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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

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!

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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

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Pacific Salon Four/Five
10:30 - 11:30 AM
January 8th, 2018

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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 under-represented 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 under-represented minorities. (http://www.aapt.org/aboutaapt/Barbara-Whitten-to-Receive-AAPT-2018-Oersted-Medal.cfm)

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 mechanics 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 Graduate Teaching Prize (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 online. 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)
2018 Richtmyer Memorial Lecture Award
Awarded to Mark Beck

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 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.”

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, 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, 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, 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.
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 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

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 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 computers.

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
## 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
- **AAUP-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 Five/Six
- **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 One
- **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
**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.

**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 oceanography 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 Oceanography) 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.

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.

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
Don Lincoln is 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.

The 2017 SPS Outstanding Chapter Advisor Award

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

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
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.

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!

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.

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!

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!

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.

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!

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: Brett Sackett

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 • Adjustible grading rubric (including sensitivity) for vector (location, direction, angles, labels, head/tail) points (location) and moments (location) • Detailed feedback provided to students 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

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

### AAPT Publications

<table>
<thead>
<tr>
<th>Booth #208</th>
<th>AIP - Policy and Advocacy</th>
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<tbody>
<tr>
<td><strong>One Physics Ellipse</strong></td>
<td><strong>Booth #208</strong></td>
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<tr>
<td>College Park, MD 20740</td>
<td>AIP, 301-209-3300, <a href="http://www.aapt.org">www.aapt.org</a></td>
</tr>
<tr>
<td><a href="#">Visit the AIP booth</a></td>
<td>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 <em>American Journal of Physics</em> and <em>The Physics Teacher</em>. 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.</td>
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### American Association of Physics Teachers

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<tr>
<td>College Park, MD 20740</td>
<td>AAPT, 301-209-3300, <a href="http://www.aapt.org">www.aapt.org</a></td>
</tr>
<tr>
<td>Welcome to San Diego!</td>
<td>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 <em>The Physics Teacher</em>. 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.</td>
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### AIP - Policy and Advocacy

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<th>Booth #408</th>
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<tr>
<td><strong>AIP Government Relations</strong></td>
<td><strong>Booth #408</strong></td>
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<tr>
<td>One Physics Ellipse</td>
<td>AIP, 301-209-3300, <a href="http://www.aip.org">www.aip.org</a></td>
</tr>
<tr>
<td>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.</td>
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### American Institute of Physics

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<td><strong>One Physics Ellipse</strong></td>
<td><strong>Booth #403</strong></td>
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<tr>
<td>College Park, MD 20740</td>
<td>AIP, 301-209-3100, <a href="http://www.aip.org">www.aip.org</a></td>
</tr>
<tr>
<td>For over sixty years, the American Institute of Physics (AIP) has provided AAPT members with <em>Physics Today</em> 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.</td>
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### American Physical Society

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<tr>
<td>College Park, MD 20740</td>
<td>APS, 301-209-3200, <a href="http://www.ap.org">www.ap.org</a></td>
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<tr>
<td>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 <a href="http://www.physicscentral.com">www.physicscentral.com</a>. We will also be demoing our new comic book app as well as SpectraSnapp for android.</td>
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### Arbor Scientific

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<td>College Park, MD 20740</td>
<td>Arbor, 800-367-6695, <a href="http://www.arborsci.com">www.arborsci.com</a></td>
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<tr>
<td>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!</td>
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### Expert TA

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<td>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 <em>The Physics Teacher</em>. 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.</td>
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### Foster Learning LLC

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<tr>
<td>College Park, MD 20740</td>
<td>Foster Learning, 618-656-6836, fosterlearning.education/</td>
</tr>
<tr>
<td>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.</td>
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### Johns Hopkins Center for Talented Youth (CTY)

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<th>Booth #401</th>
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<td><strong>One Physics Ellipse</strong></td>
<td><strong>Booth #401</strong></td>
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<tr>
<td>College Park, MD 20740</td>
<td>CTY, 410-735-6182, <a href="mailto:ctyinfo@jhu.edu">ctyinfo@jhu.edu</a></td>
</tr>
<tr>
<td>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.</td>
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### Liquid Instruments

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<td>College Park, MD 20740</td>
<td>Liquid Instruments, 650-566-4713, <a href="http://www.liquidinstruments.com">www.liquidinstruments.com</a></td>
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<tr>
<td>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 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.</td>
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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.

