
2025 AAPT
WINTER MEETING
JANUARY 18-21
ST. LOUIS, MO

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

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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 **#aaptwm24**. 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 Boston area. We look forward to connecting with you!

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2025 Melba Newell Phillips Medal Recipient is Karen Jo Matsler

Karen Jo Matsler

Sunday, January 19
11:30–12:20 p.m.

Grand Ballroom E&F

The American Association of Physics Teachers (AAPT) proudly announces that Karen Jo Matsler, UTeach Master Teacher at the University of Texas at Arlington, is awarded the 2025 Melba Newell Phillips Medal. This honor recognizes her extensive contributions to physics education and her tireless efforts to support educators nationwide.

Matsler's distinguished career spanning several decades, is marked by her leadership, advocacy, and dedication to advancing physics education. From her early days as a Physics Teaching Resource Agent (PTRA) in 2000 to becoming the national director of the PTRA Program from 2012 to 2023, Matsler has been at the forefront of physics teacher professional development. She has served a three-year elected term on the AAPT Board of Directors, been appointed to several Committees and Advisory Boards, and organized countless workshops, presentations, and sessions at AAPT national meetings. Her contributions have been recognized through numerous awards, including the American Physical Society's Excellence in Physics Education Award, the Homer Dodge Distinguished Service Citation in 2008, and as an AAPT Fellow in 2014.

Leadership in the PTRA Program: Matsler became a regional director for the PTRA Program in 2001 and co-principal investigator for the Rural Initiative in 2003. She was instrumental in expanding the PTRA's reach, overseeing PTRA workshops at 35 sites each summer across the U.S., serving thousands of teachers, many of whom lacked formal physics training. Her work helped create a more inclusive and effective professional development model for physics educators.

Statewide Advocacy: Matsler's advocacy for teaching Physics First and her efforts to influence the Texas Educational Board to require physics for all high school students showcased her commitment to improving science education. Although the mandate was later repealed, her persistent work highlighted the importance of early physics education. Matsler was elected to serve on the Science Teacher Association of Texas (STAT) board and was responsible for organizing the state conference (CAST) sessions into content strands to highlight work of TS AAPT and better support physics crossover teachers.

The Melba Newell Phillips Medal honors the legacy of Melba Phillips, a physicist, educator, and advocate for science education. The medal is awarded infrequently and only to individuals whose careers reflect Phillips' commitment to advancing physics education.

Laurie Elizabeth McNeil is the 2025 John David Jackson Excellence in Graduate Physics Education Recipient

Laurie E. McNeil

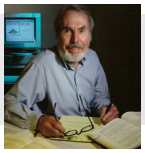
Monday, January 20
9–10 a.m.

Grand Ballroom E&F

The John David Jackson Excellence in Graduate Physics Education Award for 2025 will be awarded to Laurie Elizabeth McNeil, Bernard Gray Distinguished Professor, Department of Physics and Astronomy, University of North Carolina at Chapel Hill (UNC).

Throughout her distinguished career, McNeil has been a visible, ardent, knowledgeable, and successful advocate and practitioner for innovative and effective graduate physics education at Carolina and beyond. She has maintained her passion, energy, and excellence in graduate education, particularly through her leadership roles as Department Chair (2004-2009) and Director of Career and Professional Development (2022-present) for the Department of Physics and Astronomy at UNC-Chapel Hill, and Director of Graduate Studies (1995-1998) and Interim Chair (2007-2008) for the Curriculum of Applied and Materials Sciences (now Department of Applied Physical Sciences), all the while setting a very high standard in effective mentoring of PhD students, maintaining an active research program, improving diversity in the physics community (especially through her major role in the Climate for Women Site Visit Program of the American Physical Society), and championing excellence in undergraduate curriculum and pedagogy. She is recognized nationally and internationally for her work and has helped the University of North Carolina's physics department and the University to be a leader in physics education.

Serving as the Director of Graduate Studies (DGS) for the Curriculum in Applied and Materials Sciences, McNeil worked with faculty from partnering programs, including Physics, Chemistry, Applied Math, and Dentistry, to design the graduate curriculum and get it approved by the UNC system. She was responsible for the initial launch and implementation of the program.epreneurs.



Named in honor of outstanding physicist and teacher, John David Jackson, this award recognizes physicists and physics educators who, like John David Jackson, have made outstanding contributions to curriculum development, mentorship, or classroom teaching in graduate physics education.

Jonathan D. Perry

Monday, January 20
5–5:40 p.m.

Grand Ballroom E&F

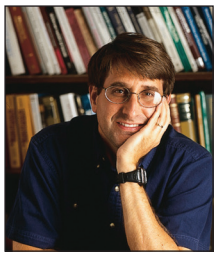
Jonathan Perry Is 2025 Doc Brown Futures Award Recipient

The 2025 recipient of the Doc Brown Futures Award is Jonathan Perry. The Doc Brown Futures Award recognizes early-career members who demonstrate excellence in their contributions to AAPT and physics education and exhibit the potential to serve in an AAPT leadership role. A member of AAPT since 2016, he earned a B.A. and M.S. in Physics at Baylor University and a Ph.D. in Physics at Texas A & M University. Perry is an Assistant Professor of Instruction, in the Department of Physics at the University of Texas Austin.

A regular attendee of AAPT's national meetings, Perry has proven to be a talented teacher, an accomplished researcher, and a dedicated student mentor. He has taken on several early leadership roles serving on the Committee for Science Education for the Public (CSEP), including being Vice Chair (2022) and Chair (2023) and well as serving on the Meetings Planning Committee. He has organized multiple sessions for national conferences in recent years and serves as a reviewer for multiple journals including Physical Review PER and *The Physics Teacher.*

Perry joined the Physics Education Research (PER) community as a graduate student developing both his teaching and research talents in parallel. His students describe him as "extremely supportive and willing to listen. He also encourages us to reach out of our comfort zone in order to reach our max potential", and as being "really good at explaining things in a way we all could understand." Having a superb reputation in the department, Perry taught introductory lectures, supported a summer boarding program for high school physics teachers, and received the highest graduate student award at Texas A&M for his teaching. In research, Perry demonstrated his abilities to generate ideas and creative suggestions to approaching problems, being instrumental in developing and studying a new self-study resources named "Freshman Physics Classroom" The results were published in the *American Journal of Physics*.

Robert William (Doc) Brown, of Case Western Reserve University, has had a rewarding five-decade career in teaching, research, and entrepreneurship. An Inaugural Fellow of the AAPT, Doc Brown is associated with a number of educational innovations, including an early use of a fiberoptics electronic educational environment (1980s), of an early use of undergraduate teaching assistants (1990s), of published PER work on both "post-exam syndrome."



Bruce Mason

Monday, January 20
5:40–6 p.m.

Grand Ballroom E&F

Bruce Mason to receive 2025 Lillian McDermott Medal

Bruce Mason is recognized with the 2025 Lillian McDermott Medal. Mason is specifically recognized "for his pioneering work on digital libraries and curriculum development, including ComPADRE as well as Physlet-based and Open Source Physics-based curricular development, all of which has influenced hundreds of teachers and thousands of students around the world". Mason got his B.A. in Physics from Oberlin College, graduating in 1980 with High Honors. Both his M.S. and Ph.D. in Physics were completed at the University of Maryland, College Park.

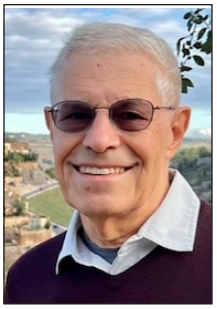
His enthusiasm for physics and physics education were apparent throughout his undergraduate career, including his senior year experience as a teaching assistant for the electronics laboratory and his thesis project on building a cloud chamber.

Mason recognized the potential of the internet early on working on behalf of MERLOT in 2000 as the physics editor, a position he held for about a decade, cataloging and organizing an extensive collection of physics software and curricular material. His talent as digital library innovator was recognized by the physics societies and he was recruited by the American Association of Physics Teachers (AAPT), the American Institute of Physics (AIP), and the American Astronomical Society (AAS) to lead the development of a multi-society National Science Digital Library (NSDL) known as ComPADRE gaining him an international reputation as a knowledgeable and skilled administrator/teacher. He was asked to serve as a member of the Board for the European Multimedia in Physics Teaching and Learning (MPTL) conference series. He was also asked to serve on the international organizing committee for Groupe International de Recherche sur l'Enseignement de la Physique (GIREP) conferences.

Named for Lillian C. McDermott, the Medal recognizes those who are passionate and tenacious about improving the teaching and learning of physics and have made intellectually creative contributions in this area. In 2021 AAPT Board of Directors voted unanimously to remove Robert A. Millikan's name from the award that recognizes "those who have made notable and intellectually creative contributions to the teaching of physics." The AAPT then sought nominations from AAPT members for renaming the award. Based upon nominations from members, the BOD unanimously approved renaming the award to Lillian C. McDermott.

