops and classes are very interactive and the feed-back and observations show the support of the students by their teachers. The students are enthusiastic and show a love of physics.

EE05 4:50-5:10 p.m. A First Course in Learning How to Think

Panel – M Colleen Megowan-Romanowicz, Am. Modeling Teachers Association, 5808 13th Ave., Sacramento, CA 95820; colleen@modelinginstruction.org

Middle school is sometimes regarded as a wasteland with respect to science education. Most states require minimal science content preparation to teach 7th and 8th grade science, and many middle school science teachers have never taken a physics course—not even in high school. Against this backdrop, teachers are expected to address the science and engineering practices, crosscutting concepts and disciplinary core ideas set forth in the NGSS. The pressure is intense. For 25 years Modeling Workshops have provided in-service physics teachers with effective pedagogy. In the past 15 years, they have provided content preparation for underprepared HS physics teachers as well. This led to the development of content-focused Modeling Workshops and curriculum resources especially designed for Middle School teachers. This presentation will outline the approach used to teach middle school teachers the necessary physics, as well as the pedagogy, to prepare their students to succeed in high school physics.

All Speakers: Panel Discussion 5:10-5:30 p.m.

Session EF: Integrating Computation with the PICUP Collection

Location: Sunset **Sponsors:** Committee on Educational Technologies, Committee on Physics in Undergraduate Education
Time: 3:30-5:20 p.m. **Date:** Monday, January 8 **Presider:** Marie Lopez del Puerto

EF01 3:30-3:50 p.m. Highlights from the PICUP Collection: The Rigid, Three-Bar Pendulum

Invited – Ernest Behringer, Eastern Michigan University, Dept Physics and Astronomy, 104 Roosevelt Hall, Ypsilanti, MI 48197; ebehringe@emich.edu

While developing computational exercise sets (CES) for the PICUP collection, it seemed useful for some CES to be based on systems with limiting-case, analytical solutions that could also be tested experimentally and affordably. The CES focused on the rigid, three-bar pendulum is such an exercise set. This physical pendulum consists of a central bar to which two additional bars are attached symmetrically. The additional bars are identical to one another, but not necessarily to the central bar. Different implementations of this CES for use in the classroom and the laboratory will be discussed, and connections to both the AAPT Computational Physics Recommendations and AAPT Laboratory Recommendations will be noted.

EF02 3:50-4:10 p.m. Discovery of New Physics Through Computation

Invited – Joshua Samani, UCLA, 475 Portola Plaza, Los Angeles, CA 90095; jsamani@physics.ucla.edu

Integrating computation into the physics curriculum affords students an opportunity to discover new physics by exploring the behaviors of complex physical systems. We present a concrete prototype for a computational exercise set in which students leverage numerical methods to discover an important, physically relevant mathematical concept: normal modes of oscillation, and we demonstrate how a computational exercise set can be structured to facilitate sensemaking and metacognition through this process of discovery.

EF03 4:10-4:30 p.m. Projectile Motion Experiment and Computational Model

Invited – Todd Zimmerman, University of Wisconsin - Stout, 410 10th Ave. E, Menomonie, WI 54751; zimmermant@uwstout.edu

Having students relate experimental results to computational models is an important skill for any physics student. I will discuss an introductory physics lab on projectile motion where students compare the results of a computational model to experimental data. I will also discuss two other experiment/computational modeling activities.

EF04 4:30-4:50 p.m. Numerical Solution of the Perturbatively Nonlinear Vibrating String

Invited – Walter Freeman, Syracuse University, 215 Physics Building, Syracuse, NY 13244; wafreema@syr.edu

While computation can enhance student understanding of the usual curriculum, computational physics pedagogy is at its best when it is used to unlock entirely new modes of thought that are otherwise inaccessible to students. Intermediate students can simulate a vibrating string using a lattice-elasticity model. At low amplitude, the familiar behavior of standing-wave patterns is apparent; however, at high amplitude, naturally appearing nonlinearities cause an amplitude-dependent perturbation of the frequencies of oscillation that can be verified empirically with a real stringed instrument. While students can use these simulations to both better understand the standard normal-mode behavior of the vibrating string, they can also explore the nonlinear behavior, something inaccessible in the standard curriculum. This both allows them to explore new phenomenology and gain an appreciation for the meaning of perturbation theory in an environment free from the analytical difficulties of its usual place in physics pedagogy.

EF05 4:50-5:00 p.m. Integrating Computation into an Electricity and Magnetism Course

Invited – Jordan McDonnell, Francis Marion University, 4822 E Palmetto St., Florence, SC 29501; jmcdonnell@fmarion.edu

The traditional approach to undergraduate electricity and magnetism relies on students having an increasing level of comfort with vector calculus and solving partial differential equations. While essential, problems with a closed-form, analytical solution are a small subset of all interesting electromagnetic phenomena, and those closed-form solutions can be challenging to comprehend. This talk will describe the use of computational exercises to complement the analytical approach to introductory electricity and magnetism. First, computational tools will be shown to play a valuable role in visualizing complicated analytical solutions, such as those obtained by separation of variables in electrostatics. Second, the use of computational tools to extend students' reach into more complicated phenomena, including the motion of charged particles in interesting non-uniform magnetic fields will be discussed. Finally, the development and classroom use of several PICUP Exercise Sets related to this topic will be described.

EF06 5:00-5:20 p.m. Overview of the Most Introductory Content on the PICUP Collection*

Invited – Chris Orban, Ohio State University, 191 W Woodruff Ave., Columbus, OH 43210 orban@physics.osu.edu

Richelle Teeling-Smith. University of Mount Union

Chris Porter, Ohio State University

Introductory physics courses at the high school and early-college level can benefit from integrating computation with traditional activities. We will describe activities that are appropriate for this level which are available on the PICUP website. The goals of these activities differ in a number of ways from computational content in more advanced physics courses, and there are a number of additional barriers to consider for the widespread adoption of content at this level. As will be discussed, at this level it is important to provide coding activities with very concisely written codes that produce interactives that resemble those available from PhET and other sites. In this way, coding activities can contribute to both computational thinking and conceptual understanding.

*Funding from the STEMcoding project (u.osu.edu/stemcoding) and the AIP Meggers Award

Session EG: The Physics of the NSF IUSE Program

Location: Pacific Salon Two **Sponsor:** Committee on Physics in Undergraduate Education **Time:** 3:30- 5:30 p.m. **Date:** Monday, January 8
Presider: Kevin Lee

EG01 3:30-4:00 p.m. University Student Conceptual Resources for Understanding Forces and Mechanical Waves*

Invited – Amy D. Robertson, Seattle Pacific University, 3307 Third Ave. W, Suite 307, Seattle, WA 98119-1997; robertsona2@spu.edu

Lisa M. Goodhew, Paula R. L. Heron, University of Washington

Rachel E. Scherr, Seattle Pacific University

Research documenting common student ideas in physics has historically focused on misunderstandings, misconceptions, or difficulties – i.e., ways in which student ideas are discontinuous with canonical understandings. In our NSF-funded IUSE project, we are identifying common student resources for understanding physics – i.e., ways in which student ideas are continuous with canonical understandings. In this talk, we will share some of the patterns in student responses that indicate resources for understanding forces and mechanical waves and describe how instructors might build on these resources in introductory physics courses.

*This material is based upon work supported by the National Science Foundation under Grant No. DUE-1608510.

EG02 4:00-4:30 p.m. Research as a Base to Develop Adaptable Curricula in Quantum Mechanics

Invited – Gina Passante, California State University Fullerton, Physics Department, 800 N. State College Blvd. Fullerton, CA 92831; gpassante@fullerton.edu

Homeyra Sadaghiani California Polytechnic University Pomona

Steven Pollock University of Colorado Boulder

Student understanding of quantum mechanics has been a topic of increasing interest to physics education researchers. Most of the research and curriculum development has taken place in the context of position-first instruction, where wave functions are typically the first quantum states students encounter. This is in contrast to spins-first instruction, where students are introduced to quantum mechanics in the context of spin-1/2 system. Our collaborative IUSE project studies the differences in student understanding in these two popular instructional paradigms: spins-first and position-first. Project goals include developing and assessing curricula that are specifically tailored to each instructional context, and researching student learning (and challenges to learning) in the two paradigms. In this talk I will give an overview of the project, describe the results of a national conversation on learning goals for QM, and provide information on how you and your colleagues can participate.

EG03 4:30-5:00 p.m. Transforming IPLS Instruction through an Online Resource and Collective Action*

Invited – Edward F. Redish, University of Maryland Department of Physics, College Park, MD 20742-4111; redish@umd.edu

Chandra Turpen, University of Maryland

Sarah McKagan, American Association of Physics Teachers

Sandy Martinuk, Teresa Neal Strategy and Design

Faculty routinely use the internet to search for teaching resources. However it's often difficult to find resources that fit their class and students. This is particularly true for IPLS classes where diverse student populations and topics make many different courses possible. In this talk we give an overview of how the multi-university IUSE project, Living Physics, is deploying a user-centered design process to build an online database of IPLS resources and an interactive community of educators and contributors. We give an overview of the planned portal components, and share some ideas on models for nucleating and nurturing contributions and community.

*Work supported in part by NSF grant DUE1624478

EG04 5:00-5:30 p.m. Identifying and Addressing Students' Mathematical Difficulties in Introductory Physics Courses*

Invited – David E. Meltzer, Arizona State University, ASU, Mesa, AZ 85212; david.meltzer@asu.edu

Instructors in introductory physics courses frequently complain that students' skills with basic mathematical operations are inadequate, despite prerequisite mathematics courses. Through use of written diagnostic tests (administered to more than 1300 students) and over 60 individual interviews with students in both algebra- and calculus-based courses, we have documented high error rates on problems involving basic trigonometry, vector addition, and algebra. Both carelessness and skill-practice deficits are evident factors. Consistent with other research, we found that students confronted by symbolic equations are often unable to carry out operations that they perform successfully with numbers, perhaps due to mental "overload" from symbols and functions rarely encountered in mathematics courses. An inability to efficiently access previous learning is also frequently evident. I will provide an overview of our investigation, and describe some of the initial strategies and materials we are developing to address these mathematical difficulties within the context of physics courses themselves. *Supported in part by NSF DUE #1504986

Session EH: Upper Division/Graduate Courses

Location: Royal Palm Five/Six **Sponsor:** AAPT **Time:** 3:30-5:10 p.m. **Date:** Monday, January 8 **Presider:** Larry P. Engelhardt

EH04 4:00-4:10 p.m. Double-Slit Interference: To See or Not To See

Contributed – David P. Jackson, Dickinson College, Dept. of Physics, Carlisle, PA 17013-2896; jacksond@dickinson.edu

Brett J. Pearson, Natalie G. Ferris, Hongyi Li, Dickinson College

Double-slit interference is a standard topic in the undergraduate curriculum, and one that is easily observed using a Helium-Neon laser as the light source. Such a laser is an excellent approximation of monochromatic plane waves, which is equivalent to a point source of (monochromatic) light that is very far away. But what does the interference pattern look like for an extended (non-point) source of light? Here we discuss some simple experiments that are designed to illustrate how an extended light source affects the interference pattern observed.

EH05 4:10-4:20 p.m. Education Research in Graduate Quantum Mechanics: Misunderstandings and Intervention

Contributed – Christopher D. Porter, The Ohio State University, 191 W. Woodruff Ave., Columbus, OH 43210; porter.284@osu.edu

Andrew F. Heckler, The Ohio State University

Compared to introductory courses, upper division and graduate-level courses have not been as widely studied by the PER community. But such studies are integral to our field, as these are the courses most densely populated by future experts and even future faculty. A study of graduate students' difficulties in quantum mechanics at The Ohio State University is currently in its fourth year, as is an effort to improve these students' conceptual understanding of quantum mechanics through active learning. This talk will provide some context for the project by giving some historical data on enrollment and attrition, and more current data on attitudes and motivation. The focus of the talk will be the misunderstandings uncovered by pre-post testing of three cohorts, and efforts to improve conceptual understanding through, among other things, guided group work sessions. Misunderstandings related to wave functions, approximation methods, and measurements will be discussed.

EH06 4:20-4:30 p.m. Off-Resonance Pulsed NMR

Contributed – David B. Pengra, University of Washington, Department of Physics, Box 351560, Seattle, WA 98195; dbpengra@phys.washington.edu

Since the Model PS1 introduced by TeachSpin in 1994, apparatus for studying pulsed nuclear magnetic resonance (PNMR) in liquids has become widely available among undergraduate physics laboratories. Students learn to understand PNMR signals, such as free-induction decay (FID) and spin echoes, to be a consequence of collective spin dynamics within a rotating reference frame (coincident with a precessing spin). Although the spin dynamics are easiest to comprehend with the applied RF pulse tuned to the spin resonance, a number of testable predictions are easily explored by detuning the RF frequency off resonance. From the geometry of off-resonance dynamics, one can predict pulse widths necessary to produce maximal FID signals and spin echoes, plus the amplitude of these signals, as a function of RF detuning. I will show how the geometrical construction leads quickly and visually to a number of qualitative predictions, and yields a complete quantitative description of observable measurements. These experiments offer another dimension of NMR for students to explore and can be carried out using existing apparatus with little to no extra hardware.

EH07 4:30-4:40 p.m. Quantum Mechanics Lessons from Delta Function Wells in Multiple Dimensions

Contributed – Kevin L. Haglin, St. Cloud State University, 720 Fourth Ave. South, St. Cloud, MN 56301; klhaglin@stcloudstate.edu

Joseph Harter, Benjamin Boe, Sutapa Biswas, St. Cloud State University

We discuss physically acceptable solutions to the Schrodinger equation in the presence of point-like delta function wells. Solutions in two and three dimensions are developed. Superposition of delta function wells within finite and infinite boxes in one and higher dimensions is then explored for negative, zero, and positive energy solutions. Rich Eigenstructures emerge which provide new insights for applications to quantum mechanical systems over a range of physical configurations.

EH08 4:40-4:50 p.m. The Ruby Phosphorescence Upper-division Laboratory Revisited

Contributed – Anthony G. Calamai, Appalachian State University, Department of Physics and Astronomy, Boone, NC 28608; calamaiag@appstate.edu

Julia Hinds, William Dulaney Tyler Dula, Brooke C. Hester, Appalachian State University

Many existing advanced laboratory experiences associated with the metastable doublet-E term of Cr IV in ruby, which gives rise to the R-lines at 692.7 and 694.3 nm, focus on a room-temperature measurement of the radiative lifetime of the doublet-E term. In our work developing a laboratory experience in atomic phosphorescence, we noted a lack of consistency in the literature for the lifetime of the Cr IV doublet-E term. These projects typically use commercially available ruby spheres for which the manufacturer(s) only state an ~2% Cr IV concentration. The uncertainty in concentration represents one source of systematic error for this laboratory experience. We present our results and corrections for systematic issues that make this project a more rewarding experience for students. Our result for the room-temperature radiative-lifetime for the doublet-E term is 3.3(0.1) ms.

EH10 5:00-5:10 p.m. A Web-based Simulation of Subatomic Particle Decays

Contributed – Ken A. Kiers, Taylor University, 236 West Reade Ave., Upland, IN 46989-1001; knkiers@tayloru.edu

Subatomic particle decays provide an excellent platform for students to study the conservation of energy and momentum within a relativistic context. We have developed a web-based application that simulates the decays of subatomic particles in a magnetic field inside a wire chamber. This simulation serves as a laboratory exercise in a sophomore-level Modern Physics course. In the simulation, charged particles follow circular tracks, registering "hits" as they pass close to wires in the wire chamber. Students use the software to fit circles to locations that have registered a hit. Properties of the circle can then be used to determine the momentum of the associated particle. Students work offline to determine the identities of various unknown particles by implementing relativistic energy and momentum conservation. The students' data is saved in a database and a TA module can be used to grade the students' work. The simulation is publicly available.

URL: particle-tracks.physics.taylor.edu

Session EI: History of Physics and Physics Education Research in Latin America

Location: California Room **Sponsors:** Committee on International Physics Education, Committee on Research in Physics Education
Time: 3:30-4:30 p.m. **Date:** Monday, January 8 **Presider:** Juan Burciaga

EI01 3:30-4:00 p.m. A History of Physics in Puerto Rico

Invited – Idalia Ramos, University of Puerto Rico at Humacao, 100th Rd 908, Humacao, PR 00792-860 idalia.ramos@upr.edu

Higher education in Puerto Rico was imparted in semi-ecclesiastical institutions since 1562 (the first equipped with a chemistry and physics education laboratory in 1843) until the late 19th century. The University of Puerto Rico (UPR) was founded in 1903. In 1909, UPR was made a Land Grant College, adopted the curricular model of the USA, and started evolving into a multi-campus system. Physics degree programs were established in the 1940s at Río Piedras and Mayaguez campuses. In the 1950s and 60s, researchers came to Puerto Rico to work at the recently inaugurated Nuclear Center and Arecibo Observatory, and graduate programs were created. My talk will include a summary of historical events that led to the development of the materials research group at UPR-Humacao and the legacy of the faculty who mentored several generations of physicists (male and female) committed to education and research, with a strong sense of social responsibility.

EI02 4:00-4:30 p.m. Physics, Physics Education and Physics Education Research in Latin America

Invited – Genaro Zavala, Tecnologico de Monterrey, Pedregal Del Acueducto 5541, Monterrey, NL 64898 Mexico genaro.zavala@itesm.mx

There are countries or regions in which the Physics, Physics Education, and Physics Education Research (PER) communities are working together in the advancement of this science. In a successful relationship, the physics community cares for the education of physics and develop programs within the physics professional associations to help physics educators to teach better this science. Moreover, the physics community has integrated PER as a branch of their larger community since they consider that the investigation in the education of physics is a research line of physics. Lastly, the PER community supports physics teachers producing results that are brought to the classroom and enhance students' understanding and appreciation of physics. However, there are countries in Latin America in which the relationship among these disciplines are far from being a successful one. This contribution will describe some cases of Spanish-speaking countries regarding this topic.

Special Session: Gemant Lecture by Don Lincoln

Location: Fleet Center (Offsite) **Sponsor:** AIP **Time:** 6–8 p.m. **Date:** Monday, January 8
Buses depart at 6 p.m.

Don Lincoln

God's Thoughts: The Modern Search for a Theory of Everything

by Don Lincoln, Fermilab

The ultimate goal of physics is to invent a theory of everything, which explains all of creation from first principles – with extra credit if the theory's equation can fit on a t-shirt. In popularized science literature, one encounters speculative theories that might fit the bill…ideas like superstrings, or an envisioned unification of known forces into a single, underlying force. Other authors imagine the wedding of the standard model of the quantum realm with the cosmic realm of Einstein's general relativity. However, physics is an empirical science. Proposals need verification and research needs a credible path forward. And the energy scale at which a theory of everything is imagined to reign is 15 orders of magnitude higher than can currently be tested in the laboratory. This is an ambitious goal to be sure and the next step is not at all clear. In this lecture, Fermilab's Dr. Don Lincoln will sketch out a realistic roadmap: where we've come and where we still must go. He will give you a realistic sense of what strides the research community is taking on this grandest of scientific journeys.

Session FA: Science and the Great War: On the Centenary of World War I

Location: Royal Palm One/Two **Sponsor:** Committee on History and Philosophy in Physics **Time:** 7:00-8:10 p.m. **Date:** Monday, January 8
Presider: Joanna Behrman

FA01 7:00-7:30 p.m. Radiology, Physics and WWI

Invited – Vivien Hamilton, Harvey Mudd College, 301 Platt Blvd., Claremont, CA 91711; vhamilton@hmc.edu

Following the discovery of x-rays in 1895, doctors were instantly captivated by the potential for this new radiation to diagnose fractures, to locate foreign bodies and to treat tumors and skin diseases. Yet despite widespread enthusiasm, and the ready availability of equipment, x-ray use was initially quite uneven in hospitals and clinics in the United States. The advent of WWI changed this dramatically. War created an unprecedented demand for x-ray equipment, spurring the development of portable x-ray units and x-ray film. The number of medical personnel with x-ray experience jumped dramatically, and these newly expert individuals helped begin to shape radiology as a distinct medical specialty. New training programs emerged emphasizing the importance of physics to the education of a radiologist, providing a expanded role for physicists as teachers in medical schools. In this talk I will consider the impact of this new attention to physics on questions of safety and measurement in radiology.

FA02 7:30-8:00 p.m. WWI and the Ideal of Scientific Internationalism

Invited – Tal Golan, University of California, San Diego, Department of History 0104, 9500 Gilman Dr., La Jolla, CA 92093; tgolan@ucsd.edu

During WWI, scientists who had worked together harmoniously faced the question of how to respond to close colleagues instantly transformed into enemies. In my talk, I will discuss how leading physicists from various European countries responded to this dilemma, both on the personal and the institutional levels. I will also examine the effects of the Great War on the prevalent pre-war ideal of scientific internationalism, which portrayed science as a shared enterprise that builds bridges between countries, fostering progress and peace.

FA03 8:00-8:10 p.m. The Non-Warrior Paradox: A Search for Pacifist Physicists from WWI Until Our Present Day

Contributed – Svilen D. Kostov, Georgia Southwestern State University, 800 GSW State University Dr., Americus, GA 31709; skostov@gsw.edu

One of the great scientific triumph stories of the 20th century was the 1919 experimental confirmation of Einstein's general theory of relativity by Arthur Eddington and crew. Eddington's sheer resolve during the astronomical expeditions is often attributed to his intention to demonstrate scientific cooperation between the recently warring countries of England and Germany. His fellow pacifist Albert Einstein and his revolutionary theory was the perfect opportunity to bring attention to the cause of peace through science in a time ravaged by war and its aftermath. Why were these famous scientist the exception rather than the rule? How has pacifism in physics faired in the century that followed? How is it related to social and political activism within the physics community? This paper aims to offer some thoughts on these and related questions by looking at a few key examples.

Session FB: Best Practices in Educational Technology

Location: Pacific Salon One **Sponsor:** Committee on Educational Technologies **Time:** 7:00-8:30 p.m. **Date:** Monday, January 8
Presider: Jeff Groff

FB01 7:00-7:30 p.m. The Development and Assessment of MyTech: A Mobile Laboratory App

Invited – Colleen Countryman, Ithaca College, 953 Danby Rd., Ithaca, NY 14850; 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. We will discuss how students directly guided the development of the app, and how we determined the impact of the use of smartphones and our app in the lab over the course of a four year study. We will discuss these results and how instructors can utilize the app and curriculum in their own classroom.