Quantum Design

Booth #204
10307 Pacific Center Ct.
San Diego, CA 92121
658-461-4400, 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.

University Science Books

Booth #1108
111 Prospect Place
South Orange, NJ 07079
973-378-3900
University Science Books is proud to feature our newly released physics text, COLLEGE PHYSICS: PUTTING IT ALL TOGETHER by Helling, 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...

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 Russell, Philip Kesten and David Tauc. 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 unparalled 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.
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  

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  
800-837-6437, 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.

#AAPTWM18

JOIN US FOR AN OFFICIAL TWEET-UP

SATURDAY, JANUARY 6TH 6-7 PM  
ROOM: ROYAL PALM SIX

Meet up with your Twitter friends and discuss how social media impacts your physics classroom. Not sure how to use Twitter? Learn from the Tweeting experts on how to use it to improve your teaching. Snacks will be provided.
Workshops Held at University of San Diego Saturday and Sunday
(Shiley Center for Science and Technology)

- **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 Gwynn

- **W01** 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 Sauney, Texas Lutheran University, Department of Physics, 1000 West Court St., Seguin, TX 78155; tsauney@tlu.edu; Brad Conrad

- **W02** 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 85322; dwain.desbien@estrellamountain.edu; Thomas O’kuma

- **W03** 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, Department of Physics, Boston Univ., 590 Commonwealth Ave., Boston, MA 02215; aduffy@bu.edu; Wolfgang Bauer

- **W04** 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 92668; james@physicsvideos.com

- **W05** Improv for Physics
  Sponsor: 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

- **W06** 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@currmudgeonhill.org; Eric Mazur, Kelly Miller, Laura Tucker

- **W07** 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

- **W08** 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
  Greg Mulder, Department of Physical Sciences, Linn-Benton Community College, 6500 Pacific Blvd. SW, Albany, OR 97321; mulderg@linnbenton.edu
  Evan Thatcher, Heather Hill

- **W09** 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

- **W10** 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 Heathner, 3990 Herman Sipe Rd., Conover, NC 28613-8907; heathnerj@gmail.com

- **W11** 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 Merrill

- **W12** 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: $80  Non-Member Price: $85  Location: 7
  JB Sharma, Department of Physics, University of North Georgia, Gainesville, GA 3050

- **W13** 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; lengagehardt@fmarion.edu; Marie Lopez del Puerto, Kelly Roos, Danny Caballero, Norman Chonacky

- **W14** 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

- **W15** 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

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January 6–9, 2018
2018 AAPT Winter Meeting – Shared Books

Princeton University Press
2. Steven S. Gubser and Frans Pretorius, The Little Book of Black Holes
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

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
Join the Coaching Staff of the U.S. Physics Team!

AAPT is seeking faculty to join the staff for the 2018 U.S. Physics Team.

The U.S. Physics Team program is responsible for the selection and training of the top high school physics students in the nation in preparation for the International Physics Olympiad. High School and College physics faculty are encouraged to apply.

Successful applicants will attend the U.S. Physics Team residential training camp in Maryland, mid May 2018 (exact dates to be announced) and will be paid a stipend.

Email programs@aapt.org for more information.