The 2025 Winter Fellow is **Kathleen A. Harper,** *Associate Professor, Division of Engineering Leadership and Professional Practice, Case Western Reserve University, Cleveland, OH.* **Monday, Jan. 20, 5–6 p.m.**

2025 Oersted Medal Winner is Fred M. Goldberg



Fred M. Goldberg

Tuesday, January 21
10 a.m.–11 a.m.

Grand Ballroom E&F

Fred Goldberg has been named as the 2025 recipient of the prestigious Hans Christian Oersted Medal, The Oersted Medal recognizes his outstanding, widespread, and lasting impact on the teaching of physics.

Goldberg is Emeritus Professor of Physics at San Diego State University, where he has been involved in research, curriculum development, and teacher professional development in physics education, working with students and teachers throughout the entire educational spectrum, K-16. He was the recipient of AAPT's 2003 Robert A. Millikan Award. He was also a 2007 Fulbright Senior Specialist, visiting scholar to Israel and in 2014 he was elected as a Fellow of the American Association of Physics Teachers. His research and development efforts have focused in three main areas: (1) Developing activity-based physics and physical science curricula for preservice and in-service elementary teachers to be used in both small and large (lecture-style) classroom environments and investigating student learning in these environments; (2) studying university and college faculty implementing research-based curricula as part of a faculty online learning community; and (3) supporting responsive teaching in science in elementary and middle school classrooms.

Goldberg's curricular work has resulted in publication of several one-semester courses that are used in colleges and universities nationwide: Physics and Everyday Thinking (PET), Physical Science and Everyday Thinking (PSET), and Learning Physical Science (a large-enrollment adaptation of PSET). Most recently, Next Generation PET is a curriculum that unites the previous versions of PET and PSET, and aligns with the Next Generation Science Standards. Work in the second area has resulted in the development of a website that supports teacher implementation of Next Generation PET, including video snippets of students engaged in small group and whole class discussions for almost all the activities in the curriculum. He has also helped develop a year-long activity-based middle school physical science curriculum, Interactions in Physical Science, and a set of professional development materials to support teachers' implementation.

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

Winter Meeting Plenary Speaker Ben Swickl:
Preparing students for a quantum future

Ben Zwickl

Sunday, January 19
5:30–6:30 p.m.

Grand Ballroom E&F

Ben Zwickl is an Associate Professor in the School of Physics and Astronomy and a member 0f the Physics Education Research Group at Rochester Institute of Technology. He is also an Adjunct Professor in the Center for Computing in Science Education at the University of Oslo. He received a PhD in physics doing experiments related to quantum optomechanical sensors, which was followed by a postdoc in physics education research at the University of Colorado Boulder. Since that time, Ben has pursued research on the nature of physics expertise, how expertise is developed, and the relationship between formal education and professional success. This has included research on graduate education, career preparation for optics and quantum jobs, and laboratory education. Ben regularly teaches courses that integrate computation, laboratory work, and projects.

Thanks to Our exhibitors for the Winter Meeting

aiPlato (202)

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ARRL The National Association for Amateur Radio (201)

Pasco scientific (106)

Society of Physics Students (SPS) (303)

Vernier Science Education (203- 205)

Workshops at 2026 Winter Meeting

Saturday, January 18, 2024 8 a.m.–12 p.m.

AP Physics Course Revisions for 2025 Exams}

This workshop will introduce the revised AP Physics curricula to teachers. The goal of this workshop is to familiarize teachers with the new curricula and science practices. The session will begin with a brief introduction, providing context for the new curriculum and its goals. This will be followed by a deep dive into the key features and major differences between the new curriculum and its predecessor, with a focus on the content changes for all four AP Physics courses and the revised science practices. Attendees will be encouraged to participate in group discussions and activities. A significant amount of time will be devoted to developing skills in adapting and implementing the new curriculum within participants' classrooms. The session will conclude with an opportunity to review sample questions tied to each science practice in a case study. The revised AP Physics exams will be reviewed, and strategies to prepare students will be discussed and modeled.. **Price: $75 (Member), $100 (Nonmember)**

Organizer(s}: John Pinizzotto, Amy Johnson, Jesse Miner, Holley Mosley

Location: Midway Suites 6

Developing Culture-Based Approaches To Physics Instruction

This workshop is tailored for physics instructors eager to create instructional units that are culturally responsive. We will cover the entire process of developing such units and assessments, from conceptualization to execution. Participants will receive resources to aid in crafting strategies that are culturally relevant to their classrooms. Furthermore, we will collaborate with teacher leaders to develop and pilot trial instructional units tailored to your specific class needs. Join us to enrich your teaching methods with cultural relevance and efficacy. Price: $75 (Member), $100 (Nonmember)

Organizer(s): Clausell Mathis

Location: Miidway Suites 7

From Atoms to Quantum Computers: Train the Trainer Workshop

From Atoms to Quantum Computers: Train the Trainer Workshop for High School Teachers: In this workshop, we will present an introduction to quantum information tailored for high school students, drawing on our experience running a summer camp titled "From Atoms to Quantum Computers" at Middle Tennessee State University. Participants will learn about fun, interactive quantum games that we've developed to make quantum mechanics more approachable for students. In addition, we will provide hands-on practice with coding on the IBM Quantum Computer, giving teachers the tools to bring quantum computing into their own classrooms. We will share all the materials we've developed, including lesson plans, games, and coding exercises, which can be adapted to fit your school's curriculum. Whether you are teaching physics or computer science or just want to expose your students to the cutting-edge field of quantum technology, this workshop will equip you with the resources you need to make quantum concepts accessible and exciting! Price: $75 (Member), $100 (Nonmember)

Organizer(s): Shane Wood

Location: Midway Suites 8

PICUP: Integrating Computation into Introductory Physics at TYCs

In this workshop, we will show you some ways in which computation can be integrated into your introductory courses. The PICUP partnership has developed a variety of computational activities for introductory physics, and we will show you how you can take these PICUP materials and adapt them to fit your needs. PLEASE BRING A LAPTOP COMPUTER. In this workshop, we will focus on computational activities using spreadsheets and web-based "Trinkets" so you do not need to have any specialized software installed. This workshop is supported in part by OPTYCs, The Organization for Physics at Two-Year Colleges (NSF-DUE-2212807), and NSF IUSE grants DUE-2337054, DUE-2337053, DUE-2337051, DUE-2337049, DUE-2337052, DUE-2337056, DUE-2337055, and DUE-2337050. Price: $75 (Member), $100 (Nonmember)

Organizer(s): Marie Lopez del Puerto, Andrew Morrison, Walter Freeman

Location: Midway Suites 5

Bridging Classical and Quantum Realms Using Nuclear Magnetic

Nuclear magnetic resonance (NMR) can bridge the classical and quantum realms and is underutilized in the undergraduate science curriculum. We have developed a set of curricular materials to cover the theory, practice, and applications of NMR in a truly multidisciplinary way as well as have the flexibility for use in a variety of different courses, classroom environments, and institutions. In this workshop, attendees will experience firsthand some of the developed class activities, learn about our research findings assessing implementations of these modules, and finally discuss how these modules may be implemented into coursework at their home institution. A laptop will be helpful to access the full set of online materials being discussed. Price: $75 (Member), $100 (Nonmember)

Organizer(s): Merideth Frey, Katyanna Sciorrar

Location: Midway Suites 8

Quantum Computing: What's the Buzz?

Are you interested in learning more about Quantum Computing? Have you been asked to teach it or introduce some of the concepts into courses you are already teaching? What's the state of the field anyway? Do you just want to be more informed about this fascinating, relatively new field? Should it be taught in Physics, Computer Science, Chemistry, Math, or all of them!? If you find yourself interested in these questions, this workshop is for you. We will give an overview of the present state of the field, present an introduction to Quantum Computing, including a discussion of our experiences learning the topics and teaching them, course coverage, format, and learning materials, research we have done on student strengths and difficulties in learning quantum computing topics, and the development of evidence-based materials to teach the course. We will share information on freely available online resources, our own evidence-based materials, and possible texts. We will focus on an undergraduate course, but it will be relevant for classes above and below that level, too. Price: $75 (Member), $100 (Nonmember)

Organizer(s): Beth Thacker, John Di Bartolo

Midway Suites 9

Observing with Unistellar Telescopes (7:30–10:30 p.m. Saturday)

Smart telescopes offer physics and astronomy faculty and students direct entry into both enhanced public outreach and astronomical research thanks to innovative bundling of mechanical, optical, imaging, and software technologies. In this nighttime workshop, participants will learn to set up and operate Unistellar telescopes outdoors. Participants must have either an iOS or Android smartphone or tablet (e.g., an iPad) with which to operate the telescope and acquire CCD (Charge Coupled Device) images. Please dress for cold weather. In case of inclement weather or cloudy skies, the workshop will be moved indoors. Two-year college physics and astronomy faculty are especially encouraged to attend, but all are welcome. This workshop is sponsored by OPTYCs, the Organization for Physics in Two-Year Colleges, and is funded by NSF-DUE-2212807..