FB02 7:30-8:00 p.m. Implementing At-Home Labs Using the IOLab System

Invited – Mats Selen, University of Illinois, Department of Physics, 1110 W. Green St., Urbana, IL 61801; mats@illinois.edu

IOLab is affordable wireless lab system that allows students to do physics experiments anywhere they can take a laptop computer. Several physics education research groups are exploring innovative ways in which this freedom can be used to both complement in-class labs (as with the pre-lab activities being developed at the University of Illinois), and to replace in-class labs (as in the on-line courses being developed at other institutions). This presentation will review the IOLab system and its built-in content-delivery and lab-report tools, and will highlight the innovative pedagogy and lesson development work being done by several collaborating institutions in their quest for effective at-home labs.

FB03 8:00-8:30 p.m. Using Jupyter Notebook for Computational Thinking

Invited – Aaron P. Titus, High Point University, One University Parkway, High Point, NC 27268; atitus@highpoint.edu

Zackary L. Hutchens, High Point University

The 2016 AAPT UCTF Computational Physics Report titled "AAPT Recommendations for Computational Physics in the Undergraduate Physics Curriculum," provides recommendations that students learn computing skills and computational physics skills, including the ability to process data, represent data visually, and prepare documents and presentations that are "authentic to the discipline." To meet these goals, we recommend Jupyter Notebook. Jupyter enables students to weave a rich narrative with data and code. By writing in markdown or HTML, students can interlace hypertext, equations (typed in LaTeX), images, videos, pdfs, and other media with runnable code written in Python, R, Julia, or other languages. The outcome is a digital story—or narrative. In this presentation, we will demonstrate our students' use of Jupyter Notebook to create a "story" in homework problems, exam problems, laboratory experiments, and research projects. We will also describe and emphasize Lorena Barba's vision of computational thinking and will show how this can be implemented throughout the physics curriculum.

Session FC: Culturally Sensitive Mentoring

Location: Tiki Pavilion **Sponsors:** Committee on Diversity in Physics, Committee on Women in Physics
Time: 7:00-8:30 p.m. **Date:** Monday, January 8 **Presider:** Juan Burciaga

FC01 7:00-7:30 p.m. Culturally Sensitive Mentoring

Invited – Ximena C. Cid, CSU Dominguez Hills, 1000 E. Victoria St., Dept. of Physics, Carson, CA 90747; ximena.c.cid@gmail.com

What is culturally sensitive mentoring? How does one practice mentoring across various cultures? In order to answer these questions, culture must be unpacked and defined. This talk will describe various ways in which culture is used in physics spaces as well as give the audience opportunities to explore their own role when mentoring diverse populations.

FC02 7:30-8:00 p.m. Mentoring for Success

Invited – Hakeem M. Oluseyi, Florida Institute of Technology, 150 W University Blvd, Olin Physical Sciences, Melbourne, FL 32901; holuseyi@fit.edu*

It's been stated that one of the main jobs of a parent is to help one's children to discover their power. The same is true in mentoring. The physics community is embedded in a larger society where one of the great evils is identity hierarchy. There are hierarchies of race, sex, income, gender, education, sexuality, religion, and more. As a result of this identity hierarchy, those near the bottom of the "hierarchy ladder" must overcome both internal and external challenges. Working in our favor is the fact that the hierarchy is false. Those at the bottom are as intelligent, talented, and of sound character as anyone else. In this talk, I will share techniques that I have developed over more than 25 years of mentoring diverse students in the U.S. and Africa that have resulted in producing successful working scientists and engineers.

*Sponsored by Juan Burciaga

FC03 8:00-8:30 p.m. What Did I Know?

Invited – Linda Fritz, Franklin & Marshall College, PO Box 3003, Lancaster, PA 17604-3003; linda.fritz@fandm.edu

"What does a 60-year-old white woman from Lancaster, PA, know about mentoring multi-cultural 18-year-olds from the largest city in the U.S.?" This is the question I had when I agreed to be the mentor for a New York City Posse at Franklin & Marshall College. According to the Posse Foundation website, "Posse is one of the most comprehensive and renowned college access and youth leadership development programs in the United States." "Founded in 1989, Posse identifies public high school students with extraordinary academic and leadership potential who may be overlooked by traditional college selection processes. Posse extends to these students the opportunity to pursue personal and academic excellence by placing them in supportive, multicultural teams – Posses." I will discuss how we learned and grew together and share thoughts on how I managed to reach outside of my cultural comfort zone and connect to the students.

Session FD: Interactive Lecture Demonstrations: Whats New? ILDs Using Clickers and Video Analysis

Location: Pacific Salon Two **Sponsors:** Committee on Research in Physics Education, Committee on Educational Technologies
Time: 7:00-8:10 p.m. **Date:** Monday, January 8 **Presider:** Kathy Koenig

FD01 7:00-7:30 p.m. ILDs in Electric Circuits and Optics: Active Learning in Lecture Including Clickers and Video Analysis

Invited – Kathleen Koenig, University of Cincinnati, Dept. of Physics, 345 Clifton Ct., Cincinnati, OH 45221; koenigkn@ucmail.uc.edu

Ronald K. Thornton, Tufts University

The results of physics education research and the availability of microcomputer-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 participation Suite materials designed to promote active learning in lecture—Interactive Lecture Demonstrations (ILDs)[2], including those using clickers and video analysis. The examples of ILDs in this session will be from electric circuits and optics.

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).

FD02 7:30-8:00 p.m. Interactive Lecture Demonstrations: Effectiveness in Teaching Concepts

Invited – Ronald K. Thornton, Tufts University, 12 Temple St., Medford, MA 02155; ronald.thornton@tufts.edu

David R. Sokoloff, University of Oregon

The effectiveness of Interactive Lecture Demonstrations (ILDs) in teaching physics concepts has been studied using physics education research based, multiple-choice conceptual evaluations.[1] Results of such studies will be presented, including studies with clicker ILDs. These results should be encouraging to those who wish to improve conceptual learning in their introductory physics course.

1. David R. Sokoloff and Ronald K. Thornton, "Using Interactive Lecture Demonstrations to Create an Active Learning Environment," Phys. Teach. 35, 340 (1997).

FD03 8:00-8:10 p.m. How to Implement ILDs Using a Non-Traditional Introductory Textbook

Contributed – Timothy A. Duman, University of Indianapolis, Dept. of Physics and Earth-Space Science, Indianapolis, IN 46227-369; zduman@uindy.edu

This talk will explore the use of Interactive Lecture Demonstrations (ILDs) while teaching with the non-traditional Matter and Interactions (M & I) textbook (Volume I, Modern Mechanics). The book is designed around three core principles (Momentum, Energy and Angular Momentum). It applies these principles to many of the physics concepts found in a traditional text as well as others that are not often mentioned. For this reason the terminology used in M & I is often different when compared to a traditional text. The ILDs' traditional terminology has been edited to fit with the M & I terminology. The presentation will describe these changes and how they improved student understanding of physics concepts.

Session FE: New Developments in Graduate Core Courses and Graduate Education

Location: Pacific Salon Three **Sponsors:** Committee on Graduate Education in Physics, Committee on Research in Physics Education
Time: 7:00-8:00 p.m. **Date:** Monday, January 8 **Presider:** Chandralekha Singh

FE01: 7:00-7:30 p.m. Helping Graduate Students Become Physicists: Core Courses and Beyond*

Invited – Alexandru Maries, University of Cincinnati, 345 Clifton Court, Cincinnati, OH 45221; mariesau@ucmail.uc.edu

Chandralekha Singh, University of Pittsburgh

Much of physics education research (PER) has focused on undergraduate students' learning; in contrast, much fewer studies have investigated graduate students' learning as well as productive approaches to helping them learn to think like a physicist and be successful in their graduate courses and research. In this talk I will discuss multiple research studies that have looked at graduate students' conceptual understanding of physics and their understanding and ability to troubleshoot commonly used lab equipment (lock-in amplifier). We have learned a great deal from the multitude of research studies in introductory and advanced physics about how people learn in general and learn physics in particular, and many of the same approaches (e.g., using research-based self-paced learning tools) can be productive for graduate students as well. I will discuss several concrete examples of effective instructional tools and provide food for thought for potential subsequent research avenues in graduate education.

*We thank the National Science Foundation for supporting this work.

FE02 7:30-8:00 p.m. Education Research in Graduate Quantum Mechanics: Misunderstandings and Intervention

Invited – Christopher D. Porter, The Ohio State University, 191 W. Woodruff Ave., Columbus, OH 43210; porter.284@osu.edu

Andrew F. Heckler ,The Ohio State University

Compared to introductory courses, upper division and graduate-level courses have not been as widely studied by the PER community. But such studies are integral to our field, as these are the courses most densely populated by future experts and even future faculty. A study of graduate students' difficulties in quantum mechanics at The Ohio State University is currently in its fourth year, as is an effort to improve these students' conceptual understanding of quantum mechanics through active learning. This talk will provide some context for the project by giving some historical data on enrollment and attrition, and more current data on attitudes and motivation. The focus of the talk will be the misunderstandings uncovered by pre-post testing of three cohorts, and efforts to improve conceptual understanding through, among other things, guided group work sessions. Misunderstandings related to wave functions, approximation methods, and measurements will be discussed.\

Session FF: Remembering Tony French

Location: Royal Palm Three/Four **Sponsors:** Committee on the Interests of Senior Physicists, Committee on History and Philosophy in Physics
Time: 7:00-8:30 p.m. **Date:** Monday, January 8 **Presider:** Lila Adair

FF01 7:00-7:30 p.m. Anthony Philip French (1920-2017): Physicist and Teacher

Invited – Charles H. Holbrow, 231 Pearl St., Cambridge, MA 02139-4510; cholbrow@colgate.edu

Tony French was singularly committed to the importance of physics teaching. He appreciated Jerrold Zacharias' assertion that a good physics teacher is as important to a physics department as a good researcher. French was a skilled lecturer, a thoughtful user and deviser of lecture demonstrations, and the author of five valuable textbooks. He strongly influenced physics teaching at MIT, played a significant role in the international community of physics educators, and was a long-time member and important leader of the AAPT. I will describe his interesting life and his ideas for changes in physics education. French maintained that physics instruction should always build up from experimental observations. He had a particular affection for classical mechanics, but as he came to recognize that its underlying Newtonian ideas are profoundly wrong, he became a strong advocate of changing the content of the introductory physics course to include relativity and quantum phenomena.

FF02 7:30-8:00 p.m. A. P. French at MIT: A Lifetime of Educational Innovations

Invited – Peter A. Dourmashkin, MIT, Room 4-350a 77 Mass Ave., Cambridge, MA 02139; padour@mit.edu

A.P. French was appointed professor of physics at MIT in 1962. In this talk I will describe Prof. French's impact on physics education at MIT and the larger physics community. His impact at MIT began with his work at the Science Teacher Center at MIT and the MIT Education Research Center resulting in the M.I.T. Introductory Physics Series Textbooks. Prof. French was one of the founding members of the Experimental Study Group, an educational study group for a small set of first-year students. Along with Prof. John King, Phil and Phylis Morrison, Tony created a new version of mechanics and electromagnetism in which students built red box desktop experiments for 8.01x and 8.02x. These two experiment-based courses were one of the starting points for the TEAL courses are MIT that were subsequently developed by Prof. John Belcher. Throughout his years at MIT, Prof. French continued to write many influential physics education articles. His work extended beyond MIT, from 1975 to 1981 he was chairman of the Commission on Physics Educational in the International Union of Pure and Applied Physics, and from 1983 to 1986 he was successfully Vice-President, President-Elect, President, and Past President of the American Association of Physics Teachers. Prof. French received the Oersted Award in 1989. He retired form MIT in 1991 but remained active in the community of physics educators. In 1993 he chaired the committee that set the examination for the XXIV International Physics Olympiad.

FF03 8:00-8:30 p.m. A.P. French from Another Side

Invited – Martin French, Baltimore City Planning Department, PO Box 25690, Baltimore, MD 21224-0390; martin.french@baltimorecity.gov

Jillian F. Peck

We will be sharing a few stories of life and times of and with my father. Some of his work was partially done at home, where we got to see (and doubtless interfere a little with) it. His dedication to physics and his dedication to education definitely helped to shape lives, including ours a home.

Session FG: Teaching Ideas for Upper Division Courses

Location: Sunset **Sponsor:** Committee on Physics in Undergraduate Education **Time:** 7:00-8:20 p.m. **Date:** Monday, January 8
Presider: David Jackson

FG01 7:00-7:10 p.m. Engineering Physics Field Session at Mines: Content and Structure

Contributed – Chuck Stone, Colorado School of Mines, Department of Physics - 1232 West Campus Rd., Golden, CO 80401; cstone@mines.edu

Following their sophomore year of studies, engineering physics majors at Colorado School of Mines enroll in the 6-week, 6 credit hour summer course, Field Session Techniques in Physics. The course introduces students to the design and fabrication of engineering physics apparatus and involves intensive individual participation in the design of machined system components, vacuum systems, electronics, optics, and applications of computer interfacing systems and computational tools. It includes supplementary lectures on safety, laboratory techniques, and professional development, along with visits to regional research facilities and industrial plants. This Oral Presentation will outline the Field Session Content and Structure, while an accompanying Poster Presentation will describe Learning Modules and Learning Outcomes in more detail.

FG02 7:10-7:20 p.m. Name the Experiment! Relating Thermal Derivatives with the Real World

Contributed – David Roundy, Oregon State University, Department of Physics, Corvallis, OR 97331; roundyd@physics.oregonstate.edu

Corinne A. Manogue, Oregon State University

When studying thermodynamics, students often struggle to understand the physical meaning of partial derivatives, often believing for instance that the adiabatic and isothermal compressibilities must be identical. We describe a series of activities to help students understand the partial derivatives that arise in thermodynamics. In these activities, students construct thought experiments that would allow them to measure given partial derivatives. These activities are constructed with a number of learning goals in mind. At the most basic, students have an opportunity to engage with operational definitions of thermal quantities, i.e. how to measure or change them. A second learning goal is for students to understand the importance of the quantities held fixed in either a partial derivative or an experiment. Students additionally are given an experimental perspective—particularly when this activity is combined with real laboratory experiments—on the meaning of either fixing or changing entropy.

FG03 7:20-7:30 p.m. Physics vs. Mathematics Classroom Use of Differentials and Thick Derivatives*

Contributed – Tevian Dray, Oregon State University, Dept. of Mathematics, Corvallis, OR 97331; tevian@math.oregonstate.edu

Paul J. Emigh, Elizabeth Gire, David Roundy, Corinne A. Manogue, Oregon State University

Mathematics courses tend to emphasize well-posed problems that are described using symbolic representations, whereas physicists routinely need to determine the appropriate representation(s) based on available information, including experiment. This difference in perspective leads students to treat partial derivatives as limiting ratios "with all other variables held fixed," whereas in thermodynamics the first challenge is often to determine how many quantities are in fact independent. Based on student data, we discuss physics students' difficulties transitioning from purely symbolic computation of partial derivatives as taught in mathematics courses to the expert physicist's use of differentials to identify and relate the appropriate partial derivatives.

* This work was supported in part by NSF grant DUE-1323800.

FG04 7:30-7:40 p.m. Determining Partial Derivatives from Contour Graphs

Contributed – Paul J. Emigh, Oregon State University, 2410 NW Rolling Green Dr., Corvallis, OR 97330-4862; emighp@oregonstate.edu

Corinne A. Manogue, Oregon State University

At Oregon State University, we are developing a learning progression for partial derivatives in undergraduate mathematics and physics courses. One important skill for students in upper-level physics is the ability to determine and interpret partial derivatives from graphical representations of data. We administered an open-ended interview prompt in which students were asked to determine such derivatives from two types of contour graphs with electromagnetic and thermodynamic contexts. We describe the various procedures that students attempted, how productive these procedures proved, and what led students to switch from unproductive to productive strategies.

FG05 7:40-7:50 p.m. Raising Physics to the Surface

Contributed – Robyn Wangberg, Saint Mary's University of Minnesota, 700 Terrace Heights Box #32, Winona, MN 55987; rwangber@smumn.edu

Elizabeth Gire, Oregon State University

Aaron Wangberg, Winona State University

The Raising Physics to the Surface project is developing student-centered activities with carefully engineered tools to help students develop a rich, geometric understandings of physics. The tools include 3D, transparent, dry-erasable surfaces that represent functions of two variables, corresponding contours maps and gradient maps, and inclinometers for measuring slopes on a surface. At this early stage of the project, we are prototyping activities and tools for topics in mechanics, E&M, and thermal physics courses. We present some of this preliminary work, including examples of activities and tools that represent physical systems that are relevant to physics instruction.

FG06 7:50-8:00 p.m. PHYS 370: The Momentum of the Photon

Contributed – Gabriel C. Spalding, Illinois Wesleyan University, 201 E. Beecher St., Bloomington, IL 61701; gspaldin@iwu.edu

I'll discuss the curricular context of a course on the photon, which highlights some of the weirdness of modern physics and clarifies quantum principles that also apply to particles other than the photon, while at the same time reviewing classical electrodynamics, here presented as a story of energy and momentum. In lab, students design, assemble, and test components for applied optical systems appropriate to next-next-generation communications systems, explicitly asking about the information content that might reasonably be associated with a single photon. Students also design, assemble, and test components for experiments involving the linear or angular momentum carried by light, creating applied optical systems appropriate to highly dexterous micromanipulation of various types of micro- and nano-scale samples, requiring discussion (and analysis) of the "violence" associated with thermal fluctuations at the nano-scale, and how recent fluctuation theorems lead us to an appreciation of how an arrow of time emerges.

FG07 8:00-8:10 p.m. Relativity on Rotated Graph Paper: Calculating with Causal Diamonds

Contributed – Roberto Salgado, U Wisconsin La Crosse, 1725 State St., La Crosse, WI 54601; rsalgado@uwlax.edu

We use simple geometrical constructions on rotated graph paper to perform Lorentz-invariant calculations visually. We emphasize two properties of the causal diamond between a pair of events in spacetime: the area represents the square-interval and the aspect ratio represents the square of the Doppler factor. Quantitative results can be read off the diagram by counting boxes, using a minimal amount of algebra. We demonstrate the clock effect/twin paradox and a relativistic collision.

Relativity on Rotated Graph Paper, American Journal of Physics 84, 344 (2016); http://dx.doi.org/10.1119/1.4943251

FG08 8:10-8:20 p.m. Octahedral Skeleton (origami) for Learning Vector Analysis[1]

Contributed – Adebanjo Oriade, University of Delaware, Dept of Physics and Astronomy, Newark, DE 19716; adebanjo@udel.edu

We present an active learning tool, the octahedral skeleton, which makes mastery of vector analysis[2] accessible to more students. By "more students" we mean more than the minority that are competent in spatial and visual (SaV) reasoning. We are making a claim that students with spatial and visual competencies are in the minority, a sample population being students recruited and retained in a physics program. The positive correlation between success in STEM disciplines and SaV competency [1,4] is supported in the literature. The audience will be polled for feedback on the utility of the learning tool. We will fold [3] octahedral skeletons in groups of three and use the structures to discuss concepts in Vector Analysis. Two examples we shall focus on are: 1. Representing vectors and performing algebra on vectors, and 2. Helmholtz Theorem.

1. Sevil Arc and Fatma Aslan-Tutak. The effect of origami-based instruction on spatial visualization, geometry achievement, and geometric reasoning. International Journal of Science and Mathematics Education, 13(1):179-200, 02 2015. 2. D.J. Griffiths. Introduction to Electrodynamics. Prentice Hall, 1999. Vector analysis at the level of Chapter 1. 3. Thomas Hull. Project Origami Activities For Exploring Mathematics. CRC Press, Taylor & Francis Group, Boca Raton, FL 33487-2742, USA, 2 edition, 2013. 4. Nora S. Newcombe. Picture This Increasing Math and Science Learning by Improving Spatial Thinking. American Educator, 34:29-43, 2010.

Session FH: Teaching and Learning Physics in a Second Language

Location: Royal Palm Five/Six **Sponsors:** Committee on International Physics Education, Committee on Diversity in Physics
Time: 7:00-8:00 p.m. **Date:** Monday, January 8 **Presider:** Geraldine Cochran

FH01 7:00-7:30 p.m. Teaching Physics in a Foreign Language: Challenges and Opportunities

Invited – Marina Milner-Bolotin, University of British Columbia, 2125 Main Mall, Vancouver, British Columbia V6T2K1Z4 Canada; marina.milner-bolotin@ubc.ca

With the growing number of North American physics teachers for whom English is their second, third, or even fourth language, we often focus on the challenges they face in our classrooms. However, this disregards the fact that many North American students are also non-native English speakers. Moreover, teaching requires much more than mastering the language, such as cultural fluency and familiarity with local education system. How does that affect physics teaching? By focusing solely on these challenges, we forget that physics teachers who come from different countries also have significant advantages compared to their native counterparts. By "speaking" multiple languages and cultures, they can trace the history of international science curricula and terminology. They can also better relate to non-native English speaking students. In this presentation I focus on advantages of teaching physics in a foreign language that are often overlooked in teacher education programs and in the teaching practice.

Session FI: Controlled Fusion

Location: California Room **Sponsors:** Committee on Science Education for the Public, Committee on Modern Physics
Time: 7:00-8:00 p.m. **Date:** Monday, January 8 **Presider:** Richard Gelderman

FI01 7:00-7:30 p.m. Driving Fusion at 100,000,000 K: The DIII-D Tokamak

Invited – Richard Lee, General Atomics, 3483 Dunhill St. MS G34/220, San Diego, CA 92121-1200; rick.lee@gat.com

General Atomics, located in San Diego, CA, operates the DIII-D ("D-3-D") tokamak device for the Department of Energy and is a world leader in the advancement of nuclear fusion science. Using the DIII-D device, which incorporates a toroidal vacuum chamber and orthogonal magnetic coils, scientists study the behavior of 100,000,000 K deuterium plasma discharges and the resulting fusion reactions and contribute research results to the massive ITER ("The Way") fusion project being built in France. The highly active research by the DIII-D team is an integral part of a world-wide effort to harness the fusion process as a path to ensure the world's electrical needs are satisfied for millennia. For the young intellectual, concepts central to plasma and fusion science are readily brought into the classroom to pique their curiosity and reinforce many of the standard topics already presented in today's physics and chemistry classes.

FI02 7:30-8:00 p.m. Bringing Controlled Fusion Activities into the High School Classroom

Invited – Deborah Roudebush, Retired, 4410 Mariner Lane, Fairfax, VA 22033; droudebush@cox.net

Teachers often search for a method of energizing students about physics. Including activities in the classroom that help the students understand the importance of 21st century research often serves as a catalyst towards increased student enthusiasm for science. This talk will focus on building an activities pathway through the background knowledge leading to an improved student appreciation for controlled fusion. Even if there is not time to complete the entire pathway, mentioning controlled fusion as a motivator for studying classic concepts can enliven students interest in further study.