Come to the Quiet Room for some peace and quiet during the meeting

Old MSI
Upstairs on the North Atlas Foyer

* Relaxation
* Take a private phone call
* Prayer and reflection
* Lactation

Hours:
1/6 – 7:00 a.m. to 10:00 p.m.
1/7 – 7:00 a.m. to 10:00 p.m.
1/8 – 7:00 a.m. to 10:00 p.m.
1/9 – 7:00 a.m. to 3:00 p.m.
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

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; clarissalcarr@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 Mattem,* Ida Crown Jewish Academy, 6721 n Francisco, Chicago, IL 60645; mashamattener@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 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
We have measured the birefringence properties and the effect of electric field on the optical transmission of 5CB (4'-pentyl-4-cyanobiphenyl) liquid crystal. We have 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.

*Supported 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 (1000°C). 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 300°C, 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 crossed 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 crossed 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  President: Kenneth Cecire

AA01  10:30–11:00 a.m.  Neutrinio 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 neutrinio 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; runterman@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.  Brining 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.

*Supported by Ian Bearden

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 system. 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 an even 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; rm@barnett@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 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

**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 47908 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 phenomenography 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 scientific 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.

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**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

**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 texts, 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, NJIT.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 Canvas. 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 261964, 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, SPM5 - PAF, 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 activities 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; agavin@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.

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

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 (LEDs), 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/dcm/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 92039; 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; kruabin@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.  Habitability 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**

<table>
<thead>
<tr>
<th>Location: Pacific Salon Three</th>
<th>Sponsor: Committee on Educational Technologies</th>
<th>Time: 10:30 a.m.-12:20 p.m.</th>
<th>Date: Sunday, January 7</th>
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**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 programs. 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, Dongwoo Lee, Su young Jin, Juno Hwang, Seoul National University

To visualize magnetic field of magnets or slownoid, we augmented 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 electrostats 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 – Jeff Goff, Shepherd University, PO Box 5000, Shepherdstown, WV 25443, jgoff@shepherd.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; ddeshp@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 analyzing data collection mechanisms. I recently explored the use of Twitter to collect contextual data on learners’ thinking at my university. I will share details of how this new tool was used to assess the effectiveness 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

At Boston University, we have been developing HTML5 simulations that are used in introductory physics courses. Students can access these simulations on the web 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, I will 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  12:20-12:30 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 explicit 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 Emeritus, 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

January 6–9, 2018
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 helpful for standard students learning 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

**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 Mylatt, 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 opened-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, delegating 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 prism 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; smitr@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; jcostewart1@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 – Chuhhee Kwon, California State University Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840-0119 chuhhee.kwon@csulb.edu
Galen Pickett, Laura Heniques, 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.
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; llwang626@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.

*Supported by Andrew Zhou*

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**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 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. Each student, in making these predictions, learns the concept they are about to study. This enables 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:** Jacqueline Chin

**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@fleetscience.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 Chin

**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 contexts, 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
- David Jones
- Justine Boecker, AAPT
- 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. Saunty

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

Contributed – Lars A. Helberg, Chalmers University of Technology, Fysikgränd 3, Göteborg, - 41296 Sweden; lars.helberg@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 adaptation 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.
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.

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.

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.

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).

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.

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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 if 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
Edward Price, Charles J. DeLeone, 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 and 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. 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 curriculum context, and generating support for project “requirements” such as assessment.

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

Claresell 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 Claresell Mathis

**BE09  3:20-3:30 p.m. Examining Student and Faculty Perceptions of Physics Innovation and Entrepreneurship**
Contributed – Anne E. Leal, Rochester Institute of Technology, 85 Lomb Memorial Dr., Rochester, NY 14696; aelsps@rit.edu

James Marshall, San Diego State University
Physics majors pursuing 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.

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 Community 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-12 students. Examples of physics topics within these lessons include intuition, 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 Hamletonian 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 simultaneously. 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.

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.
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.

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—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.

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 imaging with laser spectroscopy to characterize and physically map organic materials 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.

The Planetary Instrument for X-Ray Lithochemistry (PIXL) 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.

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.