Organizer(s): Paul J. Heafner Price: $75 (Member), $100 (Nonmember)

Location: Outside Courtyard

POSTER SESSION I:
Location: Midway West **Sponsor: AAPT**
Time: 5:30–6:30 p.m. **Date: Satuday, Jan. 18**

ASTRO Posters (5:30–6:30 p.m., Saturday)

POS-SAT-C301 | Poster Presentation Traditional | Teach Astrobiology

Presenting Author: Gregory Topasna, Virginia Military Institute

Astrobiology is a course for everyone. If taught in an accessible way, the course can reach a broad spectrum of students, ignite their curiosity about its many fascinating topics, and give them options to consider as they develop their career goals. For the past eight years, the author has taught an introductory astrobiology course with students from various majors. A presentation of the course material, how the course is run, what works and what doesn't, and what activities the students find most stimulating are presented. We've all wondered if there is life "out there." And while an astrobiology course cannot definitively answer that question, participation in an astrobiology course will help students develop their logical reasoning skills and give them the background information they need to separate fact from fiction.

POS-SAT-C303 | Poster Presentation Traditional | Making An Unlikely Connection: CATE2024 Team 017

Presenting Author: Margaret Hill, Southeast Missouri State University

The Citizen CATE 2024 project proposed to deploy 35+ identical stations of citizen scientists across the US to gather research-quality images of the inner solar corona in polarized light during the April 8, 2024 total solar eclipse. Afterward the equipment would be retained by the research teams for further education and outreach. Groups from libraries, museums, universities, and other community groups were invited to apply. Funded by NASA and the NSF, the project's purpose was not only to add to current scientific knowledge and understanding of the sun and its atmosphere, but also to involve citizen teams in underserved regions and to introduce underrepresented minorities to real scientific research. The challenges of outfitting, locating, and training these teams was enormous, but the outcome for Team 017, collecting data in McLeansboro, IL, was tremendous! This poster details the challenges and triumphs of the unlikely and high-stakes pairing of Southeast Missouri State University undergraduates from Cape Girardeau, MO, with minority middle school students at One City School in Madison, WI.

POS-SAT-C305 | Poster Presentation Traditional | Observations of the April 8, 2024 Total Solar Eclipse from Kentucky and Ohio

Presenting Author: Jennifer Birriel, Morehead State University
Co-presenting Author | Ignacio Birriel, Morehead State University
Additional Author | Brayden Schwegman, Morehead State University
Additional Author | Kevin Adkins, Morehead State University
Additional Author | John Waite, Morehead State University

We present observations of zenith sky brightness at three locations and cosmic ray observations at one location. We obtained zenith sky brightness using a bank of 4 RGBL filtered, Unihedron Sky Quality Meters (SQMs) at two locations along the line of totality: Wickliffe, KY and Oxford, OH. At a Morehead, KY site, where the eclipse reached 95.39% coverage, we used a single, unfiltered SQM on the roof of the science building at MSU to monitor zenith sky brightness. We also used a cosmic ray detector located inside the science building: no significant change in the cosmic ray flux was observed, consistent with previous studies. Zenith sky brightness exhibited no significant change until roughly 50% coverage of the solar disk. During totality, the sky brightness dropped to 13.0+/-0.1 mag/arcsec2 at Wickliffe, KY and 13.5 +/- 0.1 mag/arsec2 at Oxford, OH; these values are consistent with past eclipse observations. Color band observations reveal some interesting phenomena, which require further investigation to understand. We conclude with suggested improvements for future observations of solar eclipses using SQMs.

POS-SAT-C307 | Poster Presentation Traditional | CMB-S4's Online Cosmology Course

Presenting Author: Kasey Wagoner, North Carolina State University
Additional Author | Juliet Crowell, University of Chicago
Additional Author | Felipe Maldonado, DaVinci Science Center

Contemporary research questions in Cosmology, such as "how did the universe start" are often fascinating for students. The CMB-S4 collaboration has developed a new online course which addresses many of fundamental research topics in modern cosmology such as dark matter and dark energy. The course started as a synchronous online lecture series intended for middle-school students and it has become an asynchronous series of lectures which are accompanied by instructional resources which are suitable for more advanced learners. Here we will describe all aspects of the course in the hopes that it can be a useful resource for physics and astronomy instructors at any level.

Cross-Disciplinary Posters (5:30–6:30 p.m., Saturday)

POS-SAT-D401 | Poster Presentation Traditional | Art and Science in Virtual Worlds

Presenting Author: Michael Gallis, Penn State Schuylkill

The course "Art and Science in Virtual Worlds" is an integrative general education offering that bridges the Natural Sciences and Arts. This multidisciplinary course introduces students to the theories, concepts, and technologies underpinning virtual worlds. By leveraging the open-source WebVR framework A-Frame, students are empowered to create immersive virtual objects and spaces that align with their unique narratives and storylines. Throughout the course, students delve into the implementation of virtual physics, exploring object interactions, lighting, material effects,

and animation. This hands-on approach not only enhances their understanding of physical sciences but also fosters creativity and innovation in the digital arts. The course exemplifies the synergy between narrative arts and physical sciences, providing a comprehensive learning experience that prepares students for the evolving landscape of technologically mediated environments. In recent iterations of the course, students have used generative AI to help with both the creative writing aspects and the technical development, to mixed levels of success.

POS-SAT-D403 | Poster Presentation Traditional | A Physics Seminar Course on Renewable Energy with Hands-on Engagements for First-Year University Students

Presenting Author: Roberto Ramos, Saint Joseph's University

I describe a Physics Seminar Course on "Introduction to Renewable Energy" for first-year students I have been teaching for over a year. This course has impacted over 60 first-year students from Business, Finance, Math, Computer Science, Biology, Psychology, and Biomedical Sciences who received instruction and training in solar, wind, geothermal, biomass, hydroelectric, hydropower, and fuel cell energies and energy storage, and the physics underlying these approaches. Students experienced hands-on project-building of solar-powered fidget spinners, model solar cars and boats, wind turbines, solar trackers, and biomass fermentation. Students use thermal imaging cameras to audit energy loss and study thermal insulation to conserve energy. Students also learn the language of climate change, carbon financing, carbon sequestration, and environmental justice. Reflective essays, objective quizzes, a research paper, and a three-day Renewable Energy Poster Exhibit assess student learning. I report on the products of the course, student feedback using blind surveys, program assessments, and where the course is headed in the future.

R. Ramos acknowledges the support of Constellation.

POS-SAT-D405 | Poster Presentation Traditional | Project FRESH Air: Community Engagement for Health and Climate Awareness

Presenting Author: Stephen Holler, Fordham University

Additional Author | Lauren White, Fordham University

Additional Author | Usha Sankar, Drexel University

Project FRESH Air (Fordham Regional Environmental Sensor for Healthy Air) is a community-engaged environmental justice project that aims to collect and analyze air quality data in partnership with local K-12 educators and students. Marginalized communities in urban environments suffer from asymmetric pollution distributions, particularly particulate matter from vehicular emissions, which result in disparities in health outcomes, including a high incidence of respiratory diseases. Socio-economically disadvantaged communities in the Bronx experience the greatest number of asthma-related emergency department visits and hospitalizations in New York City and account for nearly one-quarter of asthma-related deaths in New York State. FRESH Air engages local middle and high schools to educate them about the impact air pollution has on their health and how those same pollution sources contribute to and will be impacted by climate change. Particulate sensors placed inside and around the school provide students with hyper-local data, while Fordham personnel work with the students and teachers to interpret the data and raise awareness of the environmental justice disparities across the city. In addition, we have developed projects for in-class and after-school programs to provide the students with hands-on STEM experiences to promote a STEM culture among marginalized communities that inspires and creates pathways for a future in STEM.

POS-SAT-D407 | Poster Presentation Traditional | Air Filters as a Model System to Teach Curve-Fitting

Presenting Author: Adam Clark, Muhlenberg College

Co-presenting Author | Tyson Sprayberry, Louis E. Dieruff High School

The SARS-CoV-2 pandemic demonstrated the importance of indoor air quality and the role enhanced air filtration can play for public health and controlling disease spread. We document a service-learning project where faculty and students from Muhlenberg College developed a multi-pronged lesson plan and delivered it to a high school physics class in Allentown, PA. The first step was constructing air cleaners from commercially available kits following the model known as the Corsi-Rosenthal Box. The high school students were then given a multi-part lesson on air quality, data taking, and curve fitting. The first part presented information on the health impacts of fine particulates and airborne disease transmission. The second part taught students a procedure for collecting time series data on particulate concentration with the air cleaner running. Finally, they were taught how to curve fit the data in a spreadsheet and use parameters from the fit to determine the Clean Air Delivery Rate (CADR) of the filters. The filters were donated to the high school classroom, providing sufficient air cleaning capacity for infection risk mitigation for 30 people in a classroom setting per ASHRAE Standard 241: Control of Infectious Aerosols.