Session PST2 Poster Session

Location: San Diego Room **Time:** 8:30-10:00 p.m. **Date:** Monday, January 8

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 10:00 p.m. Posters will be available for viewing starting at 3:30 p.m.

Pre-college/Informal and Outreach

PST2A01 8:30-9:15 p.m. Physics Career Education Day: Design, Implementation, and Assessment

Poster – Liang Zeng, The University of Texas-Rio Grande Valley, 1201 W. University Dr., Edinburg, TX 78539; liang.zeng@utrgv.edu

Ruben Ortega, John Faust, Oscar Guerrero, The University of Texas-Rio Grande Valley

A strategic intervention, Physics Career Education Day at The University of Texas–Rio Grande Valley (UTRGV), in collaboration with the McAllen Independent School District (MISD), has been designed, developed, and implemented to address youth lack of awareness about what physics entails. Based on Expectancy-Value Theory, the program aims at improving both students' intrinsic and utility values towards learning physics. The full-day activities include the following main components: visiting research facilities, attending both Physics major testimonials and faculty career pathway presentations; and a Q&A session on student research and study experiences. Pre- and post-survey results showed that Physics Career Education Day reveals effectiveness at increasing student understanding of broad physics career opportunities and physics/physical science programs within their reach. Furthermore, Wilcoxon Signed-Ranks Tests demonstrate that this event significantly increased youth interest towards studying physics and physical science (with a secondary teaching certification: 7-12) disciplines at UTRGV.

Teacher Training/Enhancement

PST2B01 8:30-9:15 p.m. Section Outreach by PTRAs to K-12 Teachers with the Help of Grants from the AAPT Board and the Bauder Grant

Poster – Tommi Holsenbeck, Alabama State University, 5062 Cty Rd. 13, Hardaway, AL 36039; eholsenbeck@alasu.edu

The Alabama Section of AAPT meeting was the host for two workshops to help physics teachers in Alabama and to increase the knowledge of our Section. One workshop was for K-8 teachers and addressed electricity. Using a PTRA workshop as a model, PTRAs helped the teachers use "Play Dough" to create series and parallel circuits. The Play Dough was both a conducting version and a non-conducting version. The teachers were very creative in their circuits as elementary teachers usually are. All the participants left with LEDs, batteries, and alligator clips for the lab activity in their classrooms. They also received books about electricity appropriate for their grade levels to emphasize the literary/science connections. The second workshop for 9-12 physics teachers tested their engineering skills to solve a problem and create a version of a PTRA "Scribble Bot." The engineering method was followed to design their bots. All the teachers received classroom sets of motors, cups, markers, etc so they could immediately try this in their classroom.

PST2B02 9:15-10:00 p.m. Taking Elementary Teachers' Ideas Seriously in Professional Development*

Poster – Amy D. Robertson, Seattle Pacific University, 3307 Third Ave. W, Suite 307, Seattle, WA 98119-1997; robertsona2@spu.edu

Orlala Wentink, Lane Seeley, Seattle Pacific University

Stamatis Vokos, California Polytechnic State University

One of our field's age-old adages is that teachers "tend to teach as they were taught" (McDermott, 2001) and so need to experience physics instruction in ways that are consistent with how they are being asked to teach their own students. Current reforms and literature on best-practices in K-12 classrooms call on teachers to take their students' ideas seriously – i.e., for teachers to listen to, seek to understand, and build on their students' science ideas. In this poster, we illustrate what it looks like for professional development (PD) instructors to take teachers' science ideas seriously – in this case, for PD to provide teachers with opportunities to learn science in the ways we expect them to teach it. We use excerpts from interviews with teachers to show that these experiences were meaningful to teachers, both in their understanding of themselves as capable of doing science and in their thinking about their own instruction.

*This material is based upon work supported by the National Science Foundation under Grant No. DRL-1418211.

PST2B03 8:30-9:15 p.m. Turning Exploratorium Exhibits into Activities and Labs

Poster – Marc 'Zeke' Kossover, Exploratorium, 17 Pier Ste 100, San Francisco, CA 94111; zeke_kossover@yahoo.com

The Exploratorium publishes for free (www.exploratorium.edu/snacks) more than 150 physics activities, called "Snacks", that explain key ideas in ways that are informative and engaging. Many are based on our famous exhibits but made accessible for classrooms and lecture halls by being smaller and cheaper. Most can be made for less than $25. Each contains detailed build instructions, explanations of physics, and ways to use the activity in class. They are perfect for becoming the phenomena for NGSS-style instruction and can be used for both demonstrations and labs. We'll bring some examples so that you can see what we offer.

PST2B04 9:15-10:00 p.m. Assessing Group Effectiveness: A Case Study in Physics Education

Poster – Javier Pulgar, University of California Santa Barbara, 759 Oak Walk Apt. D, Santa Barbara, CA 93117; jpulgar@ucsb.edu

Alexis Spina, Danielle Harlow, University of California Santa Barbara

This paper presents an analysis of group effectiveness involving three physics majors solving an open-ended physics education problem. Research subjects were observed throughout an academic quarter in the context of a course on conceptual physics and children's thinking adapted from the Physics and Everyday Thinking (PET) curriculum. Course participants discussed how school students learn physics and their common pre-instructional ideas and models of physics phenomena. Participants were asked to collaboratively design a physics learning activity, including at least two questions either for the elementary, middle, or high school level. Field notes and audio were collected and recorded from group work. We identified themes that emerged from the group discussion and used Hackman's conditions for effectiveness to determine effective group processes. Results suggest that the group decided the content and questions for the task addressing different themes related to the nature of the problem, while simultaneous meeting conditions of effectiveness.

PST2B05 8:30-9:15 p.m. Behind the Scenes of Education

Poster – Ellie Prim, Appalachian State University, 256 Rogers Dr., Boone, NC 28607; primer@appstate.edu

Teaching may be viewed as routine and repetitive: plan a lesson, teach, grade, and repeat. I was not familiar with the tasks and obligations of a being teacher. This summer, I was given the opportunity to submerge myself in the world of teaching, and my eyes were opened to the extended work educators do. My experience included spending time in the machine shop welding apparatus used for eclipse education and sharing my knowledge with the public through outreach events. In addition, I was responsible for helping to prepare courses, to design and implement curriculum, and to update our on-campus observatory's equipment and instrumentation. This experience dismissed my notions of teaching being tedious and helped to solidify that this is the exciting profession I want to be involved in.

PST2B08 9:15-10:00 p.m. Next Gen PET: An NGSS-aligned Curriculum for Preservice Elementary Teachers

Poster – Fred Goldberg, San Diego State University, 5250 Campanile Dr., San Diego, CA 92182; fgoldberg@mail.sdsu.edu

Next Generation Physical Science and Everyday Thinking (Next Gen PET) [1] is a research-based, guided inquiry curriculum for preservice and inservice elementary teachers, designed to provide learning experiences aligned with the Next Generation Science Standards. Versions are available for either small or large enrollments, and covering either physics or physical science content. Teaching and Learning activities help students make explicit connections between their own learning, the learning and teaching of elementary school children, and the NGSS. Engineering Design activities require application of the module's physical science content. An extensive online instructor's guide[2] includes instructor materials, homework activities, videos of experiments, classroom video clips, test banks, etc. An associated online faculty learning community [3] provides an opportunity for faculty to collaboratively improve their instruction, study student thinking and conduct classroom-based research. This poster will describe the curriculum, instructor resources, student learning outcomes, and online faculty community.

(1) Supported by grants from the National Science Foundation and the Chevron Foundation (2) http://nextgenpet.iat.com (3) http://www.ngpfolc.org

PST2B09 8:30-9:15 p.m. Preparing Faculty Across Multiple Disciplines to Incorporate Active Learning*

Poster – Jeff Saul, Tiliadal STEM Education Solutions, 12200 Academy Rd. NE, Apt. 312, Albuquerque, NM 87111; jsaul@stemedsolutions.com

Luanna Gomez, Rebecca Lindell, Tiliadal STEM Education Solutions

Physics Education Researchers have developed many techniques and insights on how to improve teaching and learning in physics courses by incorporating student-centered activity-based learning. As educational institutions incorporate more active engagement across their programs, physics education researchers are sharing their expertise with colleagues in other departments on educational improvement projects and providing professional development outside of physics. Last summer, we gave a series of workshops at Universidad EAFIT in Medellin, Colombia to help faculty make the transition from a teacher-centered lecture approach to a student-centered active-learning one. In addition, we advised individual course development teams to help them incorporate active learning. Our visit was sponsored by EAFIT's Project 50, which supports and trains faculty to adopt innovative technologies and pedagogies. Project 50 has established over 50 active-learning classrooms. In this poster, we describe our professional development work with EAFIT faculty to help them take advantage of these new classrooms.

*For more information on EAFIT Project 50, go to http://www.eafit.edu.co/proyecto50/Paginas/inicio.aspx. For more information on Tiliadal STEM Education Solutions, go to stemedsolutions.com

Upper Division and Graduate

PST2C01 8:30-9:15 p.m. Teaching Experiment Design with Optical Tweezers

Poster – Janet Y. Sheung, Vassar College, 169 College Ave. Apt. 26, Poughkeepsie, NY 12603; jsheung@vassar.edu

Duncan L. Nall, Paul R. Selvin, University of Illinois

An inquiry-driven optical tweezer experiment was developed and added to the upper division biophysics lab course offered by the physics department at the University of Illinois. We supplemented the inexpensive and well-supported kit from Thorlabs with an E. Coli mutant strain (KAF95) acquired from Howard Berg at Harvard University. The eight-hour lab was taught in two four-hour parts. In the first, students learned basics on the biology, capabilities of the instrument, and analysis techniques. During the second, students came up with and conducted their own experiments in groups of four. While the lack of experiment time meant none of the datasets were large enough to draw clear conclusions, students received points on clarity of their hypotheses and effective use of the instrument. Post-lab surveys were extremely positive: nearly all students indicated a preference for more labs in the course to be taught in a similar style.

PST2C02 9:15-10:00 p.m. Using Computational Methods to Calculate the Magnus Force

Poster – John S. Di Bartolo, NYU Tandon School of Engineering, 6 Metrotech Center, Brooklyn, NY 11201; john.dibartolo@nyu.edu

Julia Kapran, NYU Tandon School of Engineering

Steady, incompressible, two-dimensional fluid flow can be modeled using a stream function, which must solve Laplace's equation. Depending on the boundary conditions and symmetries of a system, a solution can often be found analytically. A numerical approach, however, allows for solutions to be found under much broader conditions. Using the "simultaneous over-relaxation" computational method, we modeled a rotating cylinder in uniform fluid flow, and with the assistance of the Bernoulli equation, we calculated the resulting Magnus force. Because such a system can be solved analytically as well, we were able to compare the numerical results with the analytical predictions. The numerical model we created is valuable in that it is essentially a virtual wind tunnel. It can be used as a laboratory for all kinds of fluid "experiments" by simply replacing the rotating cylinder with other objects of various shapes and sizes. One could calculate the lift on an airplane wing in this way, for instance.

PST2C03 8:30-9:15 p.m. 3D Printed Instruments as an Exploration of Acoustics

Poster – Mark F. Masters, Purdue University Fort Wayne, Department of Physics, Fort Wayne, IN 46805; masters@ipfw.edu

Jacob Millspaw, Justin Yoder, Panyioti Panayi, Purdue University Fort Wayne

We explore using 3D printed reeds for clarinet and 3D printed trumpet mouth pieces as well as 3D printed simple "instruments" to explore the acoustics of instruments. The reeds we control stiffness and density with design and compare the printed reeds with natural reeds. We examine the sound produced using Fourier Transforms as well as the performer's experience. For the mouth pieces we explore the impact of shape and density on sound and performer experience. Finally, we examine the impact of instrument shape on acoustic impedance and the "color" of the sound using Fourier Transforms.

PST2C04 9:15-10:00 p.m. A Web-based Simulation of Subatomic Particle Decays

Poster – Ken A. Kiers, Taylor University, 236 West Reade Ave., Upland, IN 46989-1001; knkiers@tayloru.edu

Subatomic particle decays provide an excellent platform for students to study the conservation of energy and momentum within a relativistic context. We have developed a web-based application that simulates the decays of subatomic particles in a magnetic field inside a wire chamber. This simulation serves as a laboratory exercise in a sophomore-level Modern Physics course. In the simulation, charged particles follow circular tracks, registering "hits" as they pass close to wires in the wire chamber. Students use the software to fit circles to locations that have registered a hit. Properties of the circle can then be used to determine the momentum of the associated particle. Students work offline to determine the identities of various unknown particles by implementing relativistic energy and momentum conservation. The students' data is saved in a database and a TA module can be used to grade the students' work. The simulation is publicly available.

URL: particle-tracks.physics.taylor.edu

PST2C05 8:30-9:15 p.m. Engineering Physics Field Session at Mines: Learning Modules and Outcomes

Poster – Chuck Stone, Colorado School of Mines Department of Physics - 1232 West Campus Rd., Golden, CO 80401; cstone@mines.edu

Following their sophomore year of studies, engineering physics majors at Colorado School of Mines enroll in the 6-week, 6 credit hour summer course, Field Session Techniques in Physics. The course introduces students to the design and fabrication of engineering physics apparatus and involves intensive individual participation in the design of machined system components, vacuum systems, electronics, optics, and applications of computer interfacing systems and computational tools. It includes supplementary lectures on safety, laboratory techniques, and professional development, along with visits to regional research facilities and industrial plants. This Poster Presentation will describe Learning Modules and Learning Outcomes, while an accompanying Oral Presentation will outline the Field Session Content and Structure.

Technologies

PST2D01 8:30-9:15 p.m. New Tools for Smartphone Experiments through "phyphox"

Poster – Sebastian Staacks, RWTH Aachen Univ., 2nd Institute of Physics A, Templergraben 55, Aachen, 52062 Germany; staacks@physik.rwth-aachen.de

Simon Hütz, Heidrun Heinke, Christoph Stampfer, RWTH Aachen University

The free app "phyphox" (Android and iOS, see http://phyphox.org) adds to the well-known concept of smartphone-based physics experiments by introducing data analysis within the app itself and a simple way to remote control any experiment from a second device (laptop PC, tablet, a second smartphone etc.). This gives direct feedback to students and avoids a common disconnection of the collected data from the experiment. In addition to these specific uses of data analysis, more generic analysis setups open up a whole set of tools for students, that can be used in their own experiments. Frequencies of motors can be measured as an acceleration spectrum, the microphone turns into an acoustic stopwatch, and an array of magnets becomes a ruler.

PST2D03 8:30-9:15 p.m. Stop-Motion Video to Assess Conceptual Understanding in Motion

Poster – Bradley F. Gearhart, Buffalo Public Schools, 1982 Stony Point, Grand Island, NY 14072; fizz6guy@yahoo.com

Typical high school students carry in their pockets an extremely powerful tool for scientific expression, but rarely use it beyond their capabilities for social media. Many schools have improved their beliefs about the value of smartphones in the classroom setting, paving the way for innovative uses in our physics instruction. This poster will present my exploration into using Stop-Motion Video as a tool to assess students' understanding of motion by pushing beyond typical "initial' and "final" states having students create a conceptually rich story fills the gaps between these two moments in time.

PST2D04 9:15-10:00 p.m. Using Physics Toolbox Apps to Teach about MEMs Technology

Poster – Rebecca Vieyra, Vieyra Software, 225 C St. SE, Apt. B, Washington, DC 20003; rvieyra@aapt.org

Chrystian Vieyra, Vieyra Software

Using technology often runs the risk of serving as black box for student understanding. While mobile sensors are effective for data collection and display, teachers and students frequently have little concept of how the data is sensed at such a small scale. Visit our poster to learn about MEMs (micro-electro-mechanical) technology inside your smartphone, and to get free resources through Physics Toolbox apps for helping your students understand what is going on inside of their mobile devices.

PST2D05 8:30-9:15 p.m. 360 Images and Video Animations for Physics and Astronomy

Poster – Michael R. Gallis, Penn State Schuylkill, Penn State Schuylkill, 200 University Dr., Schuylkill Haven, PA 17972; mrg3@psu.edu

360 Images place the viewer at the center of complete panorama and when used with smartphone VR glasses can provide a truly immersive experience. Emerging technology and software enables the creation of still images and animation that can aid in presenting topics in physics and astronomy involving 3D geometry. This poster presents examples from the Animations for Physics and Astronomy project at Penn State Schuylkill, and includes student projects. The software used to create these works will be discussed as well as strategies for displaying and sharing imagery and videos.

PST2D06 9:15-10:00 p.m. A Controlled Study of Stereoscopic Virtual Reality in Freshman Electrostatics

Poster – Christopher D. Porter, The Ohio State University 191 W. Woodruff Ave., Columbus, OH 43210; porter.284@osu.edu

Chris M. Orban, Tim McCormick, Joseph Smith, Amber Byrum, The Ohio State University

The incorporation of virtual reality (VR) into instruction has been difficult due to high-cost headsets or "caves," and the challenge of serving an entire student population with only one or a few such devices. This has changed with the advent of smartphone-based stereoscopic VR. Inexpensive cardboard headsets and smartphones already in students' pockets are the only elements needed for a virtual reality experience. We have designed short VR training sessions and have studied the utility of this training in the context of Gauss's Law and electrostatics in a cohort of students in calculus-based introductory physics at The Ohio State University. We compare performance on pre-post tests between students trained using VR, those trained using a video of the VR content, and those trained using static 2D images as in a traditional text. Although data are preliminary in this growing study, we comment on possible reasons for differences among student groups.

PST2D07 8:30-9:15 p.m. BuckeyeVR 3D Plot Viewer – A Free Resource for Smartphone-based VR*

Poster – Chris Orban, 191 W Woodruff Ave., Columbus, OH 43210; orban@physics.osu.edu

Chris Porter, Joseph Smith, Ohio State University

Although there are a number of smartphone apps that can produce interesting stereoscopic visualizations using a cheap VR viewer (often called Google Cardboard), until recently there did not exist a resource to allow STEM educators to use this VR technology to display user-defined functions, curves and vector fields. The BuckeyeVR 3D plot viewer is a free resource that allows educators to both render a user-defined function in a web interface and to quickly view this function in stereoscopic 3D using smartphone-based VR. This is made possible by a freely available smartphone app for Android and iPhones that can take information from the web interface and reproduce the visualization on the smartphone. This resource is available at buckeyevr.osu.edu and we encourage STEM educators to adopt it and to collaborate with Ohio State in examining the pedagogical benefits of this technology.

*Funding from OSU internal sources including the STEAM factory

PST2D08 9:15-10:00 p.m. Making Space Research Affordable for Community College Students

Poster – Barbra M. Sobhani, Red Rocks Community College, 13300 W. Sixth Ave., Lakewood, CO 80228; barbra.sobhani@rrcc.edu

Victor Anderson, Community College of Aurora

Jennifer Jones, Arapahoe Community College

Space research involving rocket launches is rewarding for undergraduate students, but costly. To bring this opportunity to our community college students, we developed an interdisciplinary, cross-campus collaboration to launch a rocket payload through the NASA Space Grant RockSat program. The three campuses involved share the launch and materials costs. Each school has a student team, including a team lead and an advisor. The student team designs the experiment, builds the payload, and participates in integration and launch. The first collaborative project tested viability of unprotected DNA, radiation shielding, and detection during the flight. This year, our team is developing a more detailed radiation and astrobiology payload. This provides an outstanding opportunity to engage high-achieving undergraduates and leads to successful transfer.

PST2D09 8:30-9:15 p.m. Use of Facebook Facilitates the Learning of the Photovoltaic Theory

Poster – Mario Humberto Ramirez Diaz, IPN-CICATA, Legaria 694, Col. Irrigación, Mexico, MEX 11500 México mramirezd@ipn.mx

Mario Rodríguez Castillo, IPN-CICATA
Isaias Miranda Viramontes, CICATA-IPN

In this experiment, we show a positive perception of the use of Facebook as a virtual education tool from a students' point of view both before and after the application. Even those students who without previous experience in the use of Facebook as a virtual learning tool and social platform, gave it good comments on this social network for academic use. To answer this research question about how Facebook facilitates the learning of photovoltaic theory from the perspective of instrumental Genesis, several categories were explored to discover unique instrumental elements of Instrumental Genesis, which would help the student to approach in a way more solid the use of Facebook platform as a technological learning tool.

Physics Education Research II

PST2E02 9:15-10:00 p.m. Real:Digital – Extending Mayer's Cognitive Theory of Multimedia Learning

Poster – Daniel Laumann, University of Münster, Wilhelm-Klemm-Straße 10, Münster, 48149 Germany daniel.laumann@wwu.de

Current physics education is caught between traditional approaches focusing real students experiments and an increasing impact of digital media content. The project "Real:Digital" aims to identify the potential benefit resulting from an integrative usage of these diametrically appearing representations. Richard E. Mayer's cognitive theory of multimedia learning (CTML) is fundamental for the application of multiple representations in educational settings. Since CTML only considers words and pictures, the theory cannot be applied directly to physics education. Experiments and real-world phenomena are essential for physics education but outside the scope of CTML. We present an extension of CTML in physics (CTML-P) adding typical physical representations, considering the tactile sense and taking haptic models into account. In order to apply CTML-P, we demonstrate how multiple representations are useful to teach the Doppler effect.

PST2E04 9:15-10:00 p.m. Student Use of Free Body Diagrams to Solve Physics Problems

Poster – Sara Altemara-Arnold, University of Arizona, 1638 N Winstel Blvd., Tucson, AZ 85716-3319; oboephysics@gmail.com

Free body diagrams are commonly used by college instructors to help students visualize and simplify classical mechanics problems. This study examines whether undergraduate students in an introductory classical mechanics course for non-science majors are using these representations to correctly solve introductory classical mechanics problems. After completion of the relevant unit, students were asked to solve an equilibrium problem of a block on a ramp being held by a rope. The problem consisted of six parts, four conceptual and two analytical. Students were asked to a) draw the free body diagram b) calculate the tension and c) calculate the normal force. For the remaining three parts, d) through f), students were asked to draw rough sketches of position, velocity, and acceleration due to time graphs for the block after the rope was cut. An extremely weak to no correlation was found between correct free body diagrams and correct calculations of the normal force (r= 0.231) and tension (r=0.192). This suggests that students did not use the free body diagram to assist in completing the problem.