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Sunday

**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 A rdmore Ave., Hermosa Beach, CA 90254-5230; mjpolicelli@gmail.com

This 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 will 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 associated 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, Eddelbaum (1959) showed that the spacecraft’s asymptotic speed $v_{\infty}$ 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.
Sunday

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

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 92039-0230; 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
In this computational thinking activity, we introduce students to the idea of using computer simulations to explore a physical system. Matching a known Python presents a series of labs that build from basic programming constructs and gently builds the programming framework supporting key concepts of computational thinking. Students 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 motion).
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 43210; orban@physics.osu.edu*
*Richelle Teeling-Smith, University of Mount Union*

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 (us.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 | President: Jim Hicks |

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**CF04 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.  Physics Activities Outside the Classroom**
*Mark Welter, mark.welter@d214.org*
*Jim L. Hicks, ujhicks2015@gmail.com*

The Physics activities will be depicted where students complete assignments designed for hallways, gymnasiums, football, and soccer fields. These low budget investigations, some on a grand scale, can be implemented easily allowing participants to “ride the equations” they will eventually see or have utilized before. Hopefully, an intuitive sense for the basic principles of physics will be encouraged. An outline and format for a Parent Back to School Physics program—“Parents Phor Physics”—is designed to disseminate physics understanding by engaging the public with hands-on activities. The program provided an opportunity for teachers, parents, and students to connect educationally as part of a positive learning experience.

**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.

**CF05 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 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.

**CF06 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.

**CF07 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/track 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...
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

CG01  4:00-4:30 p.m.  Using Interdisciplinary Research-based Curriculum to Bridge Physical and Life Sciences
Contributed – 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 that are essential to 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
Contributed – Usha Sinha, San Diego State University, 13360 Grandvia Pk., 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
Contributed – Philbert Tsai, University of California, San Diego, 9500 Gilman Dr., La Jolla, CA 92039-0374; pttsai@physics.ucsd.edu

The Quantitative 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 jsvesenka@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

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, Origovagen 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 CHB: Student Assessment through Lab Practicum

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, etc) 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, we 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 explain how they will collect data and perform the lab, create a model (graph, force diagram, electron flow chart, etc) and analyze their data. We will share 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

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

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.
*Supported 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.
*Supported 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
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; jangu1219@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.
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 electrodynamics (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.

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Here’s how it works: Your students take a 40-question, 45-minute, multiple-choice test in March 2018 under your school’s supervision. Exam questions are based on topics and concepts covered in a typical high school physics course. Winners will be announced and awarded prizes the first week of May.
**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 chamber. 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 Ballaia, 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@pfw.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; jabaranda1@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 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)].
January 6–9, 2018

**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 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 at an accelerating rate, and yet the answers that an Astrophysicist might give to some deceptively simple questions are more inegnable 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; phil@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, Emmeritus, 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. Berlingerhi, The Citadel, 171 Moultrie St., Charleston, SC 29409; berlingerhi@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 preceded 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@uw.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-Ying Chang,* University of South Carolina Sumter, 900 Tristan St., Sumter, SC 29154-7408; changhui@uscssumter.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.  

*Supported 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  

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

**PST108 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 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*

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**Physics Education Research**

**PST101 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.

**PST102 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.

**PST103 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; rj henderson@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.

**PST105 8:00-8:45 a.m. Hands-on & Minds-on Particle Physics in S’Cool LAB at CERN**

Poster – Julia Wolthe, CERN, Geneva 23, Geneva, Geneva 1211; Julia.wolthe@cern.ch

Alex Brown, Alexandra Feistmantl, Oliver Kelter, 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

**PST106 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 described 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.
Poster – Michael T. Zwartz, Department of Physics, Lewis University, 1 University Pkwy., Romeoville, IL 60446; michaelzwartz@lewisu.edu
Joseph F. Kozmienski, 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.

Poster – Lisa Goodnew, University of Washington, 3910 15th Ave. NE, Seattle, WA 98195; goodnewl@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.