Intro & Beyond Posters (5:30–6:30 p.m., Saturday)

POS-SAT-E501 | Poster Presentation Traditional | Hands-On Group Work in Online, Semi-asynchronous Introductory Physics Courses

Presenting Author: Parker Poulos, Kansas State University

Additional Author | Brandi Lohman, Kansas State University

Additional Author | Tim Bolton, Kansas State University

While departments adapted to online courses out of necessity during the COVID-19 pandemic, the return to the classroom has seen some departments slow their efforts to meet the needs of online students. Many online physics curricula focus on the concepts and math without hands-on lab components and student-to-student interactions. The Kansas State University Department of Physics has piloted a new approach to online introductory physics courses with physical lab components and required group work. The course is a hybrid of synchronous and asynchronous content, with a fully asynchronous option for students unable to attend synchronous sessions. We present on the design and implementation of this new approach to online introductory physics courses.

POS-SAT-E503 | Poster Presentation Traditional | First-Year Teaching Experience: Integrating Active Learning and Formative Assessment in Introductory Physics

Presenting Author: Jinhyuk Lim, Eastern Illinois University

In my first year of teaching, I incorporated active learning and formative assessment techniques into a calculus-based introductory physics course with 17 students. Each class begins with a 5-minute recap quiz to reinforce key concepts from the previous lecture, serving as a warm-up to engage students with new material. The first half of the session introduces new concepts, followed by a multiple-choice pop-up quiz where students self-assess their understanding (indicating answers from A to E). This is reinforced with problem-solving examples on the chalkboard. Next, students pair up for a 5-minute group discussion, reviewing the recap quiz, clarifying concepts, and sharing insights. The second half follows a similar structure: introducing new concepts, self-checking with a multiple-choice quiz, and concluding with examples and a summary. This approach fosters active engagement and promotes deeper understanding through peer discussion and interactive learning.

POS-SAT-E505 | Poster Presentation Traditional | Emphasizing modeling and experimental design in a laboratory course for life science majors

Presenting Author: M. Jeannette Lawler, Brigham Young University

Additional Author | Kethry Walton, Brigham young university

Co-presenting Author | Madeline Maxwell, Utah State university

Additional Author | Madeline Harmer, Brigham Young University

Additional Author | Adam Benion, Brigham Young University

This presentation discusses the outcomes and behaviors of students in a newly revised, one-credit laboratory course for life science majors. The course, which can be taken alongside or after an algebra-based Newtonian physics course, includes activities on translational, rotational, and harmonic motion, as well as thermal physics and acoustics. Recently, the course was updated to emphasize modeling and experimental design, shifting from its previous focus on reinforcing conceptual understanding. To evaluate the impact of these changes, we conducted a comprehensive study involving observations of student and TA behaviors, interviews with both groups, and analysis of student work to assess improvements in modeling skills. Our findings, which highlight the effectiveness of the new course design, will be presented.

POS-SAT-E507 | Poster Presentation Traditional | Angular Displacement as a Vector Quantity

Presenting Author: Toby Dittrich, Portland Community College

Angular displacement has historically been presented as a scalar quantity even though the time derivative of it is presented to be a vector. Since it is essential for angular velocity to be a vector to support the entire structure of rotational mechanics as well as higher physics topics, the understanding of the delimna presented by havethe time derivative of a scalr becoming (somehow) a vector. This poster pesents a vector definition of angular displacement that helps eliviate this apparent difficulty in introductory physics.

POS-SAT-E509 | Poster Presentation Traditional | Integrating Quantum Computing Topics and a Quantum Festival Capstone in an Undergraduate Quantum Mechanics Course

Presenting Author: Roberto Ramos, Saint Joseph's University

I describe initiatives I have taken to weave the exciting field of quantum information and quantum technologies into an upper-division course in Quantum Mechanics. Within the framework of developing the formalisms of state vectors and the Dirac notation in classic two-level systems, I discuss the foundation and motivation of quantum computing and use examples of two-level qubits to illustrate the evolution of quantum states on the Bloch Sphere which I then use to discuss superposition, decoherence and coherence times. When I discuss quantum entanglement, I use the platform of a two-qubit system and discuss, in detail, the quantum teleportation of information between Alice and Bob and the quantum circuits and circuit diagrams for this experiment. I also discuss different physical approaches to quantum computing. To help students engage with real-world applications and issues in quantum information, students participate in a "Quantum Festival" at the end of the course through individual twenty-minute capstone presentations on topics they select from a list of quantum information-related topics. I report on the products of the course, assessment of quantum computing concepts via quizzes, and student feedback through blind surveys.

POS-SAT-E513 | Poster Presentation Traditional | An "unhiding" table of dimensionless units, to simplify physics across disciplines

Presenting Author: Phil Fraundorf, University of Missouri in St. Louis

In some fields, wavenumber is in radians per meter, in others it is in cycles per meter, but in both cases only "reciprocal distance" units are cited[1]. Planck's constant is in joule/Hz while h-bar is the same thing in joule seconds/radian. Angular momentum is most always in kg m^2/s per radian, rather than per cycle. Avogadro's number is now an integer number of molecules per mole, but no longer precisely the number of atomic mass units (or Daltons) in a gram. Boltzmann's constant k is in joules per kelvin per nat of correlation information. This makes temperature kT a measure of thermal energy needed per information unit of state uncertainty increase, and heat capacity Cv/k a multiplicity exponent e.g. in bits of uncertainty increase per two-fold increase in temperature. Thus, in some cases being explicit about dimensionless units can increase accessibility and provide insight into the assumptions behind rules of thumb, like the idea gas law, equipartition, and mass action.

POS-SAT-E515 | Poster Presentation Traditional | How a theory called the Mirrorverse will soon be the "Theory of Everything!"

Presenting Author: Andrew Ackler

The concept of time has eluded humanity since the start of written history. I have written a book called "Time, Life, and the Mirrorverse" that fully explains how all occurrences of the Universe fit perfectly into a theory I call the "Mirrorverse!" The concept comes down to the simplistic

idea that time is going one direction for our side of the "Mirrorverse," and the other side of the Mirrorverse is going the exact opposite direction. CPT symmetry and Supersymmetry are perfectly integrated into this theory since it explains how each works perfectly well if we see the Universe as actually being the Mirrorverse. The Mirrorverse consists of two exact opposite Universes in which charge, parity, and Time are exact opposites. This ensures the Mirrorverse will infinitely repeat the same exact course for the rest of time! The reason you are alive right now reading this is because to your viewpoint, you are always alive! The moment you die, time does not exist for you. If time does not exist when you are dead, you are always alive in your viewpoint, repeating the same hopefully great life infinite times!

Labs Posters (5:30–6:30 p.m., Saturday)

POS-SAT-F601 | Poster Presentation Traditional | Incorporating Computational Techniques into Undergraduate Physics Laboratories

Presenting Author: Joseph Murphy, Southeast Missouri State University

At Southeast Missouri State University, a regional public institution, computational techniques have been incorporated into both algebra-based and calculus-based physics laboratory courses to enhance student engagement and data analysis skills. In algebra-based courses, students use Excel for linear fitting and graphical analysis to extract physical parameters. While these methods primarily improved students' proficiency in computational tools and data analysis, gains in conceptual understanding of physics content were not necessarily observed. Calculus-based labs incorporate Python for more advanced graphical analysis, fostering both technical skill development and deeper engagement with physics principles. Separate grading rubrics tailored to each lab sequence support the development of computational and experimental skills appropriate to their respective levels. Additionally, LabVIEW and USB DAQ devices are being introduced in calculus-based labs to enhance real-time data acquisition capabilities. These experiences demonstrate opportunities to integrate computational approaches effectively, which may inform similar efforts at high schools, two-year colleges, and other undergraduate institutions seeking to modernize their physics curricula.

POS-SAT-F603 | Poster Presentation Traditional | Undergraduate Physics Laboratory Curriculum Recommendations Refresh

Presenting Author: Steve Spicklemire, University of Indianapolis

Co-presenting Author | Joe Kozminski, Lewis University

The Committee on Labs is embarking on a process to update the Undergraduate Physics Laboratory Curriculum Recommendations. To that end we've conducted a survey to gather input to inform this process. We'll be sharing our findings from the survey as well as inviting further input to ensure we hear from all interested stakeholders.

POS-SAT-F605 | Poster Presentation Traditional | A Comprehensive Approach to Developing a Rubric for Evaluating Physics Lab Reports

Presenting Author: Klebert Feitosa, James Madison University

Additional Author | Masoud Kaveh, James Madison University

Additional Author | Jessica N Jacovidis, Inflexion

The physics laboratory is an integral part of college physics curriculum designed to develop laboratory skills, reinforce physics concepts, and train students in experimental approaches that lead to discovery. The lab report stands as the ultimate product for the laboratory class emulating experts' practice from observation to publication. Publicly available rubrics for lab reports in physics often lack comprehensive evaluation criteria. Here we report on the development of a standardized and comprehensive lab report rubric focused on assessing laboratory skills in the broader scientific context of the experiment. This rubric followed a rigorous development process involving the compiling of the criteria, structuring the performance descriptors, and establishing performance standards through standard setting methods. Following its initial development, the rubric underwent pilot testing to evaluate its reliability, validity, and overall effectiveness in assessing the intended outcomes. The resulting rubric standardizes lab report evaluations, ensuring consistent and thorough assessment of student performance, thereby contributing substantially to physics education. Moreover, the rubric has been developed with a robust framework adaptable to other disciplines and applicable across education levels, ensuring its relevance and impact across a variety of contexts.