PST2E05 8:30-9:15 p.m. Sustaining a Thriving Undergraduate Physics Program*

Poster – Peter A. Sheldon, Randolph College, 2500 Rivermont Ave., Lynchburg, VA 24503; psheldon@randolphcollege.edu
Sarah Sojka, Tisha Colvin, Peggy Schimmoeller, Katrin Schenk, Randolph College

Randolph College has instituted a recruitment and retention program that has doubled the number of science majors in the last five years, more than tripling the number of physics majors. While the college has a total enrollment of 700 students and a physics department with 2.5 faculty, we have recently consistently had 8-10 physics majors each year. The program includes a number of recruitment and retention initiatives, and was initially boosted by an NSF S-STEM grant. While the grant provided scholarships to two cohorts of 12 students, we have exceeded our goal to recruit 24 science students into our Step Up to Physical Science and Engineering at Randolph (SUPER) program each year, and to retain those students at a higher rate. With a second NSF grant, we are now carefully researching the impacts of each part of our program. We will discuss the initiatives implemented and the resulting permanent changes.

*This project is supported by the National Science Foundation under Grants No. DUE- 1153997 and DUE-1564970. 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.

PST2E06 9:15-10:00 p.m. The Effects of Switching Groups on Students' Resource Networks

Poster –James E. Wells, W. M. Keck Science Dept of Claremont Mckenna, Pitzer and Scripps Colleges, 925 N. Mills Ave., Claremont, CA 91711-5916; jwells@kecksci.claremont.edu

Working collaboratively with peers has a positive effect on student learning and is a skill valued by employers. Students may work with their peers formally, in class and on group assignments, or informally, typically outside of class, on homework assignments and in study groups. In many physics courses, students are assigned groups for formal group work and these groups are changed at intervals during the semester. This study uses network analysis to investigate the effect these enforced group changes have on the resource network of introductory physics students. Will a student placed in a new group expand their network to include their new group members, potentially increasing the amount of interaction with their peers, or do the new group members simply replace their former group members in their resource network?

PST2E07 8:30-9:15 p.m. Updating the Real-time Instructor Observation Tool Usability and Collaboration Features

Poster – Zairac Smith, San Jose State University, 215 Wilbur Avenue, 24, Antioch, CA 94509; zairac.smith@sjsu.edu
Cassandra Paul ,San Jose State University

The Real-time Instructor Observation Tool (RIOT) was developed to provide immediate pedagogical feedback to instructors. This is achieved through a web-based user interface that allows an observer to classify instructor interactions in real-time. RIOT then auto-generates plots and charts that allow the observer and the instructor to visualize how class time was spent. However, the current user interface has several limitations. For example, the current interface does not allow users to share observation sessions between each other, nor does it allow users to compare changes in observations over time. RIOT's color scheme is also not currently accessible to users who have trouble reliably distinguishing between colors. We present these and additional features currently being developed for RIOT.

PST2E08 9:15-10:00 p.m. Vertical Course Alignment Between Introductory Physics and Sophomore Engineering Courses

Poster – Jonathan D. Perry, Texas A&M University, 4242 TAMU, College Station, TX 77843-0001; JPerry@physics.tamu.edu
Tatiana L. Erukhimova, William H. Bassichis, Texas A&M University

Introductory physics forms a significant part of the foundation of knowledge for engineering disciplines, and as such it is vital that courses be well aligned within the progression of undergraduate curriculum. This work begins from a perceived misalignment of course content in introductory physics relative to sophomore-level engineering courses. Inventories of concepts and mathematical skills used in problem solving are done by the creation of a Q-matrix for three versions of introductory physics and two follow-on engineering courses at Texas A&M University (TAMU). Alignment of course content is investigated using direct comparison and principal component analysis. Using grades received in introductory physics, paired with q-matrices, this work endeavors to create a model for student scores in subsequent engineering courses using item response theory, incorporating guess and slip parameters, as an additional evaluative measure.

PST2E09 8:30-9:15 p.m. Acoustic Beamforming for Sound Recording in Noisy Classroom Environments

Poster – Benedikt W. Harrer, San Jose State University, One Washington Square, San Jose, CA 95192-0106; benedikt.harrer@sjsu.edu

George Condit, San Jose State University

The complex and dynamic nature of classroom environments often prevents effective and non-obtrusive observation and audiovisual recording of authentic learning activities. In an effort to reduce the complexity of the recording setup and therefore minimize the intrusiveness of the research activity while maintaining reasonable audio quality, we use an array of microphones to record audio from a large portion of the room from a distance. Using the principles of beamforming, we align the recordings from different microphones to amplify the desired signal and diminish unwanted noise, in the process creating and directing a "virtual microphone" within the room.

PST2E10 9:15-10:00 p.m. Assessing Assessment for Learning in a Freshman Mechanics Course within SCALE-UP Model

Poster – Mark Akubo, Florida State University, 624 Miccosukee Rd., Tallahassee, FL 32308-4999; ma15d@my.fsu.edu

Cody Smith, Sherry Southerland, Clausell Mathis, Florida State University

This qualitative study was conducted within student-centered active learning environment for undergraduate programs (SCALE-UP).[1] Our purpose was to examine a freshman classical mechanics course in a large research university southeastern USA, for formative assessment and feedback practices. The significance of this study is because detailed and student-focused formative assessment and feedback influence student self-regulation, motivation, self-efficacy beliefs, and "epistemic agency"[2] in relation to science learning. Instructor-students, student-student or peer formative assessment and feedback practices are non-detailed and scanty.

1. Beichner, R. J.; Saul, J. M.; Abbott, D. S.; Morse, J. J.; Deardorff, D.; Allain, R. J.; Bonham, S. W.; Dancy, M. H.; Risley, J. S. The student-centered activities for large enrollment undergraduate programs (SCALE-UP) project. Research-based reform of university physics 2007, 1, 2-39. 2. Stroupe, D. Examining Classroom Science Practice Communities: How Teachers and Students Negotiate Epistemic Agency and Learn Science-as-Practice, Science Education 2014, 98, 487-516.

PST2E11 8:30-9:15 p.m. Assessing Learning by Observing Engagement in an Interactive Physics Exhibit

Poster – Ron K. Skinner, MOXI, The Wolf Museum of Exploration + Innovation, 125 State St., Santa Barbara, CA 93101; ron.skinner@moxi.org

Danielle B. Harlow, UC-Santa Barbara

How do we assess learning when curriculum involves more open-ended, multiple-outcome learning experiences? Can observable evidence made available through students' actions and words be used to determine whether and how students meet learning standards? We introduce a framework to describe student engagement at an interactive science museum exhibit where students build and test ball roller coasters. Our framework consists of two dimensions: (1) levels of engagement, which describe what students are doing and how they are interacting with the exhibit, and (2) practices of learning, which are derived from the Next Generation Science Standards (NGSS). Plotting the levels of engagement against practices of learning allows us to characterize which practices of learning students might be engaged in based on our observation of their behavior. Our initial findings suggest this framework can be used to assess engagement in NGSS science and engineering practices in classroom-based open-ended learning experiences.

PST2E12 9:15-10:00 p.m. Teaching Introductory Undergraduate Physics Courses Using Multimedia Resources

Poster – Adriana Predoi-Cross, 512 Silkstone Cres. West, Lethbridge, Alberta T1J4C1 Canada; adriana.predoicross@gmail.com

The educational tools discussed here provide a stimulating class environment at undergraduate level. They include: physclips developed at the University of South Wales, Australia, intertwined with short lecturing sections, in-class testing of student comprehension through multiple choice questions, physlets or concept questions, videos of experimental demonstrations, solved examples, "multi level" homework and online quizzes. Each of these tools enhances students' learning abilities and deepens their understanding of physics concepts. The students show increased confidence when using mathematical computations based on physics laws, graphical elements and animations. The quality of questions asked by students following this enhanced learning process, changes towards deeper questions that show an accurate understanding of physics processes. Fewer low-quality questions continue to be present, and they may be due to limitations of the simulations software or idealizations. The overall performance of the students has improved as shown by a different grade distribution, centered on higher grades.

PST2E13 8:30-9:15 p.m. CK-12's SIM Impact Study: Traditional Lecture vs Interactive Physics Simulations

Poster – Sonia Tye, CK-12 Foundation, 3430 W. Bayshore Rd. #101, Palo Alto, CA 94303; Sonia.tye@ck12.org

CK-12 currently offers over 100 simulations (SIMs) that enable students to discover the laws of physics that govern the world around them in a fun and interactive way. CK-12 recently conducted a SIM Impact Study to compare the use of these simulations with traditional class lectures. A group of high school teachers prompted half of their physics classes to engage with a CK-12 SIM to learn a physics concept and the other half listened to a traditional class lecture. All students completed a short survey to assess their achievement of the learning objective, as well as their ability to recognize relationships between variables, dispel common misconceptions, explain the concept in their own words, and ask further related questions. We look forward to sharing the results of this exciting study with the physics education research community and engaging in a discussion about ideas for further research.

PST2E14 9:15-10:00 p.m. Creative Ways Students Interpret Experiences as Physics Majors

Poster – Mary K. Chessey, University of California, Davis, One Shields Ave., Davis, CA 95616-5270; mkchessey@ucdavis.edu

David J. Webb, University of California, Davis

Performance feedback offers a valuable opportunity to guide students' development of knowledge and skills. Undergraduate physics majors in upper division classes dedicate many hours to coursework, yet the feedback for their effort often takes the form of numeric scores with uncertain meaning, especially for students who recently transferred to the university from a community college. This year-long study focuses on the experiences transfer students within a large cohort of physics majors and reveals the creative work that students do to fill in the gaps in the assessment of their performance. Findings from observations, interviews, and participation in the student community indicate that students use many indirect means to guess how they're really doing in their major, such as informal conversations with classmates and instructors, and time spent solving problems. These findings have useful implications for instructors working towards creating an inclusive physics classroom by centering students' perspectives.

PST2E15 8:30-9:15 p.m. Development of the Epistemic Agency Classroom Observation and Analysis Tool (EPISTACOAT)

Poster – Mark Akubo, Florida State University, 624 Miccosukee Rd., Tallahassee, FL 32308-4999; ma15d@my.fsu.edu

Cody Smith, Sherry Southerland, Clausell Mathis, Florida State University

The goal of science teaching and learning is for students to develop proficiency in science by engaging in the practices of science, learning core ideas and crosscutting concepts.[1] This proficiency requires that students be active players in the construction of knowledge. Students need to be epistemic agents —taking responsibility for shaping the knowledge and practice of a science community. Thus, they share authority with the teacher. How might we characterize and analyze our observations focusing on this construct of epistemic agency in classroom discourses? To this end, we develop the epistemic agency classroom observation and analysis tool (EPISTACOAT) which focuses on the epistemic, conceptual, social, socio-epistemic, and affective markers of agency in a student-centered active learning environment for undergraduate programs (SCALE-UP).

1. National Research Council A Framework for k-12 Science Education: Practices, Crossscutting Concepts and Core Ideas. The National Academy Press: Washington DC, 2012.

PST2E16 9:15-10:00 p.m. The Einstein Box for Skills Development in Preschool in Mexico

Poster – Mario Humberto Ramírez Díaz, IPN-CICATA, Legaria 694, Col. Irrigación, México, México 11500 México; mramirezd@ipn.mx

Gabriela Nieto Betance, CICATA-IPN

Physics has historically been seen as a goal and as a media to reach out for other educational skills. In this sense, at the preschool level science must be a path to build thinking skills and attitudes to learning. Unfortunately in Mexico teachers in this level lack tools to develop science in their little students. To help in this situation, we propose the use of "Einstein Box," a set of toys where the kids can select and play with, then teachers explain the general physics concepts involved in the working of the toys. Previously, the preschool teachers took a workshop with physicists to know the fundamentals of physics and could make a good translation to the kids. The results for the kids are amazing because they not only learn about basic physics, furthermore, mathematical thinking, social skills and verbal abilities, all around physics concepts.

Lecture/Classroom II

PST2F01 8:30-9:15 p.m. Desert Island Astronomy 101 Classroom Toolbox

Poster – Mikhail M. Agrest, The Citadel, 87 Droos Way, Charleston, SC 29414; MAgrest@Citadel.edu

Joel Berlighieri, The Citadel

Information Technology Achievements provide Teaching Toolbox with unbelievable opportunities. Unfortunately, those tools are not available 100% of the time. Another disadvantage is hidden in the complicity of some demonstrations and simulations that in turn leads away from understanding of the concepts rather than unveiling them. Haven't you ever felt in the classroom being Robinson Crusoe [1] in front of a crowd of Fridays looking at you with absolutely no clue about your topic? While having no Demo equipment handy, using a "Stick and a String" you are capable of explaining sophisticated concepts of Stix Waves [2] and String Theory.[3] We continue the series of presentations [4] where teachers are encouraged to be creative finding very simple miscellaneous objects for their toolbox to be used explaining complex concepts. Author will be sharing some experience based on observations and teaching about the Solar Eclipse of 1964 and the one of 2017.

1. Daniel Defoe. Life and Adventures of Robinson Crusoe. 1719 Philadelphia, PA. USA 2. Thomas H. Stix. The theory of plasma waves. New York City: McGraw-Hill. 1962 3. Brian Greene. The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory 4. M. Agrest. Desert Island Survival Physics 101. AAPT 2015 Summer Meeting: College Park, Maryland.

PST2F02 9:15-10:00 p.m. Flipping the Large-Enrollment Introductory Physics Classroom

Poster – Chad Kishimoto, University of San Diego, 5998 Alcala Park, San Diego, CA 92110-2492 ckishimoto@sandiego.edu

Michael Anderson, University of California, Riverside

Joe Salamon, MiraCosta College

Most STEM students experience the introductory physics sequence in large-enrollment classrooms led by one lecturer and supported by a few teaching assistants. This poster outlines methods and principles we used to create an effective flipped classroom in large-enrollment introductory physics courses by replacing a majority of traditional lecture time with in-class student-driven activity worksheets. We compare student learning in courses taught by the authors with the flipped classroom pedagogy versus a more traditional pedagogy. By comparing identical questions on exams, we find significant learning gains for students in the student-centered flipped classroom compared to students in the lecturer-centered traditional classroom. Furthermore, we find that the gender gap typically seen in the introductory physics sequence is significantly reduced in the flipped classroom.

PST2F03 8:30-9:15 p.m. Is It Feasible to Incorporate VPython Programming into Introductory Physics?

Poster – Deva O'Neil, Bridgewater College, 402 E College St., Bridgewater, VA 22812; doneil@bridgewater.edu

In 2016, students in General Physics at Bridgewater College were introduced to programming in Glowscript, a web-based environment for VPython. Most students were physics and chemistry majors with little or no previous programming experience. In homework assignments and in recitation section, students used Glowscript to simulate objects moving under the influence of forces. A written survey at the end of the semester probed student comfort level with the programming activities (N = 30). Results were mixed; while most students (25) felt adequately prepared, a significant minority of students expressed frustration with the coding assignments. In response, two changes are being implemented in the 2017 course offering: more templates are provided to students to structure their code, and lab activities will replace most of the take-home assignments, so that students will have immediate access to the instructor while developing and debugging their code.

PST2F04 9:15-10:00 p.m. LECTURE vs SCALE-UP: Setting the Odds

Poster – Guillaume Schiltz, ETH Zurich (Swiss Federal Institute of Technology), LFKP, HPF G 3.2, Zurich, CH 8093 Switzerland schiltz@phys.ethz.ch

Gerald Feldman, George Washington University

Andreas Vaterlaus, ETH Zurich (Swiss Federal Institute of Technology)

We have divided a non-physics undergraduate student cohort into two parallel teaching settings. We offered a highly interactive flipped class (SCALE-UP) to one group of 52 students and a traditional LECTURE to the remaining 318 students. We compared student performance in both settings, based on FCI pre-/post-tests and on a common mid-term exam. The SCALE-UP students performed significantly better on conceptual problems, but for numerical problems, SCALE-UP and LECTURE students showed similar results. In addition, a survey provided feedback about the students' learning experience and about their time effort in the two settings. Both groups spent about the same time for out-of-class preparation, but engagement was higher for the SCALE-UP students. Concerning available classroom space and teaching staff requirements, the LECTURE class is less demanding. Thus, setting the odds for the match LECTURE vs SCALEUP highly depends on the relation of available resources and intended outcomes. Our poster will present data to evaluate the competition prognosis.

PST2F05 8:30-9:15 p.m. My Journey in Physical Science w/Elementary Education Majors: Project-Based Learning

Poster – Beth Marchant, Indiana University South Bend, 25756 Little Fox Trail, South Bend, IN 46628; lotsobooks@comcast.net

I am currently teaching a 3-credit-hour university course called "Physical Science for Elementary Teachers" for my 7th semester. It is the only college-level physics and chemistry course that this group is required to take before entering the elementary school classroom as a full-time teacher. The course has evolved from a lecture and lab course to a project-based course. I incorporate researched-based backwards design principles; some standards-based grading measures; three overarching projects; and repeated assessment opportunities to lead to student success. I will present data on my students' learning outcomes as found in MOSART pre- and post-test results, and student course evaluation data. This will be presented as both an oral and a poster session.

PST2F06 9:15-10:00 p.m. The STEM Connections Program at Lewis University*

Poster – Joseph F. Kozminski, Department of Physics, Lewis University, One University Pkwy., Romeoville, IL 60446; kozminjo@lewisu.edu

Jason J. Keleher, Department of Chemistry, Lewis University

The STEM Connections Program provides a cohort experience for first-year students planning to major in a program offered by the Physics and Chemistry Departments at Lewis University as well as additional professional development opportunities throughout their college careers. An overview of the program's goals and of the cohort experience will be presented as will a preliminary analysis of data from the first 2.5 years of this program.

*The STEM Connections program is supported in part by NSF S-STEM Award #1458353.

Session GA: Report on the International Conference on Women in Physics

Location: Royal Palm One/Two **Sponsors:** Committee on International Physics Education, Committee on Women in Physics
Time: 8:30-10:30 a.m. **Date:** Tuesday, January 9 **Presider:** Sissi Li

GA01 8:30-9:00 a.m. Providing Professional Development for Women Physicists in the U.S. and Beyond

Invited – Beth Cunningham, American Association of Physics Teachers, 1 Physics Ellipse, College Park, MD 20740-3845; bcunningham@aapt.org

The 6th IUPAP International Conference on Women in Physics was held July 16-20, 2017 in Birmingham, U.K. Over a dozen women were selected to be members of the U.S. delegation to the conference based on previous engagement and activities to advance women in physics or science, the special attributes they would bring to the delegation, and impact of the conference on their future career success. Members of the U.S. delegation traveled to the conference and all members supported writing and editing the U.S. paper for the proceedings, creating the U.S. poster, and other projects of the U.S. delegation. This experience provided an opportunity for U.S. delegates to learn about the advances of women in physics in other countries as well as form a cohort to continue collaborations on projects that support women in physics after the conference. One outcome is the creation of the Gender Bias in Physics Forum (https://genderbias.compadre.org) which is a space where women and people who are gender and sexual minorities can share experiences of gender and sexuality bias in physics, find resources, and report responses to bias. An overview of the conference and a summary of the activities of the U.S. delegation will be discussed.

GA02 9:00-9:30 a.m. Lessons Learned from the International Conferences on Women in Physics

Invited – Adriana Predoi-Cross, 512 Silkstone Cres West Lethbridge, Alberta T1J4C1 Canada adriana.predoicross@gmail.com

I had the privilege to participate at four of the six conferences in the series of IUPAP International Conferences of Women in Physics, the latest one being the conference held earlier this year in Birmingham, UK. As at previous conferences, there was a blend of interesting research presentation, examples of career paths of eminent women in physics and presentations on the status of women in physics in different countries. The workshops and informal discussions contributed to the breadth and depth of the presentations and fostered or enhanced networking among participants. Selected discussion topics included the "the under-representation of women in physics, breaking gender stereotypes, conscious and unconscious bias, the gender wage gap, and attrition of women as they continue to climb the academic ladder" [Sarah Tesh, IOP Physics World blog]. One of the conference highlights was the visit of the Nobel Peace Prize laureate Malala Yousafzai.

GA03 9:30-10:00 a.m. ICWIP 2017: Highlights in Physics Education from Around the World

Invited – Arlisa L. Richardson, Chandler-Gilbert Community College, 11829 E Parkview Ln., Scottsdale, AZ 85255; arlisa.richardson@cgc.edu

This summer in Birmingham, U.K., women in physics from the around the world convened to share, learn, discuss and identify best practices in academia and the workplace that would improve the support, and recognition of women in physics. As a delegate on the U.S. team, I had the pleasure of presenting at one of the Physics Education workshops. This 3-day workshop series included presenters from the U.S., U.K., China, Tanzania, and Iran, who all shared physics education best practices with reference to gender awareness in their own country. The presenters shared insights on creating an active-learning classroom, designing effective outreach initiatives, and applying contextual physics curriculum. The highlight of the series was observing local middle school students engage in active-learning, inquiry-based physics lessons. There was something for all levels of academia, from elementary school to college. The recommendations resulting from this series are related to sharing teaching resources internationally.

GA04 10:00-10:30 a.m. ICWIP 2017: Supporting all Women in Physics

Invited – Jolene L. Johnson, St. Catherine University, 2004 W Randolph Ave., St. Paul, MN 55105; jljohnsonarmstrong@stkate.edu

I had the privilege of being part of the U.S. Delegation to the International Conference on Women in Physics in Birmingham, England. One aspect of the conference that I found very helpful was the focus on the social science research around supporting women in physics at all stages of their careers. I will report on talks and posters related to this area. In addition I will report on my experience on being a breastfeeding mother attending an international conference and provide some ideas on simple steps that can be taken to help support conference attendees with young children.

Session GB: Experiences of Early Career Teachers (Panel)

Location: Pacific Salon Four/Five **Sponsors:** Committee on Teacher Preparation, Committee on Physics in High Schools
Time: 8:30-10:30 a.m. **Date:** Tuesday, January 9 **Presider:** Duane Merrell

You have finished you first years teaching. What did we miss in your physics teaching preparation programs that we can perhaps do better at? What were the biggest challenges that you faced as a new teacher? What were you comfortable with as a new teacher? What would you like new teachers to understand about the first years of teaching? What area would you suggest physics teaching preparation programs rethink?