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
Bao Zhang, Raymond Hall, Gerardo Munoz, Mihai Gherasce, 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 DFWR 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 (FlipFl, Physics), (2) interactive demonstrations, (3) class practice, (4) iClicker pop quizzes, (5) peer coaching (i.e., SI leader), along with CFI (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.

Poster – Christopher B. Colborn, Cal Poly, 885 Lef Rd 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.

Poster – Bethany N. Campbell San Diego State University / University of West Florida, 1415 2nd St Apt 16, San Luis Obispo, CA 93401; bnwcampbell@calpoly.edu

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.


Poster – Rayia 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 PIR 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

Poster – Miriam T. Simpson, Cuyamaca College, 900 Rancho San Diego Pkwy., El Cajon, CA 92019; miriam.simpson@gcccd.edu

Analysis of preliminary data on the math background and skills of beginning physics students and its impact on their performance in an introductory
January 6–9, 2018

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

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 understanding 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
Kiyoko 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; hwjiang@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.

*Leveraging of LAs is 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; quarderrer@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, Hieg-gelke) 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 scientists 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.

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**NSHP Plenary Speaker – Gabriela González, Louisiana State University, for the LIGO Scientific Collaboration and the Virgo Collaboration**

**Gravitational-wave Astronomy**

*by Gabriela 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.

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**Special Session – AIP Science Communications Awards**

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.
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**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 superset 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 Nadi, 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 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; jbk55@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’, builtL Bunnies; exCePT i buiLD raBBITrS 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 altogether. 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 “@”; “u” for addition to symbolize “plus”; and “e” for equals. Most constants and variables are indeed consonants, i.e. “c” = speed of light”, and “x” = “altitude”. ADDITION CONSONANTS may be inserted for intelligibility. An acronym for The Quadratic Equation: <=exCePT i buiLD raBBITrs 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 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.
**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; jacobram613@live.com**

Ezra Schur, Allen Sears, Ida Crown Jewish Academy

Nathan A. Untereman, 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@uwfc.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 than 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/m². Known safe shades reduced levels to 5-6 w/m². Unsafe shades had levels from 8-13 w/m² 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@stkat.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 bundgi@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,
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 involved materials makes this laboratory ideal for high school and introductory college classrooms.

Robert R. Polak, Andrew Fischer, Jared Rafferty, Loyola University Chicago

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.

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 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.

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 – Mary Blair-Loy

Laura E. Rogers, Daniela Glaser, Y. L. Anne Wong, Danielle Abraham and Pamela C. Cosman

This paper presents the results of an analysis of race and gender differences in the letters of recommendation (LORs) written 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 Three/Four  Sponsor: AAPT  Time: 11:00 a.m.-12:10 p.m.  Date: Monday, January 8  President: 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.

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.

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 60666; adavdenny1@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 12:00-12:30 p.m. A Novel, Simple, Friendly, Cousin of the Double-Cone System

Contributed – Constantin Rasinaru, 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 demon-
strate, 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 Borther, 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 damps 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 fenghrui@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 NSFC1210304 & 11101094

**DD07** 12:00-12:10 p.m. **Atom Trap Using a Pyramidal Mirror**

*Contributed – Sun Yong Seo,* Korea National University of Education, Dept of Physics Education, Cheongju, CB 28173 S Korea; syyoung0425@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 atomic 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  **Time:** 11:00 a.m.-12:20 p.m.  **Date:** Monday, January 8  **Presider:** Alexandra Marlies

**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 course1,2, 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 Jarwala, 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, M0XI, 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 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@sjtu.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 other students in the classroom. 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 Stetzer, 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; mchessey@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.
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 – Claudell Mathis, Florida State University, 1130 High Meadow Dr., Tallahassee, FL 32306-9936; cm15@my.fsu.edu
Mark Akubo, Sherry Southender, 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 (CROP) 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; calvaradolevy@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 inequality 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 problematize 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 post-test 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; rhenderson@mix.wvu.edu
John Stewart, Adrienne Traxler, West Virginia University
Wright State University
Rebecca Lindell, Triadial 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 had 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 interviewee'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. Caillan, Colorado School of Mines, 1232 West Campus Rd., Golden, CO 80401; kcaillan@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.
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 Stamper, 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  12:20-12:30 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  