POS-SAT-F607 | Poster Presentation Traditional | Auto-ramping Franck-Hertz experiment construction and data analysis

Presenting Author: Zengqiang Liu, Saint Cloud State University

In this presentation, I will show in details how to construct a Franck-Hertz (FH) experiment, collect data, and analyze data for advanced laboratory. The construction requires these parts: FH tube and electrometer from PASCO, a KEPCO 0-120VDC remote-controllable power supply, a 0-24VDC variable student power supply, and electronics. An instructor with basic knowledge of electronics and programming and similar parts at hand should be able to build this apparatus. Every function block can be explained to and constructed by junior-level physics student groups, under instructor's supervision. The basic concepts involved in the apparatus include operational amplifiers, analog-to-digital converters, digital-to-analog converters, vacuum tubes, biasing voltages, and basic programming. Even though a complete FH experiment system can be purchased off the shelf, this instructor/student-constructed auto-ramping system serves as a great example that lab instruments are not black boxes thus CAN be constructed and understood by students. It also shows that the knowledge that students learn in modern physics, electronics, and programming courses have practical applications in a physics laboratory. This project also serves as a spring board to other scientific instrumentation with control loops and data acquisition.

POS-SAT-F609 | Poster Presentation Traditional | An Experimental Thermal Analogue to Ohm's Law and RC Discharge

Presenting Author: Patrick Polley, Beloit College

While experiments in ohmic circuits abound in the introductory laboratory experiments in thermal physics are less common. Two experiments are presented here; one involving the thermal equivalent of Ohm's Law and the other the thermal equivalent of RC discharge. In both cases the

electrical current, dq/dt, is replaced by the thermal current dQ/dt, where Q is the energy transferred. We have Rth(dQ/dt) = (T2 – T1), where Rth is the thermal resistance and (T2 – T1) is the temperature difference across the thermal resistance. Newton's law of cooling is also investigated and is shown to be similar to the equations for RC discharge in electrical circuits. The thermal resistance calculated in the first experiment may be used in this second experiment to calculate the specific heat of the object undergoing cooling. The experimental apparatus consists of a 0-3 amp dc power supply, two multimeters, a thermometer, a heater constructed from ten 100 ohm resistors wired in parallel, and a food can filled with mineral oil.

POS-SAT-F613 | Poster Presentation Traditional | Assessing the Feasibility of Using Arduino to Teach Projectile Motion in Traditional Physics Labs

Presenting Author: Aaron Straus, Alfred State College

Co-presenting Author | Alexander Lutheran, Evergreen High School

This presenation investigates the use of Arduino microcontrollers in Physics education to teach projectile motion, offering a hands-on experience that reinforces core physics concepts. The experimental setup, utilizing an Arduino UNO with IR proximity sensors, was tested to calculate projectile velocity and determine its trajectory. The results confirmed the accuracy and effectiveness of Arduino in measuring velocity, thereby validating the theoretical principles of projectile motion. The researchers suggests that a student-built approach to lab equipment enhances engagement and fosters essential 21st-century technology and engineering skills. The success of this method in measuing projectile motion indicates that similar technological integrations should be considered for other physics principles, highlighting the importance of innovative teaching practices in preparing students for future STEM careers.

PER Posters (5:30–6:30 p.m., Saturday)

POS-SAT-G703 | Poster Presentation Traditional | Data-Based Learning Behavior of students as depicted in Lower-Level Physics Class at the University of Arkansas at Fort Smith

Presenting Author: Nawa Dahal, University of Arkansas at FortSmith

Active learning technique provides students with opportunity to practice and solve problems and have higher order understanding of the subject material through group discussion, critical thinking, reasoning, and decision making. This presentation discusses data-based learning behavior of students as depicted in lower-level Physics class. The observation made in University Physics class at the University of Arkansas at Fort Smith supports the positive learning experience among students with the use of group discussions followed by Think-Pair-Share questions. The observation also notes that the choice of final answer for a Think-Pair-Share question either by an individual or by a team does not always align with the correct reasoning for the choice. This observation demands for more research to understand the underlying cause and to look for a solution which most probably is multi-faceted. Reasoning based on logics irrelevant to or not supported by an equation in Physics or in Mathematics, misconceptions, erroneous pre-conceptions are a few underlying causes identified.

POS-SAT-G705 | Poster Presentation Traditional | Discuss with your friends and neighbors: Integrating custom materials and modular design for active learning.

Presenting Author: Eric Remington, Samford University

Introductory physics courses are a critical foundation for students, yet traditional models of content delivery frequently fail to engage learners effectively. To address this, I have developed a flipped-classroom model for algebra based physics that integrates combines video lectures, in class collaborative problem solving using a custom designed workbook, and traditional laboratory activities that are tightly integrated with class in weekly modules. Each week has a set of homework problems students work individually as well as a quiz which are all aligned to a set of learning objectives for each module. A hallmark of this approach is the seamless integration fo these components, with each week's activities building on the last to create a cohesive learning trajectory. The workbook, written specifically for this course, guides students through key concepts and problem solving strategies in class, fostering engagement and collaboration. Student feedback frequently highlights the straightforward nature of the videos and clarity of the overall structure. This poster will share the design principles, teaching strategies, and materials that will make this course an accessible and effective flipped classroom model. Attendees will gain insights into implementing a similar approach and are invited to discuss potential adaptation and challenges in their own courses.

POS-SAT-G707 | Poster Presentation Traditional | The implementation of team-based learning (TBL) approach in introductory physics courses*

Presenting Author: Edgar Corpuz, University of Texas-Rio Grande Valley

Additional Author | Ma Aileen Corpuz, University of Texas-Rio Grande Valley

Additional Author | Natalia Guevara, University of Texas-Rio Grande Valley

Additional Author | Pamela Kelley, Kelley Analytics, LLC

At least 10 physics faculty members at the University of Texas-Rio Grande Valley (UTRGV) were provided professional development training on the elements of TBL through a series of workshops, where the faculty went through the same cycle of activities that students in a TBL class would. Learning through practice, being able to experience first-hand how to be in a TBL class, detailed explanations, and group work were reported by the participants as the most important aspects of their workshop experience. In addition, we ascertained the perceptions of introductory physics students regarding the use of TBL. Overall, students showed a positive perception of the approach. At least 80% of the respondents perceived that TBL made the class more enjoyable, made students more engaged with the course materials, improved their learning and performance in the course; at least 75% perceived that TBL helped sustain their interest in the course, increased their motivation to learn and helped foster a sense of belonging and community. At least 87% of the students recommend the use of TBL in their other science courses. In this presentation, we

will provide details of the faculty professional development and our implementation of the TBL approach in our algebra-based and calculus-based introductory physics courses.

POS-SAT-G709 | Poster Presentation Traditional | Developing a Department-level Retention Rate for Physics Graduate Programs

Presenting Author: Bill Bridges, Kansas State University
Additional Author | Christopher Overton, University of Georgia
Additional Author | Nicholas T Young, University of Georgia
Additional Author | Jacquelyn J Chini, Ohio State University
Additional Author | Rachel Henderson, Michigan State University
Additional Author | James T Laverty, Kansas State University

Student retention has historically been a point of research interest in understanding how healthy a program is. While this has been largely conducted for undergraduate students, there is significantly less information for graduate programs. We are interested in a measure that can effectively capture a physics graduate program's rate of students earning a graduate degree. This work expands on our previous study identifying measures of national retention of physics programs, resulting in a measure agreeing with historical rates of students earning a PhD at 50%. We propose now a measure of institutional physics graduate student retention utilizing data collected by the American Institute of Physics. From this study, we find that there are variations in retention rates among physics departments, which could help to motivate further investigations into the connection that physics graduate program requirements have on student retention.

SPS Student Research Posters (5:30–6:30 p.m., Saturday)

POS-SAT-A101 | Poster Presentation Traditional | Total Solar Eclipse Effects on Cosmic Ray Showers

Presenting Author: Sydney Stapleton, Downers Grove South High School
Additional Author | Monika Afredeen
Additional Author | Garrett Chong
Additional Author | Aitak Mosen Harzandi
Additional Author | Anna Halwax
Additional Author | Tara Hecht

This research investigated the effect of the solar eclipse on April 8th, 2024, on the rate and energies of cosmic ray muons. To measure the rate and energy level of muons, arrays of nested detectors were placed in the path of totality. Collection of data started two weeks before the eclipse. This poster shows our findings.