Panelists:

Robert Field, Brigham Young University, robbyfield7@gmail.com

Wesley Morgan, Brigham Young University, wesleyrm76@gmail.com

Anna Bell, Brigham Young University, anna_bgp@yahoo.com

Rachel Kruger, Brigham Young University, wesleyrm76@gmail.com

Session GC: Highlights from the TPT AstroNotes Column

Location: Royal Palm Three/Four **Sponsor:** Committee on Space Science and Astronomy **Time:** 8:30-10:30 a.m. **Date:** Tuesday, January 9
Presider: Joe Heafner

GC01 8:30-9:00 a.m. Notable AstroNotes Notes for Novice astroNomy iNstructors

Invited – Timothy F. Slater, University of Wyoming, College of Education, Laramie, WY 82071; timslaterwyo@gmail.com

Novice astronomy instructors have few places to turn to access the long-standing folk knowledge of "how to teach astronomy." Arguably the best resource to date for constructing the pedagogical content knowledge for teaching astronomy are the backlog of articles and notes from earlier issues of The Physics Teacher. In celebration of the end of the 20th century, Timothy Slater, then at the University of Arizona, and Michael Zeilik, then at the University of New Mexico, worked with the publishing arm of the American Association of Physics Teachers to produce an organized, thematic compendium of published astronomy teaching resources published in The Physics Teacher during the 1990s. The resulting monograph was titled Insights Into the Universe: Effective Ways to Teach Astronomy, ISBN 978-1931024044, and is a collection of brief teaching ideas that should be on the shelf of every astronomy teacher.

GC02 9:00-9:30 a.m. Connecting Above and Below: Students Observing Human-made Satellites

Invited – Donald Smith, Guilford College, 5800 W. Friendly Ave., Greensboro, NC 27410; dsmith4@guilford.edu

For most astrophotographers, satellites are annoying streaks that can ruin hours of work. However, capturing a resolved image of an artificial satellite can pose an interesting challenge for a student, and such a project can provide connections between objects in the sky and commercial and political activities here on Earth. I will report on our efforts to capture decent images of two satellites, and I will describe the observational and interpretive challenges such a task poses for students. Images of objects of known size and at comprehensible distances might make an easier subject for understanding how to calculate an image scale than using, say, a spiral galaxy. Finally, analysis of the morphology of the objects in the images can empower students to learn about the international politics of space: to connect the "up there" and the "down here."

GC03 9:30-10:00 a.m. Curvature of Spacetime: A Simple Student Activity

Invited – Monika R. Wood, University of Michigan, 450 Church St, 1425 Randall, Ann Arbor, MI 48109-1040; monikak@umich.edu

Warren M. Smith, Matthew Jackson, University of Michigan

This is a discussion of an inexpensive and simple student experiment for measuring the differences between the three types of spacetime topology – Euclidean (flat), Riemann (spherical), and Lobachevskian (saddle) curvatures. It makes use of commonly available tools and materials, and requires only a small amount of construction. The experiment applies to astronomical topics such as gravity, spacetime, general relativity, as well as geometry and mathematics.

GC04 10:00-10:30 a.m. Providing Professional Opportunities for Students: Projects, Presentations, Publications, and Outreach

Invited – David J. Sitar, Appalachian State University, 231 Garwood Hall, 525 Rivers St., Boone, NC 28608; sitardj@appstate.edu

From my earliest days as a physics and astronomy education student through graduate school, my mentors involved me in projects that manifested into some type of talk, poster, or publication. These extraordinary experiences shaped me into the educator I am today. In addition, they are also the reason why I want to provide as many out-of-the-classroom opportunities as I can for students. This talk will address the impact that my mentors had on me, examples of the projects my past students have worked on and where some of them are today, and how I believe that even though we can only reach an extremely small number of students with these activities, the exchange is so rewarding for both parties.

Session GD: PER Beyond Single Course Content

Location: Pacific Salon Three **Sponsors:** Committee on Research in Physics Education, Committee on Physics in Undergraduate Education
Time: 8:30-10:30 a.m. **Date:** Tuesday, January 9 **Presider:** Gary White

GD01 8:30-9:00 a.m. Connecting Equations with Concepts in University Physics and 6th-grade Science

Invited – Eric Kuo, University of Pittsburgh, 3939 O'Hara St, LRDC 718, Pittsburgh, PA 15260; erickuo@pitt.edu

Coherence between physical concepts and mathematical equations is an essential contributor to physicists' productive thinking. Rather than using conceptual ideas or mathematics separately, learning physics means learning how to integrate these for new insights. Yet, research has shown that physics students can learn the procedural mathematics without learning the connections between mathematics and conceptual meaning. I will provide examples of novel instructional approaches for teaching the connections between equations and concepts, in both introductory physics at the university level and 6th-grade science. Compared to traditionally taught students, students who experienced these novel approaches were better at recognizing inconsistencies between equations and physical behavior or at adapting equations to new situations. These results illustrate the opportunities to prepare students for productive insights across their school science careers.

GD02 9:00-9:30 a.m. Teaching Students to Check Solutions: Two Steps Forward, One Step Back

Invited – Tiffany-Rose Sikorski, The George Washington University, 2134 G. Street NW, Washington, DC 20052; tsikorski@gwu.edu

Checking solutions for reasonableness is a valuable practice that students can develop in physics courses. In prior work, my colleagues and I found that consistently emphasizing three easy-to-remember checks—units, limits, and numerical values—led to more students checking solutions, especially in comparison to other similar studies. In this talk, I elaborate on a secondary finding: learning the three checks came at a cost. Over time, students stopped doing other potentially useful checks and relied on the three checks emphasized in class. Different ways of understanding this cost, and its implications for research and teaching, are discussed.

GD03 9:30-10:00 a.m. Is Practicing Essential Skills Essential?

Invited – Andrew F. Heckler, Ohio State University, 191 W Woodruff Ave., Columbus, OH 43210; heckler.6@osu.edu

While experts are typically fluent in basic skills used in their domain, it does not necessarily follow that, in order to become an expert, a novice should deliberately practice these skills in isolation from more complex and authentic tasks. Yet an ostensibly reasonable instructional reaction to a deficit in proficiency in "essential skills" is to provide practice in these individual skills. In fact, we will present results indicating that fluency in at least some of these skills can be relatively efficiently achieved in introductory physics. But achieving this goal still leaves some very basic questions unanswered and will be discussed. For example, the "grain size" and hierarchy of the skills seems to matter, and it is not clear that practice with many "reps" of an individual skill is more productive than fewer reps with the skill embedded in more complex problems, or whether some combination of the two is optimal.

GD04 10:00-10:30 a.m. An Upper-division Learning Progression on Partial Derivatives

Invited – Corinne Manogue, Oregon State University, Department of Physics, Corvallis, OR 97331; corinne@physics.oregonstate.edu

Tevian Dray, Paul Emigh, Elizabeth Gire, David Roundy, Oregon State University

It is a constant complaint of physics faculty that students do not remember their lower-division mathematics content, particularly multi-variable and vector calculus. This talk reports on 21 years' experience developing and validating a learning progression (LP) aimed at helping students use and extend their mathematics knowledge about partial derivatives in upper-division physics courses. The LP acknowledges where mathematics courses actually leave off and emphasizes new content that requires conceptual physics reasoning and complex physics tasks. Group activities included in the LP explore the two quite different contexts of the geometric combinations of partial derivatives that appear in E & M and the differentials and chain rules that appear in thermodynamics. This work was supported in part by NSF grant DUE-1323800.

Session GE: Science Results from the 2017 Solar Eclipse

Location: Paciifc Salon Six/Seven **Sponsor:** Committee on Space Science and Astronomy **Time:** 8:30 -10:30 a.m. **Date:** Tuesday, January 9
Presider: Peggy Norris

GE01 8:30-9:00 a.m. Nationwide Network of Total Solar Eclipse High Altitude Balloon Flights: Science and Technology Results

Invited – Angela C. Des Jardins, Montana Space Grant Consortium, Montana State University. Bozeman, MT 59717; angela.desjardins@montana.edu

Shane Des Mayer-Gawlik, Jennifer D. Fowler Montana, Space Grant Consortium

Four years ago we envisioned tapping into the strength of the National Space Grant Program to make the most of a rare astronomical event to engage the general public through education and to create meaningful long-lasting partnerships with other private and public entities. In addition to public engagement, the multidisciplinary project presented an in-depth hands-on learning opportunity for the hundreds of student participants. We believe strongly in giving student participants career-making opportunities through the use of the most cutting edge tools, resources, and communication. The project used a network of 55 high altitude ballooning teams positioned along the path of totality from Oregon to South Carolina to conduct coordinated collaborative activities during the eclipse. These activities included 1) capturing and streaming live video of the eclipse from near space, 2) partnering with NASA Ames on a space biology experiment, and 3) conducting high-resolution atmospheric radiosonde measurements. This presentation will summarize the challenges, results, lessons learned, and professional evaluation from developing, training, and coordinating the collaboration. In addition, the presentation will highlight first science results from the space biology and atmospheric science experiments.

GE02 9:00-9:30 a.m. Balloon Borne Solar Radiation Measurements During 2017 North American Eclipse

Invited – William Slaton, The Univ. of Central Arkansas, 201 Donaghey Ave, Dept of Physics & Astronomy, Conway, AR 72034; wvslaton@uca.edu

Russell Jeffery, The University of Central Arkansas

Tillman Kennon, Arkansas State University

Peggy Norris, Black Hills State University

Bill McLean, Arizona Near Space Research

Sarah Graham, Pellissippi State Community College

Creighton Helms, Silverton High School and the South Metro Salem Stem Partnership Wyoming NASA Space Grant Consortium

Suzanne M. Smaglik, Wyoming NASA Space Grant Consortium

A solar eclipse provides a well-characterized reduction in solar radiation. Solar radiation is a driving factor in meteorological and climate models as well as solar renewable energy generation. Easily accessible total eclipses are rare so a high-altitude balloon-borne experiment to measure solar radiation from six locations in the path of totality of the 2017 North American eclipse was designed, built, and flown. The sensor measured the solar radiation before, during, and after the eclipse and provides data that can be compared to theoretical models at the upper atmosphere. The photodiode sensor used covers the range of visible light and produces a small amount of electricity in proportion to its illumination. This project was made possible by a Robert Noyce Teacher Scholarship, a subaward from the Arkansas Space Grant Consortium, and Student Research Funds from the Department of Physics and Astronomy at the University of Central Arkansas.

GE03 9:30-10:00 a.m. Do Cosmic Ray Rates Change During a Solar Eclipse?

Invited – Mark Adams University of Illinois at Chicago, 1701 Millbrook Ct., Geneva, IL 60134-1837; adams@uic.edu*

The QuarkNet program has distributed hundreds of cosmic ray detectors for use in high schools and research facilities throughout the world over the last decade. To test the hypothesis that the rate of cosmic rays may change during a solar eclipse, a collaboration of high school students and teachers throughout the US came together to build cosmic ray telescopes and collect data to measure rates of muons during the solar eclipse on August 21, 2017. General results will be presented. Students will make individual presentations including results, at this conference.

*Sponsored by Nate Unterman

GE04 10:00-10:30 a.m. High School Students' Cosmic Ray Telescopes for the Solar Eclipse

Invited – Allen J. Sears, Ida Crown Jewish Academy. 8233 Central Park Ave., Skokie, IL 60076-2908; searsphysics@gmail.com

Mark R. Adams, QuarkNet

Nathan A. Unterman, Emeritus, Glenbrook North High School

Students and teachers from high schools near Chicago designed cosmic ray telescopes to measure the rate of cosmic ray muons in the direction of the sun during the August 21, 2017, North American solar eclipse. Teams constructed prototypes, made measurements of background rates of muons and designed two types of telescopes to be reproduced by other QuarkNet groups throughout the country. For four days teams operated four types of telescopes in Hillsboro, MO, in the path of totality, and developed the analysis protocol for other QuarkNet schools as an independent study project. Students who participated will be included in a panel discussion about the experience.

Session GF: Selecting an Apparatus for Effective Learning in the Upper Level Labs

Location: Pacific Salon Two **Sponsor:** Committee on Apparatus **Time:** 8:30-10:30 a.m. **Date:** Tuesday, January 9
Presider: Robert Hobbs

Panelists will address issues related to selecting apparatus to achieve desired outcomes in the upper level laboratory course. Attendees hoping to meet specific laboratory learning outcomes or to better align courses with the AAPT laboratory guidelines will hear about relevant experience and assessment tools or results to guide them in making choices for their own laboratories.

Panelists:

Mark Beck, Whitman College, Walla, Walla, WA

Eric Ayars, CSU Chico

Natasha G. Holmes, Cornell University, Ithaca, NY

Elizabeth George, Wittenberg University, Springfield, OH

Enrique J Galvez, Colgate University, Hamilton, NY

John Essick, Reed College, Portland, OR

Session GG: Session for Paul Doherty

Location: Royal Palm Five/Six **Sponsor:** AAPT **Time:** 8:30 -10:30 a.m. **Date:** Tuesday, January 9 **Presider:** David Marasco

GG01 8:30-10:30 a.m. Snacks with Paul

Invited – Marc 'Zeke' Kossover, Exploratorium 17 Pier, Suite 100 San Francisco, CA 94111 United States zkossover@exploratorium.edu

In an interview shortly before his death, Paul Doherty said that his involvement in the creation of the Exploratorium Snackbook, a collection of activities for teachers, was one of the things he was most proud. Written as a collaboration between scientists and classroom teachers, Snackbook activities contained detailed building instructions, correct and straightforward explanations of the science, and hints on how to use them in the classroom. Most importantly, the activities absolutely worked, having been tested by teachers who knew what was essential for classrooms. Over the years, snacks have been demonstrated at conferences, taught in workshops, published in articles and in book form, and now they are being spread to an even wider audience through the web. We will revisit some of Paul's favorite snacks and look at how his work and inspiration are spreading even more thoroughly around the world.

GG02 8:30-10:00 a.m. Memorial Session for Paul Doherty

Invited – Bree K. Barnett, Dreyfuss Amador Valley High School, Pleasanton, CA 94566; breebarnettdreyfuss@gmail.com

Paul Hewitt, City College of San Francisco, retired

Zeke Kossover, Don Rathjen, Exploratorium Museum of San Francisco

Dean Baird, Rio Americano High School

Multiple presenters will share physics lessons and demonstrations originating from or inspired by Paul Doherty. Paul was a Senior Scientist and Science Educator at the Exploratorium Museum of San Francisco who passed away on August 17, 2017. For three decades he worked with middle and high school teachers in the Exploratorium Teacher Institute, having a significant impact on teachers locally in the San Francisco Bay Areas. Paul was well known in many other regions of the United States and worldwide throughout the physics and museum scientist/ educator communities. The presenters have had long and treasured associations with Paul, both through the museum and the local Northern California/ Nevada section of AAPT. This session will include remembrances of personal experiences, references to Paul's role at the Exploratorium and to the breadth of his activities and experiences through a selection of demonstrations connected with Paul.

GG03 8:30-10:00 a.m. Paul Doherty – A Teacher for All Seasons

Invited – Paul G. Hewitt, City College of San Francisco, 300 Beach Dr., NE St. Petersburg, FL 33701; pghewitt@aol.com

A great benefit of belonging to the AAPT is meeting new friends. At such a meeting back in the 70s I met Paul Doherty while he was a physics professor with Paul Tipler at Oakland University in Michigan. We have been friends since. When Rob Semper of the Exploratorium told me he was looking to hire a physicist for the Exploratorium, I enthusiastically recommended Paul. I've since felt that to be one of my personal merit badges. Next to Ken Ford, Paul was always the one I'd come to with questions about physics in general. He was a great resource. His vast knowledge of physics was matched with his ability to explain complex ideas in a simple way. And he'd always add, "it's more complicated than that." Paul Doherty was a teacher for all seasons.

GG04 8:30-10:30 a.m. Remembrances of Paul Doherty

Invited – Don Rathjen, Exploratorium Teacher Institute, Pier 15, San Fancisco, CA 94111; drathjen@exploratorium.edu

Dean Baird, Rio Americano High School

Paul Doherty was a Senior Scientist and Science Educator at the Exploratorium, in San Francisco. He died this past August. His three decades working with middle and high school science teachers in the Exploratorium Teacher Institute had a significant impact on science teachers in the San Francisco Bay Area as well as on science museum/science educator communities in many other regions of the United States and worldwide. Both presenters have had long and treasured associations with Paul. This session will include remembrances of personal experiences, references to Paul's role at the Exploratorium and to the breadth of his activities and experiences, and a selection of demonstrations connected with Paul.

Session GH: The Wonderful World of AJP

Location: Pacific Salon One **Sponsor:** Committee on Physics in Undergraduate Education **Time:** 8:30-10:30 a.m. **Date:** Tuesday, January 9
Presider: David Jackson

GH01 8:30-9:00 a.m. Dripping Faucet in Extreme Spatial and Temporal Resolution

Invited – Thorsten Poeschel, Friedrich-Alexander University Erlangen-Nuremberg, Nägelsbachstrasse 34, 91052 Erlangen, Erlangen, 91052 Germany thorsten.poeschel@fau.de

Achim M. Sack, Friedrich-Alexander University Erlangen-Nuremberg

Besides its importance for science and engineering, the process of drop formation from a homogeneous jet or at a nozzle is of great aesthetic appeal. We introduce a low-cost setup for classroom use to produce quasi-high-speed recordings with high temporal and spatial resolution of the formation of drops

Tuesday morning

at a nozzle. The visualization of the process can be used for quantitative analysis of the underlying physical phenomena. The experimental setup can be also used to produce high-speed recordings of other periodic processes. [1] Achim Sack and Thorsten Pöschel, "Dripping faucet in extreme spatial and temporal resolution" Am. J. Phys. Vol. 85, 649 (2017); http://doi.org/10.1119/1.4979657

GH02 9:00-9:30 a.m. Zeeman Effect Experiment with High-Resolution Spectroscopy for Advanced Physics Laboratory

Invited – Andrew Taylor, 34 Worthington St. Apt. #1, Boston, MA 02120; as.taylor@outlook.com

Alex Hyde, Oleg Batishchev, Northeastern University

An experiment studying the physics underlying the Zeeman effect and Paschen-Back effect is developed for an advanced physics laboratory. We have improved upon the standard Zeeman effect experiment by eliminating the Fabry-Perot etalon, so that virtually any emission line in the visible spectrum can be analyzed. Emitted light from a ~1T magnet is analyzed by a Czerny-Turner spectrograph equipped with a small-pixel imaging CCD. The experiment was taught as part of the Principles of Experimental Physics course at Northeastern University to a combination of graduate/undergrad students. Zeeman's original sodium experiment is recreated, and the splitting of argon and helium lines is measured as a function of field strength. The students analyze the proportionality of the splitting magnitude to both the B-field strength and lambda squared. The Bohr magneton is calculated and compared to theory. Student feedback is positive, citing the ability to experimentally witness a quantum mechanical effect.

GH03 9:30-10:00 a.m. The Chain Fountain

Invited – Jim Pantaleone, University of Alaska Anchorage, 3211Providence Dr., Anchorage, AK 99516; jtpantaleone@alaska.edu

The chain fountain is an entertaining, counterintuitive phenomenon. When a ball chain flows up over the edge of a container and then falls to the ground below, it is observed that the top of the chain rises up above the container's edge. This demonstration is easy to do in a classroom. The physics responsible for the rise can be readily described. A simple model agrees well with most quantitative observations, however there are still a few open questions.

GH04 10:00-10:30 a.m. Magnetic De-Spinning of Space Objects

Invited – Mark A. Nurge, NASA. Mail Code: UB-R3, Kennedy Space Center, FL 32899; Mark.A.Nurge@nasa.gov

Modeling the interaction between a moving conductor and a static magnetic field is critical to understanding the operation of induction motors, eddy current braking, and the dynamics of satellites moving through the Earth's magnetic field, yet this topic is not well presented in modern textbooks. Analysis was performed in the late 1950s to understand the dynamics of rotating space objects in the Earth's magnetic field based on the seminal work of Hertz in 1880. Now, there is interest in using a magnetic field produced by one space object to stop the spin of a second space object so that docking can occur. Using a conducting sphere as a space object analog, this presentation will cover four increasingly complex cases of a rotating sphere in a magnetic field with closed form solutions and associated experimental results confirming the theory.

Session GI: PER: Diverse Investigations

Location: Golden Ballroom **Sponsor:** AAPT **Time: 8:30-9:30 a.m.** **Date:** Tuesday, January 9 **Presider:** André Bresges

GI01 8:30-8:40 a.m. Toward a Functional Grammar of Physics Equations

Contributed – Kirk Williams, California State University, Chico, 400 W. First St., Chico, CA 95929-0202; kwilliams10@mail.csuchico.edu

David T. Brookes, California State University, Chico

An area of difficulty for students in introductory physics courses is how they use and reason with equations. We propose that part of this difficulty is due to meaning that is embedded in the structure of equations. As equations are manipulated, their structure and concomitant meanings change. As mathematics is considered the "language of physics," our starting point will be to propose that it has a grammar. As equations change form and meaning, they are doing so within a certain grammatical system. We will show how physics equations can be categorized and mapped to ideational clause types as devised by Halliday (1985). This mapping could be useful in relating the mathematical "language" used in physics to "natural language," benefiting physics instructors who are trying to understand the struggles of their students, and helping students to understand the rich meanings embedded in physics equations.

GI02 8:40-8:50 a.m. Mindset in Introductory Physics: Implications From a Novel Coding Methodology

Contributed – Bridget L. Humphrey, Michigan State University, 3839 Hunsaker St., apt 2132, East Lansing, MI 48823; humph139@msu.edu*

Angela Little, Abby Green, Vashti Sawtelle, Michigan State University

Mindset is a significant area of research in psychology with substantial implications in education. The mindset literature focuses on how students respond to challenges and their beliefs about the nature of intelligence. We found that methodologies used to study mindset are limited in the context of college physics. We developed a novel coding methodology that allows us to analyze complex college physics experiences described by students in interview data. We examined students' narratives of challenges they faced in their Introductory Physics for Life Sciences (IPLS) courses. In this talk, we identify common themes in educational experiences across student interviews and explore their implications. Our ultimate goal is to develop design principles for educational environments that support students to embrace challenge, believe it is possible to grow and improve in physics, and move toward greater retention in STEM majors.

*Sponsored by Vashti Sawtelle

GI03 8:50-9:00 a.m. Are Intuitions and Embodied Experiences for Regaining Balance Aligned?

Contributed – Jose P. Mestre, University of Illinois at Urbana-Champaign, 1110 West Green St., Urbana, IL 61801; mestre@illinois.edu

Jason W. Morphew, Patrick Kwon, Ryan Lin, University of Illinois at Urbana-Champaign

People possess knowledge about the physics underlying situations from intuitions, observations and experiences. Sometimes intuitions are in conflict with physics laws as well as physical experiences. We explored the connection between people's embodied understandings, and their intellectual understandings of balance. Participants were asked questions that evoked their intuitions about balancing, performed balancing activities on a balance beam, and finally recalled how they swung their arms when balancing. Results from six experiments indicate that: Fewer than twenty percent of the participants' intuitive answers about balancing were correct; after balancing, fewer than fifty percent of the participants correctly recalled how they moved their arms while trying to regain balance; when asked to visualize what they did while on the balance beam before answering, recall accuracy improved significantly but it was still far from accurate. We find that students' intuitions and embodied experiences are not well linked.