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 CO2. 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

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, 3007 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.płañinsic@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

EB01  3:30-3:40 p.m. Backward Reaction Force on a Fire Hose, Myth or Reality?
Contributed – Rodrigo Rivera, Pontificia Universidad Catolica de Valparaíso, av valparaiso 230, depo 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.
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 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 further than the Torricelli 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 transport of water in a metastable regime of negative pressures.
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

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**Session EC: PER: Student Content Understanding, Problem-Solving and Reasoning**

**EC01 3:30-4:30 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/MrR37, Fresno, CA 93740; rogerk@cfsufresno.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 inexperience 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.
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.

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.

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 mastery of 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.

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 in this professional development opportunity or curious about life as a graduate student!

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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.

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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.

*Supported by Fred Goldberg

**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 (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 Buford 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 age 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 feedback 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 Workshop 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.

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**Session EF: Integrating Computation with the PICUP Collection**

**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

Homing 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 strung 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.
Monday afternoon

**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; jmcdonnel1@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 resources 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 interactive trajectories 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 STEMencoding project (u.osu.edu/stemencoding) and the AIP Meggers Award*

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**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
**President:** Kevin Lee

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**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*

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**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 the context for the first quantum state 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 will 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*

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**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 prerequisites 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*
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.

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 experience for students to explore and can be carried out using existing apparatus with little to no extra hardware.

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.

Subatomic particle decays provide an excellent platform for students to study the conservation of energy and momentum within a relativistic context.

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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

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 Mayagüez 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 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.

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

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.  WWII 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 WWII, 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 – Svilan D. Kostov, Georgia Southwestern State University, 800 GSU State University Dr., Americus, GA 31709; skostov@gsu.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 faded 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

**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@ithaca.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 – Katie Ansell, University of Illinois – Urbana Champaign, Department of Physics, 1110 W. Green St., Urbana, IL 61801; crimmin1@illinois.edu

IOLab is an 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; attitus@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 interface 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

**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. Oluwaseyi, 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 the 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

**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; koenigk@ucmail.uc.edu

Ronald K. Thornton, Tufts University

Sponsors: Committee on Research in Physics Education, Committee on Educational Technologies

Presider: Jeff Groff

Committee on Diversity in Physics, Committee on Women in Physics

Presider: Juan Burciaga

Committee on Research in Physics Education, Committee on Educational Technologies

Presider: Kathy Koenig

Sponsors: Committee on Research in Physics Education, Committee on Educational Technologies

Presider: Jeff Groff

Monday afternoon
The results of physics education research and the availability of microcomputer-based tools have led to the development of the Activity Based Physics Suite. 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.


**FE02 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. 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.


**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-Science Institute, Indianapolis, IN 46227-369; zduman@indy.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.

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**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 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, 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; 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 as a physics department as a good researcher. French was a skilled lecturer, a thoughtful user and designer 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 Phyllis 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 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**

<table>
<thead>
<tr>
<th>Location: Sunset</th>
<th>Sponsor: Committee on Physics in Undergraduate Education</th>
<th>Time: 7:00-8:20 p.m.</th>
<th>Date: Monday, January 8</th>
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</thead>
</table>
| **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; gsip@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-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 Saigado, U Wisconsin La Crosse, 1725 State St., La Crosse, WI 54601; rsaigado@uwlec.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.

**FG08  8:10-8:20 p.m. Octahedral Skeleton (origami) for Learning Vector Analysis**

*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 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 is supported in the literature. The audience will be polled for feedback on the utility of the learning tool. We will fold 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.