POS-SAT-A103 | Poster Presentation Traditional | The Effect of Coronal Mass Ejections on Cosmic Ray Muon Flux

Presenting Author: Evangeline Selking, Downers Grove South High School
Co-presenting Author | Zoya Siddiqui, Downers Grove South High School
Additional Author | Rex Paster, Rochelle Zell Jewish High School
Additional Author | Kristian Qirko, New Trier High School
Additional Author | Sydney Stapleton, Downers Grove South High School
Additional Author | Maya Zacks, New Trier High School

This study investigates the effects of coronal mass ejections (CMEs) on cosmic ray muon flux using Quarknet detectors. Our analysis included the time of flux change in Illinois and Hawaii, determining time of onset, and recovery of the CME event of May 2024. We compared the atmospheric-pressure corrected cosmic ray flux with disturbance of the geomagnetic field. Results show the structure of the flux recovery

POS-SAT-A105 | Poster Presentation Traditional | Removing the Effect of Barometric Pressure on Muon Flux to Isolate the Coronal Mass Ejection

Presenting Author: Maya Zacks, New Trier High School
Additional Author | Monika Alfredeen, New Trier High School
Additional Author | Anna Halwax, New Trier High School
Additional Author | Rex Paster, Rochelle Zell Jewish High School
Additional Author | Evangeline Selking, Downers Grove South High School
Additional Author | Zoya Siddiqi, Downers Grove South High School

High school students analyzed the cosmic ray flux data changes resulting from the coronal mass ejection (CME) of May 8, 2024. The barometric pressure was masking the muon flux signal, making onset and recovery difficult to measure. This poster discusses techniques used to remove the barometric pressure's effect on the cosmic ray flux in order to isolate the effect of the CME on muon flux.

POS-SAT-A107 | Poster Presentation Traditional | The Bumpy Ramp Problem

Presenting Author: Alaina Snider, Randolph College
Co-presenting Author | Greg Wietrzykowski, Randolph College
Additional Author | Peter Sheldon, Randolph College

Describing motion of a vehicle in one-dimension (1D) is a common situation used to teach motion in general physics. It requires the understanding of the kinematic variables and differential relationships between displacement, velocity, acceleration, and time. In teaching general physics, there are not too many variations on 1D motion problems, and one also finds that it can be surprisingly easy to complicate a problem to the point where it is no longer tractable. On the 2016 Advanced Placement (AP) Physics 1 Exam, a variation to the 1D **motion question was asked about a vehicle going** down an inclined plane with regular bumps. This engendered many comments because some believed the question was not easily answered with the physics learned by a first-year student. We studied this problem with computational and physical models to determine the motion of a car on a bumpy ramp, varying the angle of the ramp and the distance between bumps as the AP problem suggested.

POS-SAT-A109 | Poster Presentation Traditional | A Comparison of Earth-Jupiter Orbital Transfers Involving the ZK Spirals

Presenting Author: Daniel Bailey, Indiana State University
Additional Author | Dalton Bogdon, Indiana State University
Additional Author | Joseph West, Indiana State University

Rapid increases in commercial space flight volume and continuing interest by ESA and NASA in deep space missions have increased the need to research varying orbital transfer maneuvers in order to optimize future missions. Decades of research have gone into optimizing chemical rocket missions but low-thrust ion missions have not been optimized to the same degree. A distinct question in the field is the efficiency of using ion thrusters as a replacement for chemical rockets in low-thrust scenarios such as those necessary in deep space. This study considers one of the most important maneuvers needed for almost every mission, a circle-to-circle orbital transfer. The best known, traditional version, the chemical powered Hohmann transfer, is compared to hybrid chemical + ion-powered and ion-powered variations. The CESEC (Circle-Ellipse-Spiral-Ellipse-

Circle) transfer, which has the potential to rely only on ion engines, is introduced. For comparison, the mission is assumed to transfer the NASA LISA Pathfinder from the L1 Lagrange point of Earth to the L1 Lagrange point of Jupiter.

POS-SAT-A111 | Poster Presentation Traditional | Orbital Mechanics Under Alternative Gravitational Force Laws

Presenting Author: Dalton Bogdon, Indiana State University
Additional Author | Daniel Bailey, Indiana State University
Additional Author | Joseph West, Indiana State University

The law of universal gravitation tells us that the gravitational force of attraction between two bodies is, among other things, inversely proportional to the square of the distance between the two bodies. We explore the effects of changing the radial dependence of gravity by generalizing the law of gravitation such that it represents an entire family of force laws. Particular interest is given to the orbits described by the polar equations r = R*exp(k*theta), r = R*(1 + cos(theta), and r = R*cos(theta), which are solutions to three distinct gravitational force laws 1/r3, 1/r4, and 1/r5, respectively. Additionally, we explore "ZK" logarithmic spiral orbits as an alternative to the well-known Hohmann transfer in order to transfer between orbits of various sizes, as well as a new "walking" maneuver used to reorient orbits that are not symmetric about the origin.

POS-SAT-A113 | Poster Presentation Traditional | Chicken and the Egg: Does Outreach Lead to a Growth Mindset or Vice Versa?

Presenting Author: Isabella Oaks, Texas A&M University
Additional Author | Jonathan D Perry, University of Texas at Austin
Additional Author | Tatiana L Erukhimova, Texas A&M University
Additional Author | Jonan P Donaldson
Additional Author | James K Hirons, Texas A&M University
Additional Author | Toni Sauncy,

Research has indicated connections between student facilitation of informal physics outreach programs and their physics identity, resilience, and career skill development. Previously, studies were limited to individual institutions and small numbers of participants. This work draws from a national survey distributed to Society of Physics Students chapters, collecting self-reported data on individual experiences. Quantitative analysis of these data indicated strong connections between students' participation in outreach and mindset. This motivated an analysis of the open-response questions to explore themes of mindset reported. In this work, we explore this relationship by analyzing free-response questions distributed in the survey, extracting themes surrounding growth/fixed mindsets from students, with particular attention to directionality: outreach changing mindset or mindset brought to outreach. Growth mindset was defined as malleability of physics intelligence and abilities. Though survey questions did not directly probe mindset, a minority of students were observed to include these themes. Through a thematic analysis of national results and a semantic network map, we explore the connection between growth mindset and participation in outreach, highlighting self-reported experiences that indicate directionality of this relationship. Students exhibiting mindset cues in their responses suggested outreach to be the key element in fostering growth mindset.

POS-SAT-A115 | Poster Presentation Traditional | What Can Nuclear Magnetic Resonance Teach Students about the Quantum Realm?

Presenting Author: Katyanna Sciorra, Sarah Lawrence College
Additional Author | Merideth Frey, Sarah Lawrence College

Many new Quantum Information Science and Engineering (QISE) programs are being developed to address the growing need for quantum awareness and training in quantum technologies to expand the future STEM workforce. Nuclear magnetic resonance (NMR) is a widely used quantum mechanical tool with many classical analogs that can provide a valuable entryway to quantum technology and research. This poster presents two research-based active-learning lab modules that were developed as part of an NSF-IUSE grant to make the quantum realm more accessible to undergraduate students by introducing the basic physics behind NMR earlier in the undergraduate science curriculum. All the developed materials have been designed and tested to be used in introductory science courses without the expectation of prior physics or chemistry knowledge. These two lab modules utilize the NMR basics introduced in previous modules, connect them directly to fundamental quantum principles, and relate them to important aspects of quantum computing - for example, visualizing qubit states using the Bloch sphere and identifying NMR pulses that can serve as quantum gates. We are currently refining these modules and would value feedback regarding additional topics to cover or ways these modules could be implemented into QISE programs.

POS-SAT-A117 | Poster Presentation Traditional | Teaching Science Practices in Historical Context

Presenting Author: Nathan Van Dyke, BRIGHAM YOUNG UNIVERSITY
Co-presenting Author | Adam Bennion, BRIGHAM YOUNG UNIVERSITY

Research into teaching science practices, according to Next Generation Science Standards (NGSS), in an interdisciplinary classroom combing both science and history, and how the added historical context affects the students' understanding of NGSS principles. Study was done in a class that focused on the history and science of the atomic bomb, comprising the development of nuclear physics and the accompanying historical events from the late 1800's to the Cold War era (1960's).

POS-SAT-A119 | Poster Presentation Traditional | Guidance on selecting suitable test wavefunctions to use in variational principle calculations

Presenting Author: Christian Laurent, Central Washington University
Co-presenting Author | Benjamin D White, Central Washington University

To participate in the emerging quantum economy, students need practical and applied training in quantum mechanics. Given the difficulty of

solving for exact state energies of realistic quantum systems, students typically learn several approximation techniques. Among these techniques, the variational principle is used to calculate an upper bound for the ground-state energy of a quantum system. A test wavefunction must be selected and used in any variational principle calculation, and the accuracy of the energy estimate is predicated on how closely the test wavefunction matches the true ground-state wavefunction of the quantum system. This presentation concerns guidance instructors can offer students on the nuances of selecting a suitable test wavefunction. To develop some rules of thumb, we studied several different quantum systems, represented by single-potential wells with different characteristics (e.g., widths, curvatures), using five distinct test wavefunctions. A Gaussian test wavefunction provided the most accurate results for a wide range of potential wells, but we also studied systems for which a Lorentzian, hyperbolic secant, or infinite-square well test wavefunction offered better accuracy. The results of this study offer a toolkit instructors can provide to students when they study the variational principle.