GI04 9:00-9:10 a.m. Models of Physics Learning Related to Scientific Investigation

Contributed – Oleg Yavoruk, Yugra State University, Krasnoarmeyskaya Street, 24-35, Khanty-Mansiysk, KhMAO-Yugra 628007 Russian Federation yavoruk@gmail.com

The process of physics learning can be related to some impressive epistemological models: 1. "Bucket theory" (We fill our mind which is originally empty through our senses). 2. "Knowledge floodlight" (Firstly we decide where to direct the "floodlight of knowledge", then we conduct our research; and we see only what our floodlight can illuminate). 3. "Interaction" (Teacher vs. students activity). 4. "Rationalism" («I am not prepared to accept anything that cannot be defended by means of argument or experience»). 5. "Criticism" (I may be wrong and you may be wrong, but through joint efforts we may get nearer to the truth). 6. "Anamnesis" (Plato's theory, explaining that knowledge is innate). 7. "Cognition cycle" (Physics learning is always carried out in a circle). 8. "Anything goes" (There are no universal learning rules). Sometimes physics teachers use these models unconsciously and in a peculiar interpretation.

GI05 9:10-9:20 a.m. Variations in Introductory Studio Physics Across Institutions

Contributed – Jacquelyn J. Chini, University of Central Florida, 4111 Libra Dr. - PSB 430, Orlando, FL 32816; jchini@ucf.edu
Erin Scanlon, Matthew Wilcox, University of Central Florida
Noel Klingler, Joshua S. Von Korff, Georgia State University

Studio-mode introductory physics courses typically combine lecture, recitation and/or laboratory activities into one meeting time in a student-centered, technology-rich meeting space. There are variations in how these activities and settings are described among the published studio models, such as SCALE-UP , Workshop Physics, TEAL (Technology Enabled Active Learning) and CLASP (Collaborative Learning through Active Sense-making in Physics). Thus, it is not surprising to find local variation in how studio-mode courses are implemented in individual universities and classrooms. We have interviewed 47 instructors at nine universities about their implementations of studio physics. Here, we focus on differences in how instructors describe their courses across universities, explore the reasons for those differences, and confirm claims with classroom observation data when possible. For example, some universities combine lecture, recitation and laboratory activities, while others keep one component, such as a single lecture hour, separate. We explore possible causes and effects of these local decisions.

Special Session: Richtmyer Memorial Lecture Award awarded to Mark Beck

Location: Golden Ballroom **Time:** 10:30-11:30 a.m. **Date:** Tuesday, January 9 **Presider:** Janelle M. Bailey

Mark Beck

Preparing Our Students for Quantum 2.0

by Mark Beck, Department of Physics at Whitman College, Walla Walla, WA

The first quantum revolution (Quantum 1.0) changed the way we think about the physical world, and allowed us to explain the behavior of atoms, molecules, solids and more. It also brought about new technologies, such as those used in the microelectronics industry. Now, however, we have unprecedented control over quantum systems. We can not only explain how things work, but we can design and manufacture, on an atomic scale, systems that have properties that we desire. We can create entangled particles that are separated by long distances, and use them to teleport information from one place to another. We are developing quantum computers that can perform certain tasks exponentially faster than any classical computer. These sorts of technologies are driving the second quantum revolution (Quantum 2.0). This presents a fantastic opportunity for physicists, not only to help drive this technological revolution, but possibly also to help us better understand the nature of quantum mechanics itself. As physics educators we must prepare our students to be leaders in this revolution, and I will describe some ways that I believe we can go about this.

Special Session: Homer L. Dodge Citations for Distinguished Service / Fellows / Presidential Transfer

Location: Golden Ballroom **Time:** 11:30 a.m.-12:00 p.m. **Date:** Tuesday, January 9 **Presider:** Janelle M. Bailey

DSCs: *Dan Schroeder, Mary Ann Klasse, Steve Spicklemire, Nancy Easterly, and Jon Anderson*

Fellows: *Timothy A. Duman, Randall D. Knight, Laureen G. Reed, Carl T. Rutledge, Toni Sauncy, Steve Spicklemire, Tim J. Stelzer, Paul Tipler, and Barbara L. Whitten*

Presidential Transfer: *George A. Amann to Gordon P. Ramsey*

Special Session: Oersted Medal awarded to Barbara L. Whitten

Location: Golden Ballroom **Time:** 12:00-1:00 p.m. **Date:** Tuesday, January 9 **Presider:** Janelle M. Bailey

The Value of Diversity in Physics

by Barbara Whitten, Physics Department, Colorado College

Barbara Whitten

In December of 2015, during discussion of an affirmative action case, Supreme Court Chief Justice John Roberts asked, "What unique perspective does a minority student bring to a physics class?" While it is difficult to know what Justice Roberts had in mind, we suggest that he believed that there is not a perspective that a minority student brings because "physics is physics, whoever you are."

Many physicists might agree with Justice Roberts, believing that the laws of physics are universal, so the makeup of the physics community should not have an effect on the physics we create.

I argue that Justice Roberts is wrong; that minority and women students do bring a new and interesting perspective to physics class, and to careers in physics. And that the physics we create will be better—more reliable, more authentic, and more creative—when we have a more diverse physics community. I will support this argument with anecdotes and statistical evidence.

Session HA: Diversity Along Multiple Dimensions

Location: Pacific Salon Three **Sponsors:** Committee on Women in Physics, Committee on Physics in Two-Year Colleges
Time: 1:00-2:30 p.m. **Date:** Tuesday, January 9 **Presider:** David Marasco

HA01 1:00-1:30 p.m. Beyond Dogma; Reconsidering Diversity

Invited – Stephanie Slater, Center for Astronomy & Physics Education, 604 S. 26th St., Laramie, WY 82070; stephanie@caperteam.com

The financial and human resources dedicated to transforming participation in STEM over the past 40 years is nearly unprecedented; and yet, the results of these efforts are decidedly unsatisfactory for many concerned stakeholders. This encourages us to ask: what if we have been addressing diversity concerns with dogma-laden, rather than research-based approaches; what if we have been using the wrong metrics to determine success; and what if we have focused on the participation of individuals as framed through group categorizations that are less meaningful than we might have supposed? This paper proposes an alternative, and perhaps controversial framework for reconsidering diversity in STEM, based upon: pragmatic categorizations of potential participants; program interventions that are based in the cognitive, rather than the social sciences; and measures of success rooted in the life satisfaction of participants rather than the programmatic needs for demographic parity.

HA02 1:30-2:00 p.m. The Student Veteran in a STEM Classroom of Higher Education

Invited – Jonathan Reiland, San Deigo State University/Student Veteran, 1001 Rosario Ln., Vista, CA 92084-4645; jonathan.reiland@gmail.com

Adjusting to college life can be difficult for students, often the transition from high school to college can take some time. Now consider being away from an academic classroom for as long as 20 years—this transition can be even more challenging. Adjusting to the teaching styles of professors, taking exams that require extensive studying and preparation, and working in groups and teams with peers that are much younger also add to the transition difficulty. My talk will first cover my background as a combat instructor in the Marine Corps, where I taught hours of platform instruction to thousands of Marines of all ages and skill levels. I'll then briefly explain the military's teaching philosophy and techniques as practiced at the Marine Corps schools of formal education. Finally I'll explain some challenges I've personally had as a transitioning veteran, going from active duty into a STEM degree at a university.

Session HB: International Trends in Teacher Preparation and Outreach

Location: Royal Palm One/Two **Sponsors:** Committee on International Physics Education, Committee on Teacher Preparation
Time: 1:00-2:30 p.m. **Date:** Tuesday, January 9 **Presider:** Cyrill Slezak

Distinctive national and international trends have emerged in teacher preparation over the last decade. A panel of educators will present their regional experiences and discuss the important role of identifying, developing and disseminating the core training concepts for the next generation of teachers.

HB01 1:00-2:30 p.m. Developing Undergraduate "Physics Identity" Through Participation in Informal Learning

Panel – Shane Bergin, University College Dublin, Schools of Education & Physics, Dublin, Leinster D4 Ireland; berginsd@tcd.ie

Science identity describes 'who we think we must be to engage in science'. Understanding student science identity is critical to the formation of a diverse and engaged community of scientists. Informal learning environments can have powerful effects on forming positive student science identities. This has consequences for more formal learning structures. In this paper, we will describe undergraduate physics students' participation in two informal learning activities – 'City of Physics' & 'Quavers to Quadratics'. City of Physics aimed to spark a city-wide, public, conversation about physics in Dublin. Quavers to Quadratics is a programme for primary school children that plays with concepts common to both physics and music. This paper describes how undergraduates' participation in one or both informal learning scenarios affected their sense of 'physics identity'.

HB02 1:00-2:30 p.m. Teaching Competencies or Learning to Reasoning

Panel – Hector G. Riveros, Universidad Nacional Autonoma de Mëxico, Instituto de Fïsica, Ciudad Universitaria, Mexico City, DIF 01000 Mëxico; riveros@fisica.unam.mx

The objectives of physics courses are that the students learn how to use what they know to solve problems in the real world (competencies), but no one learns to do this seeing as the professor thinks on the blackboard. The program of a course uses topics as examples of reasoning. Reasoning involves the ability to use their knowledge. In writing the assessments before teaching the class, you will realize what you really want to teach. Using specialized questions can recreate the Socratic Method, which has evolved as constructivism. How their new understanding is going to be used by the student gives an even better motivation. The best teaching tool that I know is the pleasure that comes with understanding, and what is learned with pleasure is not soon forgotten. Through experiments, demonstrations, and tips, a professor can motivate learning and student competencies, if one can find the relevant questions.

HB03 1:00-2:30 p.m. Addressing Cognitive Activation in a Teaching-Learning-Research-Laboratory*

Panel – Klaus Wendt, Johannes Gutenberg University of Mainz, Staudinger Weg 7, Mainz, D 55122 Germany; klaus.wendt@uni-mainz.de

At Mainz University, Germany, the nationwide initiative "New approaches to teacher training" brings together in an interdisciplinary, dispersed educational project researchers from general education with technical methodology in physics, English and history. Jointly focusing on consideration, strengthening and survey of the potential of cognitive activation in teacher education, a set of congruent lectures has been developed to stimulate concepts and teaching resources for optimum classroom appearance. Monitoring of the programme and education of the participants towards self-assessment and perception by others is done using videography, where teacher's action, impact of educational materials and experiments as well as response of learners is analyzed. This new concept "Teaching-Research-Lab" in physics teacher formation also implies active enrollment in our public outreach high school labs. Focus is put on an extensive integration of modern hands-on-experiments, covering the full range from traditional up to quantum physics and including a creative, expedient use of modern media.

*funded under the programme 'Qualitätsoffensive Lehrerbildung' by the German Federal Ministry for Education and Research, BMBF.

HB04 1:00-2:30 p.m. A Decade of Developments in NYS Teacher Preparation & Recruiting

Panel – Dan MacIsaac, State Univ of NY (SUNY) Buffalo State College, 278SAMC, 1300 Elmwood Ave., Buffalo, NY 14222-1095; danmacisaac@mac.com

The past decade in New York state has seen considerable upheaval in physics teacher certification and recruiting. The US Great Recession of 2008 shrank the NYS teaching cadre by 11% as K-12 schools consolidated or cancelled classes, left positions unfilled and laid off newly hired untenured teachers. NYS teacher preparation programs declined in enrollment by an average of 49%, with multiple closures. Simultaneously, increasingly rigorous and cumbersome state teacher evaluation standards, certification requirements and teacher program accreditation requirements inspired pushback from the public, teacher candidates, working teachers, and teacher educators. NYS school and teacher education program demographics continued to change — most public institutions now serve a majority of students of color, and the Buffalo immigrant population doubled. Finally, more than 1/3 of NYS teacher retirement program members are now over 50 years old. I will briefly discuss some initiatives being undertaken to address these challenging circumstances.

Session HC: Issues for Adjunct Faculty

Location: Pacific Salon Four/Five **Sponsors:** Committee on Physics in Two-Year Colleges, Committee on Professional Concerns
Time: 1:00-2:10 p.m. **Date:** Tuesday, January 9 **Presider:** Dennis Gilbert

HC01 1:00-1:30 p.m. The Educational and Professional Implications of a Majority Part-time Workforce

Invited – Leticia Pastrana, 418 South F St., Imperial, CA 92251-1529; lpast001@ucr.edu

Part-time faculty has become an essential faculty workforce for institutions of higher education and particularly for community colleges. Administrative reliance on a contingent workforce has increased in the last several decades, and many have questioned the educational impact on students. An overview of studies related to the educational impact as well as studies related to the consequence of a majority contingent faculty for the profession will be presented to inform discussions regarding improvement.

HC02 1:30-2:00 p.m. Exemplary Contractual and College Practices for Use of Part-time Positions

Invited – Valerie A. Wilk, National Education Association, 1201 16th Street, NW, Ste 310, Washington, DC 20036; vwilk@nea.org*

Making use of national data-bases, research has been done to identify exemplary practices regarding the use of part-time positions, primarily in TYCs. Wilk will summarize this research to support constructing specific pathways for improvement at our institutions.

*Sponsored by Dennis Gilbert

HC03 2:00-2:10 p.m. Adjunct Physics Faculty at a Small, Liberal Arts University

Contributed – Paul Ashcraft, Mercyhurst University, 501 E 38th St., Erie, PA 16546; pashcraft@mercyhurst.edu

Joseph A. Johnson Mercyhurst University

Good adjuncts are worth much more than they are paid and bad adjuncts have hidden costs that affect the entire department. The perspective of a new department chairperson, who was once an adjunct, will be presented. Characteristics to look for, along with ones to avoid when recruiting and hiring adjuncts will be discussed. Tips on cultivation and retention of successful adjuncts will be offered.

Session HD: Low-Cost Sensors and Detectors for Labs

Location: Royal Palm Three/Four **Sponsor:** Committee on Educational Technologies **Time:** 1:00-2:30 p.m. **Date:** Tuesday, January 9
Presider: Ian Bearden

HD01 1:00-1:30 p.m. 3D-Printable Things in Particle Physics Education

Invited – Julia Woithe, CERN, Geneve 23, Geneva, Geneva 1211 Switzerland; Julia.woithe@cern.ch

Alexandra Feistmantl, Oliver Keller, Sascha Schmeling, CERN

The topic of particle physics is rarely addressed in high school curricula. As one of the reasons, teachers report a lack of appropriate classroom experiments. Especially high-tech equipment used in today's particle physics experiments is far too expensive for average or even well-equipped high schools. The technology of 3D-printing has the potential to revolutionize the way physics is taught, because it makes it much easier to design and produce customized parts for experiments or to build new prototypes. Using this technology, many hands-on experiments suddenly become affordable and easily available – even in the field of particle physics. In this talk, we will present low-cost 3D-printable hands-on models which have been developed in S'Cool LAB at CERN. These models and accompanying learning activities will hopefully support teachers in their challenging endeavor of introducing particle physics in their own classroom. S'Cool LAB Website: cern.ch/s-cool-lab

HD02 1:30-2:00 p.m. Building a Low-cost Gaseous Proportional Counter

Invited – Erik Brücken, Gustaf Hällströmin katu 2, Helsinki, Uusimaa FI-00014 Finland; erik.brucken@iki.fi

The gaseous proportional counter is a device that can be used to detect ionizing radiation. These devices can be as simple as a cylindrical cathode and a very thin anode wire centered along its axis. By applying a high voltage, a strong electric field is generated close to the anode wire. Electrons, generated by passing ionizing radiation, create avalanches once they drift into the strong electric field region near the anode. The electrical charges created by the avalanche generate an observable signal which is proportional to the energy loss of the incoming radiation. We present the construction of such a device from an ordinary aluminum beverage can with a common electric wire strand as the anode. The construction of this low-cost detector offers students at universities or technically oriented high schools a detailed understanding of the design and operation of gaseous radiation detectors. In addition we demonstrate live the functionality of the presented detector.

HD03 2:00-2:10 p.m. Teaching Teachers to Make their Own Lab Equipment

Contributed – Marc 'Zeke' Kossover, Exploratorium, 17 Pier Ste 100, San Francisco, CA 94111; zeke_kossover@yahoo.com

Through shop instruction, the Exploratorium's Teacher Institute has been helping teachers make their own classroom equipment for decades. Two years ago we ventured into adding Arduinos to the mix. We learned that teachers learn best and are most likely to implement the tools in their classroom if they see novel experiments that can be better done with Arduinos, have some well-defined initial examples to copy, spend time learning the programming skills themselves, and get lots of feedback from more experienced instructors. In addition to showing an outline of our course, some of the sensors will be demonstrated. Examples can be seen at http://kossover.net.

HD04 2:10-2:20 p.m. Mobile Phone Physics Labs

Contributed – Duncan L. Carlsmith, University of Wisconsin - Madison, 1150 University Ave., Madison, WI 53706; duncan.carlsmith@wisc.edu

Smart phones contain microphones, speaker systems, sophisticated camera systems, accelerometers, gyros, magnetometers, barometers, and other sensors. This talk will describe mobile-phone based physics labs to detect and map magnetic fields, to study the Doppler effect with accelerated sources and detectors, to study simple and complex pendulum motions, and to create mobile phone based microscopes. These labs provide an opportunity for students to understand and apply the miraculous technologies in their pockets while studying the principles of physics. The labs can serve as essentially zero cost replacements for some traditional labs and are especially appropriate for blended or distance education.

HD05 2:20-2:30 p.m. Smart Home Labs in Introductory Physics Courses

Contributed – Farook Al-Shamali, Athabasca University, 16260 132 St., Edmonton, AB T6V 1X5 Canada; farooka@athabascau.ca

Martin Connors, Athabasca University

The widespread use of smartphones puts video production within the reach of almost all students and instructors. We share our experience in using this great tool in the design of home labs used in distance education physics courses at Athabasca University. Use of now-ubiquitous smartphones has allowed the elimination of the costly home lab kits in some of our introductory physics courses. Video clips allow for 2D analysis of moving objects, instead of 1D analysis of data collected by motion sensors. For some experiments, students can submit (for assessment) properly edited videos as a replacement of traditional lab reports. The technology also opens the possibility of merging the theoretical and experimental components of the course. We continue to advocate the adoption of technologies suited to distance education to make a compelling home lab experience (say as homework) even for students whose primary learning is in the classroom.

Session HE: PER on Teacher Professional Development

Location: Pacific Salon One **Sponsors:** Committee on Research in Physics Education, Committee on Teacher Preparation
Time: 1:00-2:20 p.m. **Date:** Tuesday, January 9 **Presider:** John Stewart

HE01 1:00-1:10 p.m. "Pulled in Different Directions": Navigating the Waters of Professional Development

Contributed – Richard P. Hechter, University of Manitoba, Winnipeg, MB R3T2N2 Canada; richard.hechter@umanitoba.ca

In Canada, with the absence of a national physics curriculum or framework like the NGSS, physics teacher professional development is rooted in a careful blend of practical aspects with philosophical perspectives superimposed over the provincially crafted curriculum physics education documents. Having completed a regional inservice teacher professional development program focusing on modern approaches of physics teaching in K-12 classrooms, we evaluated its successes and limits using Guskey's framework. This presentation will share insights from this analysis, and explore the tensions participants reported of feeling 'pulled in different directions' by the variables of school administration biases, philosophical physics education underpinnings, specific classroom and school dynamics, and their own physics teacher identities.

HE02 1:10-1:20 p.m. Contribution of Professional Learning Community Applying Pbl to Lesson Reform

Contributed – Kyoko ISHII, Tamagawa University, 6-1-1, Tamagawa gakuen, Machida, Tokyo, 1948610 Japan; kyokyo03@gmail.com

Yoshihide Yamada, University of Fukui

Physics by Inquiry (McDermott et al, 1996) is a curriculum for teachers to gain an in-depth understanding of basic physics. It is designed to provide the foundation on which students construct physical concepts and develop analytical reasoning skills. Both in-service and pre-service teacher experiences as a learner impact knowledge of the content and pedagogy. However, it is difficult to apply this philosophy to the actual practice of teaching, especially in countries with different culture and educational system. The Fukui Active Learning Group is a Professional Learning Community comprised of elementary, middle, and high school science teachers, as well as university professors and graduate students. It is based on the framework of reflective practitioners (Schön, 1984). We learned Physics by Inquiry, and have collaborated to investigate the application to our teaching. Results show some teachers successfully improve their application and share this with the community. Supported by the KAKENHI Grant 16K01033.

HE03 1:20-1:30 p.m. Partnerships for Science Identity: Three Populations of Active Learners (PSI^3)

Contributed – Wendy K. Adams, Colorado School of Mines, 1500 Illinois St., Golden, CO 80401; wkadams@mines.edu

Kristine E. Callan, Colorado School of Mines

We have added a new component to our science teacher preparation program that partners pairs of secondary teacher candidates (TCs) with a team of elementary teachers (ETs), and their elementary students (ESs). The goals of this partnership are to: establish expectations of vertical articulation with TCs, provide strong examples of classroom management for the TCs, empower ETs to teach more science activities, and develop science identities in both ETs and their ESs. Here we will report on the successes and challenges of the first year of this project.

HE04 1:40-1:50 p.m. Next Gen PET: An NGSS-aligned Curriculum for Preservice Elementary Teachers

Contributed – Fred Goldberg, San Diego State University, 5250 Campanile Dr., San Diego, CA 92182; fgoldberg@mail.sdsu.edu

Steve Robinson, Tennessee Technological University
Edward Price, California State University San Marcos

Next Generation Physical Science and Everyday Thinking (Next Gen PET)[1] is a research-based, guided inquiry curriculum for preservice and inservice elementary teachers, designed to provide learning experiences aligned with the Next Generation Science Standards. Versions are available for either small or large enrollments, and covering either physics or physical science content. Teaching and Learning activities help students make explicit connections between their own learning, the learning and teaching of elementary school children, and the NGSS. Engineering Design activities require application of the module's physical science content. An extensive online instructor's guide[2] includes instructor materials, homework activities, videos of experiments, classroom video clips, test banks, etc. An associated online faculty learning community[3] provides an opportunity for faculty to collaboratively improve their instruction, study student thinking and conduct classroom-based research. This talk will describe the curriculum, instructor resources, student learning outcomes, and online faculty community.