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**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*

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**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*

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**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 Roudebeush, Retired, 4410 Mariner Lane, Fairfax, VA 22033; droudebeush@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.
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/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.  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
Orilaara Wentink, Lane Seeley, Seattle Pacific University
The Alabama Section of AAPT meeting was the host for two workshops to help physics teachers in Alabama and to increase the number 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 use of the two 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.  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; tholsenbeck@alasu.edu
Ruben Ortega, John Faust, Oscar Guerrero, The University of Texas-Rio Grande Valley
The Alabama Section of AAPT meeting was the host for two workshops to help physics teachers in Alabama and to increase the number 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 use of the two 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.

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; gulgar@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 an 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.
Upper Division and Graduate

PSTC01  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. Selwin, 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 (KAP95) 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.

PSTC02  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 Millsap, 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 resonant impedance and the “color” of the sound using Fourier Transforms.

PSTC04  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@taylor.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

PSTC05  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 machine 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 Hütt, 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.

**PST2D02** 8:30-9:15 p.m. Making Space Research Affordable for Community College Students  
Jennifer Jones, Arapahoe Community College  
Victor Anderson, Community College of Aurora  
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. The device for making smartphone VR superior to using just a YouTube video is the ability to create a truly rich story filled with 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  
Christian 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-electromechanical) 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, 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 astrophysics 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, IJPN-CICATA, Legaria 694, Col. Irrigación, Mexico, MEX 11500 México mramirezdz@pn.mx
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

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. Millis 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 formal groups for 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@sj州u.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 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; jiperry@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.
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 Sotherland, 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.


**Monday afternoon**
Monday afternoon

PST2E16  9:15-10:00 p.m.  The Einstein Box for Skills Development in Preschool in Mexico  
Poster – Mario Humberto Ramirez Diaz, IPN-CICATA, Legaria 694, Col. Irrigación, México, México 11500 México; mmramirezd@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 Drosos Way, Charleston, SC 29414; MAgrest@Citadel.edu  
Joel Berligiheri, 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 Friday’s 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.


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 kkishimoto@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 – Dea O’Neil, Bridgewater College, 402 E College St., Bridgewater, VA 22812; donell@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; lotsbooks@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. Koziinski, Department of Physics, Lewis University, One University Pkwy., Romeoville, IL 60446; kozinjo@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 well 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  President: 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.predoi-cross@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 attraction 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 – Artisa L. Richardson, Chandler-Gilbert Community College, 11629 E Parkview Ln., Scottsdale, AZ 85255; artisa.richardson@cgc.edu

This summer in Birmingham, U.K., women in physics from 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; jjohnsonarmstrong@stkate.edu

I had the privilege of being part of the U.S. Delegation to the International Conference of 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  President: 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, robbbyfield7@gmail.com
Wesley Morgan, Brigham Young University, wesleyym78@gmail.com
Anna Bell, Brigham Young University, anna_bgp@yahoo.com
Rachel Kruger, Brigham Young University, wesleyym78@gmail.com
Tuesday morning

**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

**GD01 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 is 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 Zelik, 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.

**GD02 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."

**GD03 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.

**GD04 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

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 radiometric 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 Milbrook 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.
Tuesday morning

Session GF: Selecting an Apparatus for Effective Learning in the Upper Level Labs
Location: Pacific Salon Two  
Sponsor: Committee on Apparatus for Effective Learning in the Upper Level Labs  
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 Amaral Valley High School, Pleasanton, CA 94566; breekabarttndreyfuss@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 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 Francisco, 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.
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; astaylor@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, 3211 Providence Dr., Anchorage, AK 99516; jptantaleone@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.
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.