POS-SAT-A121 | Poster Presentation Traditional | Cosmic Ray Cascades: Exploring High-Energy Cosmic Particles in Modern Physics Laboratory Course at Oral Roberts University

Presenting Author: Elena Gregg, Oral Roberts University

Co-presenting Author | Pavel Navitski, Oral Roberts University

Co-presenting Author | Wesley Klehm, Oral Roberts University

Co-presenting Author | Gabriel Pendell, Oral Roberts University

In response to the challenges posed by the evolving global educational landscape, the School of Engineering at Oral Roberts University has strategically positioned its Advanced Physics course to equip students with the essential skills and experiences required for professional practice as Christian engineers or advanced studies in engineering, emphasizing the cultivation of robust research capabilities.The Advanced Physics Labs classes at ORU are designed to incorporate integrated and flexible manuals specifically tailored for engineering disciplines. One of the components of the Advanced Physics course involves experimental research using the Muon Observatory developed by PASCO. Muons, elementary particles like electrons but with 200 times greater mass, are produced in the uppermost part of Earth's atmosphere when cosmic rays interact with atmospheric molecules. The Observatory enables students to detect cosmic rays and study their interactions, producing showers of secondary particles. Our students engaged in experimental research to determine the optimal thickness of steel plates, maximizing the detection of cascades, and exploring the angular distribution of cosmic ray muons in two distinct ways, either shower mode or telescope mode. The results not only contribute to our understanding of particle interactions but also lay the groundwork for future research endeavors and enhance the development of experimental procedures.

Session A1: Ready, Set, Teach: Strategies for Your Physics Classroom

Location: Grand Ballroom A **Time:** 9–9:50 a.m. **Date:** Sunday, January 19, 2025 **Moderator:** Jason Sterlace

A1-01 9:00 AM-9:12 AM | Contributed Talk (12 Minutes) | Note Making in a Physics Thinking Classroom

Presenting Author: Marianna Ruggerio, Auburn High School

Traditionally the note-taking experience in a live classroom has one of two outcomes. Either students are frantically copying every detail without opportunity to process the material, or students are unable to keep up with the pace of the notes. A third, is that students sit back and let their technology take the notes for them so they can reference them later. Regardless of the experience, none of these results in truly active learning. In this talk I will present a way in which my students take notes in my class after engaging in an active, studio-style lesson. The results are compact and personally valuable to students.

A1-02 9:12 AM-9:24 AM | Contributed Talk (12 Minutes) | Using Vernier Video Analysis to Investigate Motion in High School Physics Projects

Presenting Author: Meghan DiBacco, Katy ISD - Cinco Ranch High School

This session explores the integration of Vernier Video Analysis software into high school physics projects to deepen students' understanding of motion. The project follows a structured three-part approach designed to support students learning. The session will cover each part of the project in detail, showcase examples of student work produced throughout the process, and key takeaways.

A1-03 9:24 AM-9:36 AM | Contributed Talk (12 Minutes) | STEP UP's Everyday Actions Guide as a Tool for Teacher Reflection

Presenting Author: Bree Barnett Dreyfuss, Amador Valley High School, STEP UP

Co-presenting Author | Elissa Dunn-Levy, Thomas Jefferson High School, STEP UP

The Everyday Actions Guide, a pedagogy handbook for teachers, is part of the STEP UP curriculum. Recently updated, the Everyday Actions Guide is the foundation of a new NSF grant supporting teachers' professional learning around inclusive practice in physics. Small actions each day can have larger impacts in our science classrooms. Building on teacher reflection and including student voices, the Everyday Actions Guide is a tool for teachers of any science class and of all levels of experience to make positive change in their classrooms. Come to learn more about the program and opportunities to participate in the program and active research to improve the field of physics for all students. We are inviting teachers with all levels of experience. The STEP UP curriculum also includes two in-class lessons for students to learn more about the benefits of pursuing physics as a career and the history of who has studied physics.

A1-04 9:36 AM-9:48 AM | Contributed Talk (12 Minutes) | Studying Iterations of Physics Teachers' Professional Learning: Uncovering Design Principles to Support the Integration of Equity in Physics Instruction

Presenting Author: Heena Lakhani, Florida Gulf Coast University

Additional Author | Rachel Scherr, University of Washington Bothell

Additional Author | Kara Gray, Seattle Pacific University

The integration of equity into high school physics instruction is an important goal of physics teaching and learning. While the literature in science and physics education has discussed the importance of and specific efforts towards advancing equity in teaching physics, few studies have investigated the design of comprehensive science teacher professional learning that integrates equity with the different aspects of science teaching. The work presented seeks to build in this area by studying four iterations of a summer professional learning experience for in-service physics teachers that focuses on integrating energy and equity in their teaching practices. We leverage design-based research (DBR) in our study, which seeks to learn from the multiple iterations of implementation and put forth design principles about integrating equity with science teacher professional learning. In our analyses, we uncover the following design principles: 1) Using representational resources that connect science concepts to equity issues, 2) Supporting teachers to address community concerns, 3) Providing a comprehensive equity framework, and 4) Supporting teachers to learn about their positionality in the class. Through this approach, we hope to advance and elevate design knowledge that can contribute to our understanding of how professional learning for physics teachers can integrate equity.

Session A2: Innovations in Assessment

Location: Grand Ballroom B Time: 9–9:50 a.m. Date: Sunday, January 19, 2025 Moderator: Sean Moroney

A2-01 9:00 AM-9:12 AM | Contributed Talk (12 Minutes) | The Inclusive CATs

Presenting Author: Shahida Dar, Mohawk Valley Community College

As classrooms become increasingly diverse, inclusive assessment practices are essential to ensure that all students have equal opportunities to demonstrate their learning. In this session, you will learn innovative classroom assessment techniques to accommodate students' diverse learning styles and needs.

A2-02 9:12 AM-9:24 AM | Contributed Talk (12 Minutes) | Ungrading in physics seminar, college physics, and preparation courses

Presenting Author: Thomas Foster, SIUE Physics

Inspired by Susan Blum's anthology Ungrading, I chose a way to ungrade each of my classes. Ungrading has at its heart the unlabeling of students, arbitary bell curves, non-communicative feedback, exclusion in all grading schemes. Gone is gamesmanship of your grading protocols. Ungrading is focusses on student learning and not behaving in the right way. I taught a physics preparation course using skills based grading, a seminar using oral negotiation, and the premed course using structured exam reassessment. Visit this talk for the damage report.

A2-03 9:24 AM-9:36 AM | Contributed Talk (12 Minutes) | Implementing Alternative Grading Strategies in an Upper-Division Mechanics Course

Presenting Author: Kristine Callan, Colorado School of Mines

Alternative grading strategies differ from traditional grading in that they often prioritize (limited) reattempts without penalty paired with rich feedback rather than partial credit. This incentivizes students to engage in feedback loops that help them learn and to focus on complete understanding of one topic at a time, rather than superficial understanding of multiple topics. It also doesn't penalize students who take longer to learn the material, as long as they learn it by the end of the semester. I will report on how I implemented these strategies for exams, problem sets, and out-of-class preparatory work in and upper-division mechanics course, as well as the lessons learned from doing so.

A2-04 9:36 AM-9:48 AM | Contributed Talk (12 Minutes) | Update Regarding a "5-Star" Student Self-Assessment to Promote Honesty, Integrity, and Learning in Solving General Physics Homework Problems

Presenting Author: Jerry Artz, Hamline University

Homework and how it promotes learning are important areas of research. Many teachers of general physics and of other physics courses have been concerned by the rampant student use of and dependence upon online homework solutions. I have developed and used for the past five years a "5-Star Rating" self-assessment done by students themselves, to indicate use, or no use, of online solutions in the solving of physics homework problems. Students are encouraged to give themselves a 5-star rating if they worked a homework problem without the use of the book, notes, online solutions, or other people. Or, they can work their way down to a 0-Star problem utterly copying without understanding. The emphasis is on honesty and integrity. If students use an online solution, they must reference it! If someone else helps, give them credit! One's homework grade is not reduced by star-rating the problem. In fact, a small bit of extra credit is awarded should a student agree voluntarily to use the 5-Star Rating. The 5-Star Rating system and possible correlations between 5-Star Rating and course performance will be discussed.

Session A3: Using AI in the Classroom

Location: Grand Ballroom C **Time:** 9–9:50 a.m. **Date:** Sunday, January 19, 2025 **Moderator:** Nicholas Nelson

A3-01 9:00 AM-9:12 AM | Contributed Talk (12 Minutes) | Does Generative AI Understand Physics? Let Your Students Decide!