1. Supported by grants from the National Science Foundation and the Chevron Foundation 2. http://nextgenpet.iat.com 3. http://www.ngpfolc.org

HE05 1:50-2:00 p.m. My Journey in Physical Science w/Elementary Education Majors: Project-Based Learning

Contributed – Beth Marchant, Indiana University South Bend, 25756 Little Fox Trail, South Bend, IN 46628; lotsobooks@comcast.net

I am currently teaching a 3-credit-hour university course called "Physical Science for Elementary Teachers" for my 7th semester. It is the only college-level physics and chemistry course that this group is required to take before entering the elementary school classroom as a full-time teacher. The course has evolved from a lecture and lab course to a project-based course. I incorporate researched-based backwards design principles; some standards-based grading measures; three overarching projects; and repeated assessment opportunities to lead to student success. I will present data on my students' learning outcomes as found in MOSART pre- and post-test results, and student course evaluation data. This will be presented as both an oral and a poster session.

Session HF: Teaching Students to Identify Pseudoscience

Location: Pacific Salon Six/Seven **Sponsors:** Committee on Science Education for the Public, Committee on Space Science and Astronomy
Time: 1:00-2:10 p.m. **Date:** Tuesday, January 9 **Presider:** Chad Davies

HF01 1:00-1:30 p.m. Teaching Pseudoscience Through Debunking Projects

Invited – Craig Callender, University of California, San Diego, 9500 Gilman Dr., La Jolla, CA 92093-0119; ccallender@ucsd.edu

Whether trained in statistics or not, students seem to have a natural aptitude for rigorously testing claims that they suspect are false. The Debunking Project I've used in class allows them to unleash these skills for credit. In my talk, I'll explain the Project, its educational value, and make some recommendations on its best implementation. The talk will also feature a small experiment that debunks a type of detox therapy as an example.

HF02 1:30-2:00 p.m. Reducing Epistemically Unwarranted Beliefs in the Classroom

Invited – Raymond Hall, Department of Physics, California State University, Fresno, 2345 E San Ramon, Fresno, CA 93740; rhall@csufresno.edu

College students (n=806) were surveyed at semester's beginning and end. Epistemically unwarranted beliefs (those held despite a lack of empirical evidence to support them, or even in the face of empirical evidence to reject) were pervasive. A critical thinking class that specifically and directly addressed pseudoscience produced a large and significant reduction of those beliefs, but scientific research methods classes and unrelated general education classes used as controls did not. Beliefs most likely to be reduced were health pseudoscience and "extraordinary life forms." Conspiracy theories were least likely to change. Demographic variables (gender, race, SES) were associated with beliefs at pre-test, but not related to reduction of belief as a result of the critical thinking class. The educational approach of directly addressing pseudoscience (via critical thinking skills, and understanding science) is effective for changing beliefs, not just increasing knowledge, and works for most college students, not just a select subset.

HF03 2:00-2:10 p.m. Using Scaffolded Exercises to Develop the Ability to Identify Pseudoscience

Contributed – Chad L. Davies, Gordon State College, 419 College Dr., Barnesville, GA 30204-1700;62 c_davies@gordonstate.edu

With the increasing number of pseudoscientific ideas that are spread through internet and new media formats, students and educators face greater challenges separating verifiable scientific information from that which is false or questionable. This presentation will describe a series of scaffolded learning activities used in Gordon State College's "Science, Pseudoscience and Snake Oil" colloquium to develop students' critical thinking skills so that they can identify the traits of pseudoscientific claims and evaluate them. These activities include the gathering and evaluation of information related to various claims, analysis of the claims, and the presentation of this analysis in ways that foster an understanding of the practices of scientific communication.

Session HG: Using Action Cameras to Teach and Learn Physics

Location: Pacific Salon Two **Sponsor:** Committee on Educational Technologies **Time:** 1:00-2:30 p.m. **Date:** Tuesday, January 9
Presider: Andre Bresges

HG01 1:00-1:30 p.m. Using Action Cameras to Enhance Learning and Facilitate Research

Invited – Florian Genz, Institute of Physics Education, GronewaldStr.2, Köln, NRW 50931 GERMANY; fgenz1@uni-koeln.de
Eleanor Sayre, KSU USA / UofC Calgary, Canada
Scott V. Franklin, RIT

Action Cameras (like GoPros, Cubes, …) became affordable, small and easy to handle for classroom observations. This talk will give an overview about the practical and technical pitfalls of action cameras, as well as their potential for facilitating physics education research (PER). Students can use cameras to capture phenomena at night and under water at extreme close-ups and wide angles in slow-motion or even time-lapse. Researchers can collect video data of student groups for later analysis with the same equipment and hence less intrusiveness. An advantage of comprehensive video data is its amenability to collaborative research; we will discuss our Professional Experiences for Emerging Researchers (PEER), international research collaborations that center around analysis of video data. This session is directed to connect teachers and researchers to, both, improve teaching and conduct relevant and more concise design-based educational research (DBER) with action cameras.

HG02 1:30-2:00 p.m. Using Action Cams to Teach and Learn Physics

Invited – Michael Vollmer, University of Applied Sciences Brandenburg, Magdeburgerstr. 50, Brandenburg, Germany 14772 Germany vollmer@th-brandenburg.de

Due to the breathtaking developments in microsystem technologies in recent years, physics teaching has become enriched by a large variety of inexpensive camera systems. These do not only allow to visualize complex physics contexts as teacher demonstration experiment but due to the rather low camera cost, they are particularly suitable to be used by students in many classroom or outdoor activities. The presentation introduces the topic by first trying to give an overview of the huge field of action cams. These cover not only regular cameras operating in the visible spectral range, high-speed cameras used for slow motion (see AAPT2016) or slow speed cameras used for time lapse, but also adjacent spectral ranges, in particular the infrared region. Second, as a specific example, the topic of learning physics using time lapse cameras is discussed in more detail. Another example, using smartphone IR cameras in physics teaching will be presented in a subsequent presentation.

HG03 2:00-2:30 p.m. Thermal Imaging for Every Teacher

Invited – Klaus-Peter Moellmann, University of Applied Sciences Brandenburg, Magdeburger Strasse 50, Brandenburg, Germany; 14770 Germany; moellmann@th-brandenburg.de

Infrared thermal imaging allows quantitative and qualitative imaging of phenomena and processes in physics, technology, and industry. Already over 15 years ago, thermography was proposed as a supporting qualitative visualization and quantitative measurement tool for physics education. Meanwhile it has become increasingly popular for science and in particular physics teaching in schools as well as at universities since it allows visualization of phenomena dealing with (sometimes minute) energy transfer, which cannot be easily demonstrated with other methods. Today every teacher has the possibility to use thermal imaging in his science classes because the competition in the profitable industry segment of camera manufacturers has recently led to the introduction of low price infrared cameras as smartphone accessories even below $500. This presentation focuses on selected thermal imaging applications for physics education using smart phone infrared cameras. A multitude of mechanical, thermal, electromagnetic and optical phenomena as well as radiation physics which can be visualized with IR imaging will be covered.

Session PST3: Post-deadline Posters

Location: San Diego Room **Sponsor:** AAPT **Time:** 2:00-3:30 p.m.
Date: Tuesday, January 9

Persons with odd-numbered posters will present their posters from 2 to 2:45 p.m.; those with even-numbered posters will present from 2:45 to 3:30 p.m.

PST3A01 2:00-2:45 p.m. PhysFESTT: Planning Applied Physics Workshop for Student/Teacher/Preservice Teams

Poster – Matthew P. Perkins Coppola, Purdue University Fort Wayne, 2101 E. Coliseum Blvd., Department of Educational Studies, Neff 250L, Fort Wayne, IN 46805; perkinsm@ipfw.edu

Mark Masters, Purdue University Fort Wayne

The Applied Physics Workshop to be held at Indiana University-Purdue University Fort Wayne on June 25-29, 2018, is a unique opportunity open to high school teachers, their students, and physics teaching undergraduates. Participants will work in teams during the workshop to learn how to build several inexpensive apparatus organized around four themes: resonance, light as a particle, light as a wave, and acoustics. Participants will develop pedagogical methods for integrating the apparatus into their curriculum and discuss plans to further utilize the materials in long-term scientific research projects. The workshop will also discuss careers in physics, with emphasis beyond those requiring a PhD. This poster will share more details as to the specifics of the workshop, including organization, topics, pedagogy, and partnering of participants. Information on how to be a participant will also be provided. This workshop is funded through The William F. and Edith R. Meggers Project award of the American Institute of Physics, a biennial award designed to fund projects for the improvement of high school physics teaching in the United States.

PST3A02 2:45-3:30 p.m. The Effect of Race on the FCI, CSEM, and FMCE

Poster – Cabot Zabriskie, 135 Willey St., Morgantown, WV 26506; cazabriskie@mix.wvu.edu

John Stewart, Seth Devore, West Virginia University

The FCI, CSEM, and FMCE are three of the most commonly deployed conceptual inventories used in college-level introductory physics courses. An active area of research in PER has focused on understanding the gender gap in student performance on these inventories. However, one area that has seen limited investigation is that of the effect of race/ethnicity. FMCE ($N = 3237$) and CSEM ($N = 2300$) data from a large Eastern land grant university and FCI ($N = 1956$) and CSEM ($N = 2595$) data from a large Southern land grant university was used to explore the effect of race/ethnicity on student performance across and between these widely adopted inventories.

PST3A03 2:00-2:45 p.m. An Inexpensive Lab Timer that Enhances Student Learning

Poster – Roland C. Woodward, University of Wisconsin--Fond du Lac, 400 University Dr., Fond Du Lac, WI 54935; tpaa@thewoodwards.net

For years, I have used a popular commercial computer interface to facilitate electronic data collection in my teaching labs. Despite its advantages, I have found that it frequently makes the labs “too easy”. In the classic free fall lab, for example (in which a striped strip is dropped through a photogate), the software allows students to plot velocity or acceleration vs. time, without understanding what the apparatus is actually measuring: namely, time, at equal intervals of position. After years of attempting to address this deficiency with followup questions, I developed a lab timer that merely reports the times it measures, that uses any software (including Excel), and that you can build yourself for under $50.[1] In this poster, I will give details of its construction, use, and advantages (and disadvantages) over its commercial equivalent.

1. http://tinyurl.com/LabSplits

PST3A05 2:00-2:45 p.m. Computational Modeling for STEM+C Literacy in a Physics Context

Poster – Rebecca E. Vieyra, American Association of Physics Teachers 225 C St. SE, Apt. B, Washington, DC 20003; rvieyra@aapt.org

Colleen Megowan-Romanowicz, American Modeling Teachers Association

Josh Rutberg

Katie Martino

Computational thinking is widely recognized as an essential skill for the future workforce and success in STEM, including physics. This NSF-funded grant engages teachers in professional development to plan and implement classroom instruction in algebra-based Physics First courses that integrates computational modeling (one aspect of computational thinking) through two existing, widely used approaches - Modeling Instruction for physics and Bootstrap for computational modeling. This program is especially focused on combating many equity concerns associated with student access to physics sand computer science. Working with Physics First teachers will allow this project to impact student populations which will be demographically more diverse than students historically enrolled in standalone computer science courses or upper-grade physics courses.

PST3A07 2:00-2:45 p.m. Online Lab Grading

Poster – Pei Xiong-skiba, Austin Peay State University, 601 College St., Clarksville, TN 37044; xiongp@apsu.edu

Andriy Kovlaskiy, Spencer Buckner, Chester Little, Whasington Alcantara, Austin Peay State University

For introductory level physics courses, many colleges and universities have successfully migrated their homework grading online, using commercially readily available sites, such as WebAssign and MasteringPhysics. Is it possible to migrate lab report grading online? This is, probably, more challenging. Most likely, each school owns a “unique” set of lab equipment and somewhat performs each lab activity in its “unique” way. Commercial companies are less willing to develop a lab course customize to each school's needs. At Austin Peay State University, we decided to carry out this migration on our own using D2L (Desire2Learn), the official course website adapted by Austin Peay State University. We have migrated our lab grading online with satisfactory results. The benefits are: a) reduction in instructor's work load; b) encouragement of active participation by all students; c) enhancement of understanding of lab activity related physics concepts; and d) better test preparation for students. This presentation reports our method and how we bypass some of the limitations posted by D2L.

PST3A08 2:45-3:30 p.m. Understanding Interactions between Student Groups and Student Leaders Using the Fusion of Epistemological Framing and Social Network Analysis on Classroom Video Data

Poster – Katarzyna E. Pomian, DePaul University, 1730 S. Arlington Heights Rd., Unit 2B, Arlington Heights, IL 60005, kasia.pomian@yahoo.com

We are exploring how interactions between student groups and learning assistants influence the epistemological frames of student groups and student reasoning. We will use video data to assess verbal and none verbal cues within student groups. We apply social network analysis (SNA) to collected video data to categorize student interactions into on-topic, on-task, and off-topic. This allows us to get an idea of how students will be primarily interacting during certain episodes and forms one set of axes for our epistemological frames. We use video data from a two-week summer program for incoming college freshman that focuses on helping students to develop metacognitive and self-assessment tools. The fusion of SNA and epistemological framing will help us to better understand the individual group dynamics within the whole class structure.

PST3A09 2:00-2:45 p.m. Success of Citizen CATE and the August 2017 Eclipse

Poster – Daniel M. Smith Jr., South Carolina State University P.O. Box 7709 Orangeburg, SC 29117-0001 dsmith@scsu.edu

Matt Penn, The National Solar Observatory

Donald Walter, South Carolina State University

Richard Gelderman, Western Kentucky University

Robert Baer, Southern Illinois University

The Citizen Continental-America Telescopic Eclipse (CATE) Experiment operated a total of 68 identical telescopes at sites distributed along the path of totality from Oregon to South Carolina during the 21 August 2017 solar eclipse. The project was highly successful with 62 of the sites acquiring data, providing continuous coverage of the event. The project goal is to produce a 90-minute time sequence of calibrated white light images of the corona. This unprecedented, continuous, temporal coverage during totality will allow us to address questions related to the dynamics in the inner 2.5 Rsun of the corona. More than 45,000 coronal images with 50,000 calibration files are being examined. We present our preliminary results including detailed time-series evolution of polar plumes and other features. Additionally we discuss the large number of EPO activities CATE supported across the country during the year leading up to and on the day of the eclipse.

PST3A10 2:45-3:30 p.m. The STEM Collective

Poster – Shane C. Spivey, 13300 W 6th Ave., Lakewood, CO 80228; shane.spivey@rrcc.edu

Professional development is critical for supporting continuous faculty growth. In addition to providing workshops on active learning techniques, our department has developed a program to foster peer learning and an exchange of ideas among the faculty, and to encourage classroom innovation. Called the STEM Collective, the long-term goal of this project is to establish an ongoing dialogue where everyone can contribute ideas and experiences, test new teaching strategies, and solicit feedback from the group. As part of the program, adjunct faculty are encouraged to observe full-time faculty who are using active teaching methods in the classroom. Each instructor then develops an action plan to introduce an innovation into their own classroom, and to assess its overall effectiveness. The goal of these professional development efforts is to improve teaching and learning and the overall student experience in science. More inclusive and engaging classrooms increase retention and promote expanding diversity in STEM.

PST3A11 2:00-2:45 p.m. A Senior Student's Perspective on an Online Homework System: WileyPLUS

Poster – Alexas Gaudet, Louisiana State University, 202 Nicholson Dr., Baton Rouge, LA 70820; agaude9@lsu.edu

Brad R. Trees, Ohio Wesleyan University

With the advent of technological innovation and digital media at the forefront of learning, web-based homework systems have become a significant constituent of STEM courses in universities across the country. This poster will evaluate the online learning system WileyPLUS (WP) as used in introductory, algebra-based physics courses at Louisiana State University (LSU). This poster will provide an overview of the resources available within WP and a discussion on how students at LSU use such resources. Student response to WP and subsequent course performance will also be discussed, along with a general evaluation of online homework completion. This will be examined in the context of personal experience as a student (AG), accounts from other physics students, as well as existing data collected on online homework system usage.

PST3A12 2:45-3:30 p.m. eFliP-CoIn – Concept Inventory Development in two Language Cultures

Poster – Florian Genz ZuS, University of Cologne Im Weidenauel 16b Rösrath, 51503; fgenz1@uni-koeln.de

André Bresges, Kathleen Falconer, Physics Education, University of Cologne

Currently, the Flight Physics Concept Inventory (FliP-CoIn) is in development in two languages and piloted it in two different cultures (USA and Germany). This brings new and unique challenges to the PER research project but also great benefits. FliP-CoIn provides feedback to college students, introductory physics courses and their teachers about current understanding of fluid dynamics in the context of aviation. Due to more focus groups and think-aloud interviews, many improvements were implemented. This tool is still in development. The author is thankful for scientific exchange to concept inventory designers as well as PER, fluid dynamics and language experts. Individuals familiar with concept inventory development and instructors of fluid dynamics, flight physics and similar fields are welcome to engage in discussion with the presenter.

PST3A13 2:00-2:45 p.m. Improving Cognitive and Affective Learning in Introductory Physics

Poster – Carolyn D. Sealfon, University of Toronto, 60 St. George St., Toronto, ON M5S 1A7 Canada; csealfon@physics.utoronto.ca

Jason J.B. Harlow, David M. Harrison, Andrew Meyertholen, Brian Wilson, University of Toronto

Michael Justason, McMaster University

Nancy Watt, Nancy Watt Communications

We will discuss ongoing work seeking to understand an observed correlation between students' personality temperament as measured by the True Colors instrument and their performance in a large, reformed introductory physics course. We will also outline efforts to improve the learning gains of students with weaker performance.

PST3A14 2:45-3:30 p.m. A Study of Learning and Attitudinal Gains in a First Year Physics Experience

Poster – Alma Robinson, Virginia Tech, 850 West Campus Dr., (0435) Blacksburg, VA 24060; alma.robinson@vt.edu

John H. Simonetti, Shadi S. Esmaeili, Kasey Richardson, Virginia Tech

Courtney Vengrin, Iowa State

First year physics majors at Virginia Tech are enrolled in two physics-majors only physics courses: Foundations of Physics, a calculus-based introductory physics course, and Seminar for Physics majors, a first year experience course for physics majors. Both courses are taught in a SCALE-UP Classroom using Peer Instruction with undergraduate learning assistants. In these courses, the students are taught the standard content of introductory physics, but they are also explicitly taught how to "think like a physicist." Through the use of both Fermi problems and traditional end-of-chapter problems, the students are taught how to make simplifying assumptions, to perform order of magnitude calculations using estimations, to employ dimensional analysis, and to check symbolic answers with limiting cases. The students were given a pre/post Force Concept Inventory and a pre/post CLASS survey, and we will present our findings. Previous semesters have shown student gains on both instruments.

PST3A15 2:00-2:45 p.m. Investigating the Progression of Language Issues Associated with Center of Gravity

Poster – Megan Mikota, DePaul University 211 Byrne Hall; 2219 N. Kenmore Ave., Chicago, IL 60604-2287; mnmikota@gmail.com*

Susan M. Fischer, DePaul University

Fifty-two algebra-based introductory physics students answered four online questions about center of gravity. Questions were multiple choice with a request to "explain your answer." Students had completed a reading and an introductory lecture prior to answering the questions. The free response data showed that many students struggled to correctly apply symmetry properties of an object or system, and often incorrectly applied the "center" aspect of center of gravity. While these difficulties were anticipated, we also found that many students applied "uniform mass density" to mean that the object had equal mass on either side of the balance point because the object "had the same mass throughout." We will present the student response data and then use these responses to reformat the original questions to include authentic student dialogue expressing correct ideas along with misconceptions largely brought about by issues of language. Work supported by EHR Core Research grant DUE-1348614.

*Sponsored by Susan M. Fischer

PST3A16 2:45-3:30 p.m. RT Diagram for Assessing Student Strategies for Solving Multi-representational Problems

Poster – Rabindra R. Bajracharya, Missouri Southern State University, 3950 E Newman Rd., Joplin, MO 64801; ab_study@yahoo.com

Paul J. Emigh, Corinne A. Manogue, Oregon State University

We investigated students' strategies for solving a multi-representational partial derivative problem in a thermodynamic context. Semi-structured interviews were conducted with eight upper-division students in a restructured thermodynamics course. We developed a new flowchart-like analysis method – representational transformation (RT) diagrams – to depict both correct and incorrect RT processes during problem-solving. Our analysis revealed three types of RT phenomena: translation, consolidation, and dissociation. Previous studies on multiple representations in K-12 and lower-division contexts have documented translations between and within different representations. However, prior studies have not discussed either consolidation or dissociation. We think that consolidation and dissociation are particularly important in upper-division physics problem-solving. The participants in this study did not seem to have as much problem with simple translation and dissociation as with consolidation. RT diagrams can be used not only for analyzing data, but also for instructional purposes to describe ideal solutions and to assess how students actually solve problems.

PST3A17 2:00-2:45 p.m. Impact of Planetarium-based Instructions on Students' Understanding of Lunar Phases

Poster – Jing Wang, Eastern Kentucky University, 3170 New Science Bldg., 521 Lancaster Ave., Richmond, KY 40475; jingwangky@gmail.com

Jessica Lair, Eastern Kentucky University

Astronomy concepts involving three-dimensional spatial relationships can be difficult for students to understand. Such difficulty can be attributed to the two-dimensional nature of traditional astronomy textbooks, as well as students' deficiency in spatial thinking skills. There has been practices to enhance the instructions with digital planetariums and hands-on activities. At Eastern Kentucky University, we start to use the Hummel Planetarium after its recent innovation to teach an introductory astronomy course which is traditionally done in a regular classroom. We are interested in its impact on the development of students' spatial thinking skills, e.g. understanding lunar phases. In this pilot study, we examined the student responses (N=135) to the Lunar Phases Concept Inventory (Lindell, 2001) after they receive two weeks' instruction on moon phases either in a planetarium or in a traditional classroom. The results provide us with guidelines for the follow-up experiment design.

1. Lindell, R. S., & Olsen, J. P. 2002, Developing the Lunar Phases Concept Inventory, Paper presented at the American Association of Physics Teachers Summer Meeting (Physics Education Research Conference), August, Boise, ID.