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.
The Value of Diversity in Physics
by Barbara Whitten, Physics Department, Colorado College

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 HB:   International Trends in Teacher Preparation and Outreach

Session HA:  Diversity Along Multiple Dimensions

Special Session:   Oersted Medal awarded to Barbara L. Whitten

Location: Golden Ballroom     Time: 12:00-1:00 p.m.     Date: Tuesday, January 9     President: Janelle M. Bailey

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Session HA: Diversity Along Multiple Dimensions

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 Diego 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

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 Mexico, Instituto de Fisica, Ciudad Universitaria, Mexico City. DIF 01000 Mexico; 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-Learning-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.

*Supported by Dennis Gilbert

Session HC: Issues for Adjunct Faculty
Location: Pacific Salon Four/Five  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; lepast001@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 ways to improve at our institutions.

*Supported 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 Beardon

HD01  1:00-1:30 p.m.  3D-Printable Things in Particle Physics Education
Invited – Julia Wolthe, CERN, Geneva 23, Geneva, Geneva 1211 Switzerland; Julia.wolthe@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 equipment. 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
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; kyoko013@gmail.com
Yoshishide 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, 2520 Campanile Dr., San Diego, CA 92182; fgoldberg@mail.sdsu.edu

The Next Generation Science Standards (NGSS) are designed to engage all students in meaningful science learning and prepare them for success in the 21st Century workforce. This presentation will describe our work developing an NGSS-aligned curriculum to prepare elementary preservice teachers to implement NGSS in their classrooms. The curriculum is designed to be used in a yearlong introductory physics methods course. The presentation will include the learning outcomes and assessment measures used in the curriculum, as well as student feedback from the first year implementation.
Next Generation Physical Science and Everyday Thinking (Next Gen PET) 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 includes instructor materials, homework activities, videos of experiments, classroom video clips, test banks, etc. An associated online faculty learning community 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.


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 research-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 Pseudoscientific Claims
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 92039-0119; 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." Conjunctive 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 Scaffolding Exercises to Develop the Ability to Identify Pseudoscientific Claims
Contributed – Chad L. Davies, Gordon State College, 419 College Dr., Barnesville, GA 30204-1700; cdavies@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 student’s 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

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.

2:00-2:30 p.m.  Hands-on Activities

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2:00-3:30 p.m.  Hands-on Activities

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 E. 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

PST3A04  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 Martin
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 and 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.

PST3A05  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 non-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 solar 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 Gern ZüS, University of Cologne Im Weidenauel 16b Rösrath, 51603; 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 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.

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
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.

Contributed – Cabot Zabriskie, West Virginia University, 135 Willey St., Morgantown, WV 26506-0002; cazabriskie@mix.wvu.edu

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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 reproducible. Using the expert so faculty members and graduate student solutions, we developed a theoretical model of the knowledge structure of the FCI.

Contributed – David Morgan, Richard Bland College, 11301 Johnson Rd., Petersburg, VA 23805; dmorgan@rbc.edu

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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 two-dimensional nature 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

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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.

Contributed – Andre Salinas, Institución Educativa Siete de Agosto, CL 72 11 C 27, Cali, Valle del Cauca 760001 Colombia; asalinasayh2003@yahoo.com

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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.

Contributed – Rabindra R. Bajracharya, Missouri Southern State University, 3950 E Newman Rd., Joplin, MO 64801; ab_study@yahoo.com

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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.

Contributed – Jing Wang, Eastern Kentucky University, 3170 New Science Bldg., 521 Lancaster Ave., Richmond, KY 40475; jingwangky@gmail.com

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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

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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.

Contributed – Jessica Lair, Eastern Kentucky University

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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@fullbrightmail.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 (DL-SCL). 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 (DL-SCL) 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 pretot posttest scores were statistically significant t (61) = 4.716, p < .001. 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.


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**Session IB: Post-deadline Abstracts II**

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<th>Location: Royal Palm Five/Six</th>
<th>Sponsor: AAPT</th>
<th>Time: 3:00-4 p.m.</th>
<th>Date: Tuesday, January 9</th>
<th>President: Mike Gallis</th>
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**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; tpa@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 follow-up 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; ashwinias@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 D. 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 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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