Session IA: Post-deadline Abstracts I

Location: Royal Palm Three/Four **Sponsor:** AAPT **Time:** 3:00-4:10 p.m. **Date:** Tuesday, January 9 **Presider:** Marla Glover

IA01 3:00-3:10 p.m. Experimentation as Didactics in the Teaching of Physics

Contributed – Andre Salinas, Institución Educativa Siete de Agosto, CL 72 11 C 27, Cali, Valle del Cauca 760001 Colombia; asalinasyh2003@yahoo.com

This work is the result of the use of the methodology ABP (Learning based on problems), developed in three stages, which allows the possibility of autonomous learning, when the student assumes an active role in their training process, relegating the teacher to yield said investiture and assume the role of observer and promoter. The proposal presents several daily scenarios to students of Physics, in which they will develop their praxis based on reflection, inquiry and concretion of activities through individual and group predictions to prove through autonomous meaningful learning, how capable they are to find the answers to their own hypotheses and using ICT platforms with their various software and technological means in a varied way for a more accurate result with evidence to support it.

IA02 3:10-3:20 p.m. Student Activity to Observe the Eclipse Using Ultraviolet Sensors

Contributed – David Morgan, Richard Bland College, 11301 Johnson Rd., Petersburg, VA 23805; dmorgan@rbc.edu

Results will be presented from a student activity designed to record the 2017 solar eclipse using Vernier UV/A and UV/B sensors. The proximity of the eclipse to the start of the school year made the activity an excellent way to introduce students to the data acquisition and analysis tools they would be using for the entire course. Not only was the effect of the eclipse clearly visible with the sensors, the percentage decrease recorded by both ultraviolet light sensors was in close quantitative agreement with the percentage of solar coverage (~86%) at the observation site in central Virginia.

IA03 3:20-3:30 p.m. Exploring the FCI Using Multidimensional Item Response Theory

Contributed – Cabot Zabriskie, West Virginia University, 135 Willey St., Morgantown, WV 26506-0002; cazabriskie@mix.wvu.edu

John Stewart, Seth Devore, West Virginia University

Despite its wide adoption and use over the past 25 years, the factor structure of the Force Concept Inventory (FCI) remains an active topic of research. Techniques such as exploratory factor analysis have hinted that a multidimensional structure may exist, but published structures have not been reproduced. Using the expert so faculty members and graduate student solutions, we developed a theoretical model of the knowledge structure of the FCI which we then refined and confirmed using multidimensional item response theory (MIRT). This model was shown to be significantly better than the original model of knowledge pieces as defined in the original Hestenes, et.al. paper.

IA04 3:30-3:40 p.m. Students' Conceptual Understanding in Discovery Learning Scientific Community Laboratories (DL-SCL)

Contributed – Muhammad Riaz, Department of Physics, Karakorum International University, Gilgit, Pakistan. 2) Department of Education and Interdisciplinary Studies, Florida Institute of Technology, Melbourne, Florida. 32901 207 Walnut Hill Rd., D-11, West Chester, PA 19382; muhammad.riaz@fulbrightmail.org

Thomas J. Marcinkowski, Department of Education and Interdisciplinary Studies Florida Institute of Technology, Melbourne, FL

The purpose of this study was to determine the students' conceptual understanding in a physics-1 lab that was thought through Discovery Learning Scientific Community Laboratories (DLSCL). Within the context of this study, students' conceptual understanding is measured as the change in students' pre- to post-test scores on the Force Concept Inventories (FCI). A pre-post comparative design was used to determine the students' conceptual change in treatment (DLSCL) group in the Physics Department. I used a convenient sample of five lab sections selected from the accessible population. The accessible population was all students' who registered for Physics Lab 1. Out of 13 physics 1 lab sections, five sections were considered for this treatment group. The total sample size was 62 samples in which 70 percent were male and 30 percent were female. The average age of the population was M = 19.92 years with SD = 2.32. Comparing students conceptual understanding the difference in FCI pretest to posttest scores were statistically significant $t(61) = 4.716$, $p < .0001$.The students who were taught physics-1 lab experiments through DL-SCL approach have improved in conceptual understanding as measured by pre and post FCI scores.

IA05 3:40-3:50 p.m. Tesla's "Egg of Columbus" Demonstration Using the PhiTOP

Contributed – Kenneth Brecher, Boston University, 725 Commonwealth Ave., Boston, MA 02215; brecher@bu.edu

Tesla's demonstration of Lenz's law was probably the most important demonstration in the history of applied physics. During the late 19th century, Thomas Alva Edison led a crusade to persuade the public to adopt his direct current technology as the major means for electrical power delivery. The young Serbian immigrant Nikola Tesla knew better, and devised an elegant display of the efficacy of alternating current that has come to be called "Tesla's Egg of Columbus". Partly as a result of this demonstration, J.P. Morgan, George Westinghouse and others backed Tesla, thus changing the course of industrial history. I have developed a simple, inexpensive version of Tesla's demonstration by combining a chemical magnetic stirrer with a non-magnetic metal spinning top that I have invented called the "PhiTOP" (cf. www.thephitop.com). By placing an aluminum PhiTOP on a concave glass mirror on top of the stirrer, it can be magnetically spun up. Dazzling!

IA06 3:50-4:00 p.m. The Use of Peer Instruction to Overcome Language Barriers and Improve Participation in a Physics Class in China

Contributed – Alfonso Reina, New York Institute of Technology, 9 Wenyuan Rd., Nanjing, China 210046 R.R. China areina@nyit.edu

This paper describes the use of peer instruction in a physics classroom to overcome language barriers that arise in courses taught in English with students who are not native speakers and without previous exposure to peer instruction in a college physics class. Students demonstrate basic understanding in testing at the end of each class where peer instruction was the main method of instruction. It was also observed that students improve performance after incentives are given to adopt the newly introduced method of learning. Participants show a positive reception of peer instruction as a tool to overcome language obstacles before and after experiencing the course.

IA07 4:00-4:10 p.m. Examining Preservice Elementary Teachers' Interpretation of Scientific Models

Contributed – Jing Wang Eastern Kentucky University 3170 New Science Bldg. 521 Lancaster Ave. Richmond, KY 40475 jingwangky@gmail.com

Mary Lamar, Martin Brock, Eastern Kentucky University

Preservice elementary teachers face challenges in learning how to teach physical science effectively. Research suggests that inquiry-based science courses can increase both interest and confidence of the preservice elementary teachers in teaching science. (Jarrett, 1998) At Eastern Kentucky University, faculty from both the chemistry and physics departments developed such a course for elementary preservice teachers with emphasis on both the Next Generation Science Standards Performance Expectations, and the Science and Engineering Practices. The course is expected to prepare students for the Praxis elementary education science subtest. The course was developed with a focus on the construction and examination of scientific models. The concept of scientific models was explicitly discussed and assessed as a part of the course. In this presentation, we will report students' understanding and persisting misconceptions about scientific models after taking this model-centered inquiry course.

Jarrett, O.S. J Elem Sci Edu (1999) 11: 49.

Session IB: Post-deadline Abstracts II

Location: Royal Palm Five/Six **Sponsor:** AAPT **Time:** 3:00-4 p.m. **Date:** Tuesday, January 9 **Presider:** Mike Gallis

IB01 3:00-3:10 p.m. An Inexpensive Lab Timer that Enhances Student Learning

Contributed – Roland C. Woodward, University of Wisconsin - Fond du Lac, 400 University Dr., Fond Du Lac, WI 54935; tpaa@thewoodwards.net

For years, I have used a popular commercial computer interface to facilitate electronic data collection in my teaching labs. Despite its advantages, I have found that it frequently makes the labs "too easy." In the classic free fall lab, for example (in which a striped strip is dropped through a photogate), the software allows students to plot velocity or acceleration vs. time, without understanding what the apparatus is actually measuring: namely, time, at equal intervals of position. After years of attempting to address this deficiency with followup questions, I developed a lab timer that merely reports the times it measures, that uses any software (including Excel), and that you can build yourself for under $50.[1] In this talk, I will describe this timer and my experiences with it, and give a brief demonstration.

1. http://tinyurl.com/LabSplits

IB03 3:20-3:30 p.m. Exploring the Tera – Universe with the LHC, Astrophysics and Cosmology

Contributed – Ashwini Sathnur, S. N. K High School; United Nations Development Programme, 1371, 24th main, 27th cross, Bangalore, Karnataka 560070 India; ashwiniashis@yahoo.com

Study of Dark matter and dark energy from the analysis of LHC experiment data. Arriving at the quantity of dark matter. Relation between the dark matter and the tera universe. Also deriving the energy scales of the dark matter from the LHC experimental derived data sets and displaying the mathematical formulas for the dark energy's quantity. Upon finding the contents of the dark matter, deriving its impacts on human lives. Also deriving the relation of the dark matter contents, its quantity and human neuronal functioning. This relation could lead to the root causes of ill–health of human beings. Associating the relations of dark matter and cosmology and astrophysics utilizing the mathematical derivations – thus leading to the proofs and conclusions of the impacts, as described above. Experimental Data is captured from the LHC Open Data. This concept is analyzed from the LHC Data's graphical representation, which is attached in the detailed presentation document.

IB04 3:30-3:40 p.m. Learning To Do Diversity Work: Continued Education of Program Organizers

Contributed – Dimitri R. Dounas-Frazer, University of Colorado Boulder, Department of Physics, Boulder, CO 80309-0390; dimitri.dounasfrazer@colorado.edu

Simone A. Hyater-Adams, University of Colorado Boulder

Daniel L. Reinholz, San Diego State University

We describe an an approach to promoting diversity in physics through students' collective and continued education about racism, sexism, other dimensions of marginalization, and models of allyship and social change. Specifically, we focus on the efforts of undergraduate students, graduate students, and postdocs who are members of CU-Prime. CU-Prime is a student-run diversity-oriented organization in the Physics Department at the University of Colorado Boulder. This group's education was accomplished through quarterly Diversity Workshops. We describe six Diversity Workshops that were co-designed and facilitated by the authors. We describe the context, motivation, and goals of the workshops, the theories underlying their design and implementation, and their content. Because the details of our workshops were tailored to the specific needs and interests of a particular student organization, our workshop agendas may not be widely applicable beyond our local context. Therefore, we share our model, design principles, and facilitation strategies in this presentation.

IB05 3:40-3:50 p.m. RT Diagram for Assessing Student Strategies for Solving Multi-representational Problems

Contributed – Rabindra R. Bajracharya, Missouri Southern State University, 3950 Newman Rd., Joplin, MO 64801; ab_study@yahoo.com

Paul J. Emigh, Corinne A. Manogue, Oregon State University

We investigated students' strategies for solving a multi-representational partial derivative problem in a thermodynamic context. Semi-structured interviews were conducted with eight upper-division students in a restructured thermodynamics course. We developed a new flowchart-like analysis method – representational transformation (RT) diagrams – to depict both correct and incorrect RT processes during problem-solving. Our analysis revealed three types of RT phenomena: translation, consolidation, and dissociation. Previous studies on multiple representations in K-12 and lower-division contexts have documented translations between and within different representations. However, prior studies have not discussed either consolidation or dissociation. We think that consolidation and dissociation are particularly important in upper-division physics problem-solving. The participants in this study did not seem to have as much problem with simple translation and dissociation as with consolidation. RT diagrams can be used not only for analyzing data, but also for instructional purposes to describe ideal solutions and to assess how students actually solve problems.

IB06 3:50-4:00 p.m. A Digital-First Physics Text

Contributed – Michael J. Tammaro, University of Rhode Island, 2 Lippitt Rd. Kingston, RI 02881; tammaro@uri.edu

I will present an innovative, interactive online environment through which the student is actively engaged with the course content. The interactive pieces include concept questions, practice problems, interactive examples, videos, animations, click-to-open footnotes, and additional examples. The robust hints that accompany the assessment pieces, as well as the pop-up glosses, take the pedagogy to a new level, as the online environment is fully exploited in this first-of-its-kind product. With interactive questions embedded with the reading, and the usual compliment of assignable end-of-chapter problems, along with innovative tracking tools, the instructor has an excellent vantage point from which to track and evaluate student progress.

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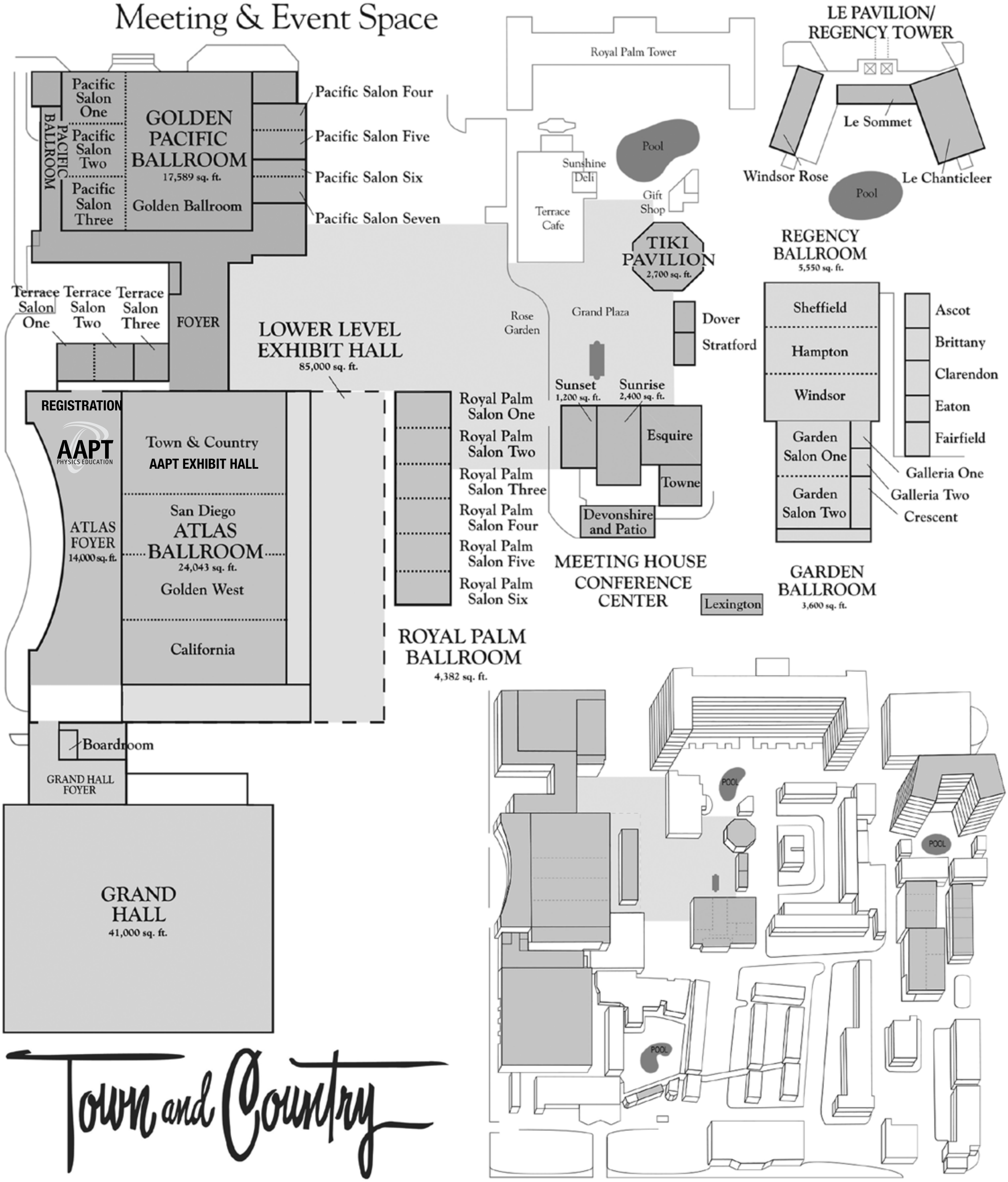
Meeting & Event Space



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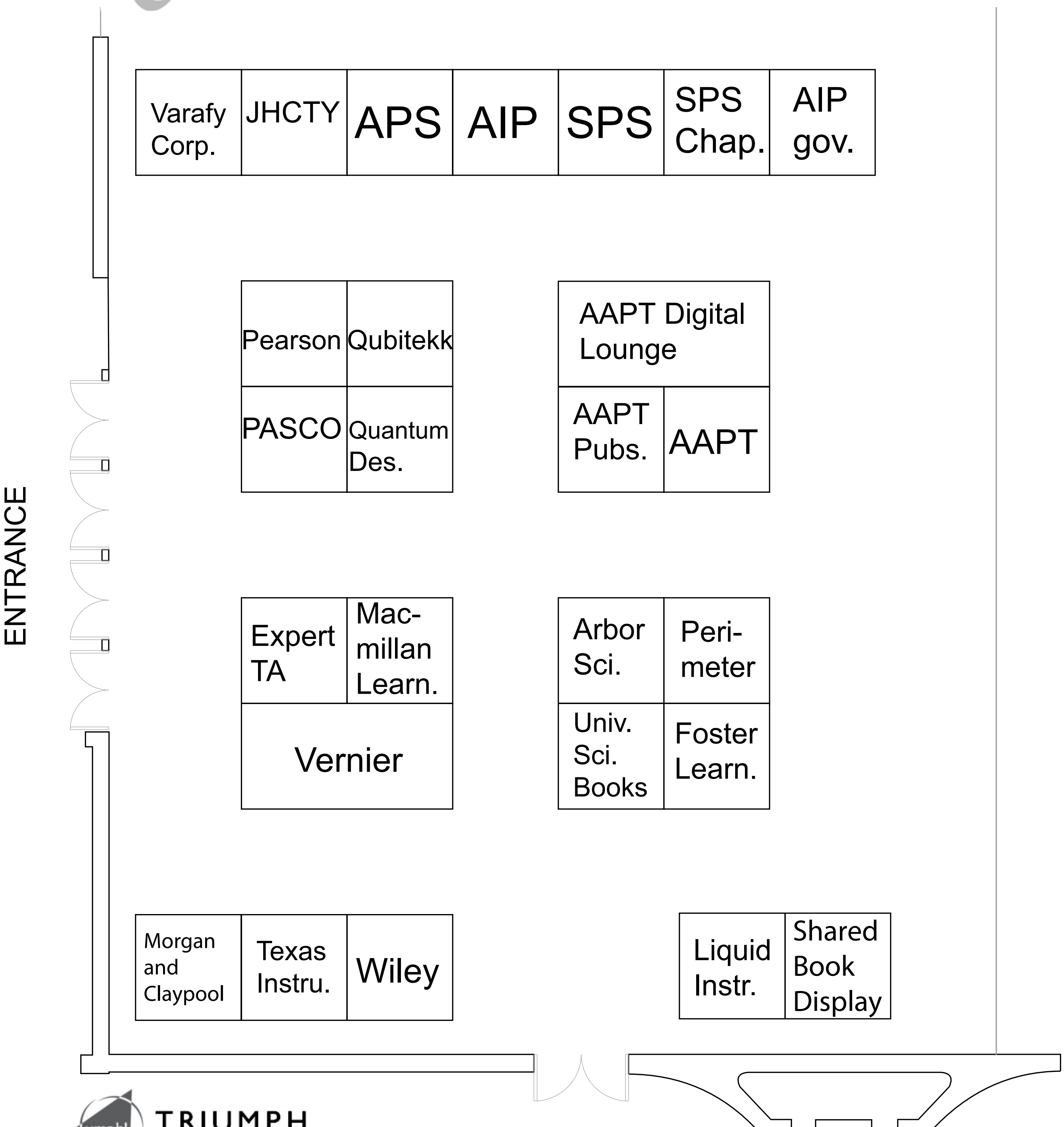

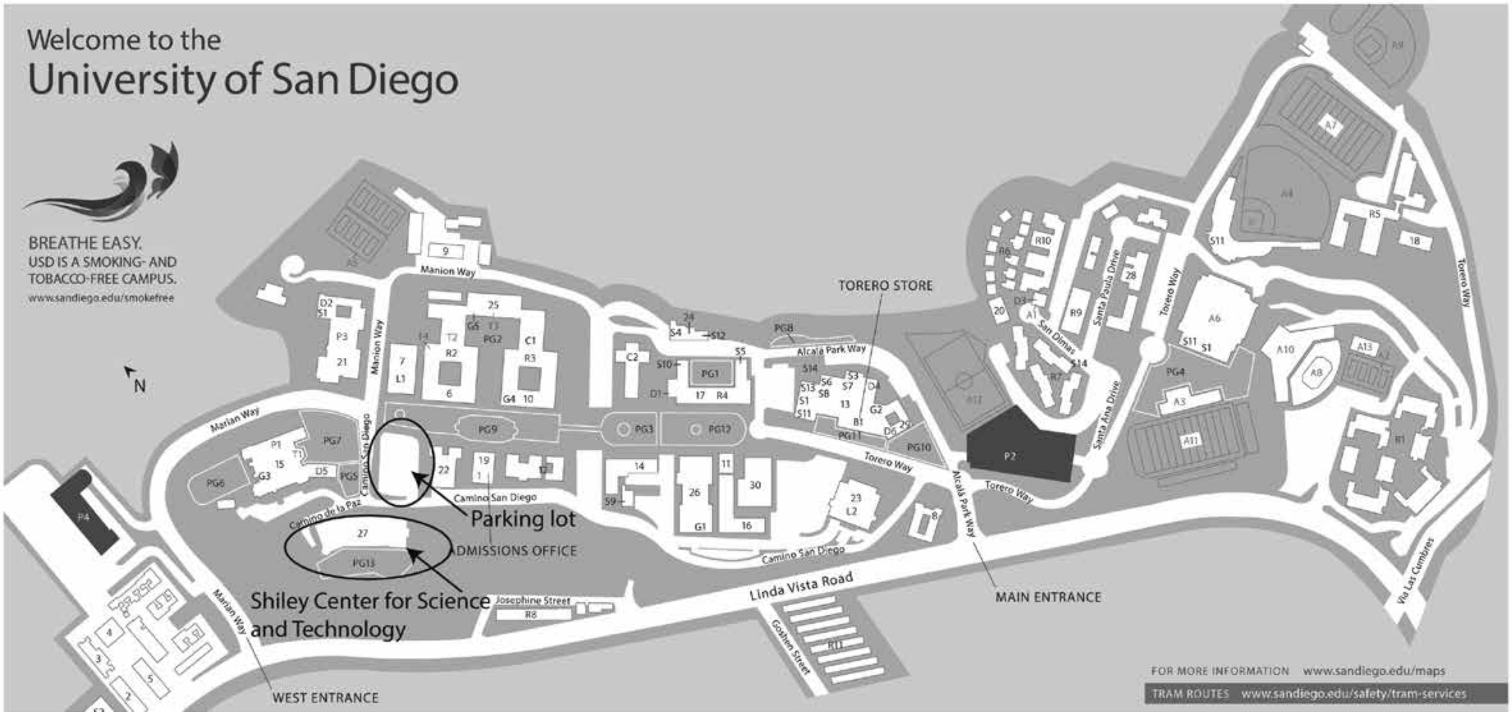

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NOTES