Presenting Author: Elissa Levy, Thomas Jefferson High School for Science and Technology

In my high school physics classroom, I use generative AI to help students engage with physics concepts. One approach has been asking large language models to explain physics concepts and ideas, including homework problems, and then asking students to assess the output given their own understanding. Another approach has been to use AI image generation to depict and predict physical scenarios, and then to have students analyze and critique the output. These conversations have increased student engagement and have empowered students to use AI to enhance their learning while remaining critical of its shortcomings. Students have come to realize that AI can help them push their thinking further, but it is more harmful than helpful when its human user lacks their own point of view.

A3-02 9:12 AM-9:24 AM | Contributed Talk (12 Minutes) | Using partially incorrect AI output as a tool on traditional exams

Presenting Author: Timothy McCaskey, Columbia College Chicago

As an instructor who acknowledges the rising prevalence of AI as a resource for students, but wants to control its use on assessments, I have started setting up exam questions where I supply ChatGPT output on the exam paper after stating the question. In, for example, my acoustics exam questions about the decibel scale and inverse square law for sound intensity, AI often recognizes what concepts are in play but often (1) uses different notation or formulations of the ideas than I present in class and (2) makes arithmetic errors. By including that AI output, I can see how students respond to and critically evaluate it. I also use AI errors and student difficulties locating them as warnings in early weeks of my courses not to blindly accept and submit AI output.

A3-03 9:24 AM-9:36 AM | Contributed Talk (12 Minutes) | Encouraging students to critically engage with AI-generated problems and solutions in introductory mechanics

Presenting Author: Seth Kimbrell, Carleton College

Additional Author | Melissa Eblen-Zayas, Carleton College

We will describe our use of an AI tool (built with Playlab.ai) in two introductory physics courses to generate practice problems which connect topics in Newtonian mechanics to other STEM fields of interest to the students. We will describe how we incorporated this tool into a homework activity that asks students to assess the practice problems and AI-generated solutions to the problems. We will provide an overview of what we hoped students would gain from this AI-engaged activity, how the activity actually worked, and our thoughts about the continued use of this type of activity in the future.

A3-04 9:36 AM-9:48 AM | Contributed Talk (12 Minutes) | AI in the Classroom: ChatGPT's Performance in Introductory Physics

Presenting Author: Bilas Paul, SUNY Farmingdale State College

Additional Author | Shantanu Chakraborty, Valdosta State University

Additional Author | Ganga Sharma, Fairmont State University

This paper presents an in-depth evaluation of ChatGPT, a large language model, within the realm of physics education. The study draws on data from several introductory physics courses at SUNY Farmingdale State College, Valdosta State University, and Fairmont State University, covering both algebra-based and calculus-based curricula. By systematically testing ChatGPT with homework assignments, class exams, and final assessments from these courses, the study aimed to evaluate the AI's performance across various physics topics, levels of difficulty, and institutional settings. The selection of these specific courses was driven by the desire to examine how ChatGPT engages with different physics curricula, teaching methods, and academic environments. Through a comparative analysis of ChatGPT's performance, the study provides valuable insights into the role of AI technologies in the field of physics education.

Session A4: Citizen Science in the K-12 Physics Classroom - Part 1

Location: Grand Ballroom D **Time:** 9–9:50 a.m. **Date:** Sunday, January 19, 2025 **Moderator:** Mike Florek

A4-01 9:00 AM-9:24 AM | | Students are Plant Scientists through Authentic Research Experiences and Educational Technology

Presenting Author: Sandra Arango-Caro, Donald Danforth Plant Science Center

Additional Author | Ash Kass, Donald Danforth Plant Science Center

The Education Research & Outreach Lab (EROL) at the Donald Danforth Plant Science Center (DDPSC) aims to connect learners at all levels with the vital role of plant science in improving the human condition through innovative STEAM+Ag® education, inclusive community partnerships, and cutting-edge research. The Authentic Research Experiences (AREs) and Education Technology (EdTech) programs facilitate student enrichment experiences to enhance learning, foster interest, and prepare a diverse STEAM+Ag® next-generation workforce equipped to meet the challenges of the future. These experiences promote a deeper understanding of and connections to STEAM+Ag® content and research while addressing fundamental plant science concepts. Students enrolled in the AREs program conduct experiments similar to those performed by scientists, contributing data to DDPSC research programs. Students enrolled in the EdTech program gain immersive plant science experiences through the

use and application of emerging technologies (e.g., augmented and virtual reality, 3D modeling, GIS). Our programs and resources are free of cost and available across the country and beyond. We use various assessment tools to examine the impact of our programs on the development of students' STEAM+Ag identities and career interests and to contribute to the understanding and best practices in STEAM education.

A4-02 9:24 AM-9:48 AM | | Be a Citizen Scientist on SuperKnova

Presenting Author: Valarie Bogan, The National Radio Astronomy Observatory

Join us as a citizen scientist on SuperKnova, the e-learning platform of the National Radio Astronomy Observatory! Despite our name, our citizen science projects focus on the physics of radio frequencies rather than traditional astronomy. These frequencies play a crucial role in wireless communication, radio astronomy, satellite communication, and more. However, the growing number of signals makes it increasingly difficult to conduct scientific research without interference. We offer two exciting citizen science projects. In the first, you can explore radio frequency uses with either an Android smartphone or an RTL-SDR dongle. Participants are invited to engage in existing activities and propose new ideas to expand the project. The second project focuses on identifying Radio Frequency Interference in data gathered from the Greenbank Observatory. SuperKnova also features a wealth of resources beyond citizen science, including middle and high school curricula, digital badge courses on radio frequency topics, undergraduate materials, and ham radio courses. Dive in and contribute to vital research while enhancing your knowledge!

Session A5: Interactive: Opening Up Demonstrations and Pathways in Physics

Location: Regency Ballroom A&B Time: 9–9:50 a.m. Date: Sunday, January 19, 2025 Moderator: Jon Anderson

A5-01 9:00 AM-9:24 AM | Interactive (e.g. panel, round table discussion, hands-on activity) | Opening up physics demonstrations

Presenting Author: Freek Pols, Delft University of Technology

In this presentation we showcase the hands- and minds-on learning through physics demonstrations. We highlight two recent open-access online books: one tailored for high school physics and the other for university-level students. These resources offer a comprehensive collection of physics demonstrations to ignite curiosity and deepen understanding of fundamental principles across mechanics, electromagnetism, optics, and thermodynamics. Other demonstration focus on the Nature of Science and learning about Scientific Inquiry. Different from typical demonstration books, we include videos, Python simulations, in browser data-analysis and, above all, a pedagogical sound description to gain maximum outcome. The presentation will include a live performance of some of the demonstrations, including the lively discussions that we hold with students in our own classes to gain a deeper understanding of the phenomenon at hand. The aim of this session is to inspire educators to adopt these open-access tools.

A5-02 9:24 AM-9:48 AM | Interactive (e.g. panel, round table discussion, hands-on activity) | "Open Zebra: An Open-Source Model for Personalized Learning Pathways with Student-Facing AI"

Presenting Author: Lisa Carpenter, Open Zebra, Zebra Ed

In this interactive session, I introduce Open Zebra, an open-source data model that enables modern curriculum design and delivery. With Open Zebra, educators can create multiple pathways for students to demonstrate their understanding, unlocking personalized learning for every student. Open Zebra supports building student-facing AI interactions, empowering students to learn how to use AI safely, equitably, and productively alongside course objectives. I'll show examples of how this approach can work in high school physics classrooms, where AI literacy content can be integrated seamlessly with Next Generation Science Standards. During the session, you'll create flexible learning pathways on your own device and experience how these tools work from a student's perspective. Finally, you'll view AI-powered analysis to assess and guide student progress. Open Zebra's innovative model can unlock the potential of AI-powered, personalized learning in education.

Session A6: Interactive: Enhancing Student Engagement

Location: Regency Ballroom C Time: 9–9:50 a.m. Date: Sunday, January 19, 2025 Moderator: Todd Leif

A6-01 9:00 AM-9:24 AM | Interactive (e.g. panel, round table discussion, hands-on activity) | The Patterns Approach in High School Physics: Adapting NGSS Concepts for Any Classroom

Presenting Author: Shannon Morey, Abbott Lawrence Academy

In this session, we will explore how the Patterns Approach supports student learning by using a "model, guide, step-aside" framework that encourages student talk to drive their own learning in the high school physics classroom. Starting with the first foundational unit on mathematical patterns development, participants will engage with an experiment that anchors students' understanding of one of four common mathematical patterns in physics. We will discuss the other experiments and how they serve as the foundation for developing students' skills in inquiry and mathematical modeling. We will also discuss how this approach can be adapted to design curricular materials for states that did not adopt the NGSS, ensuring flexibility while maintaining a strong emphasis on scientific practices. By the end of the workshop, participants will be introduced to the full year of Patterns Physics curriculum, which meaningfully integrates STEM disciplines and is designed to foster student-centered learning.

A6-02 9:24 AM-9:48 AM | Contributed Talk (12 Minutes) | Introducing Quantum Hotel as a Novel Tool for Accessible Learning Experience

Presenting Author: MOE TABANLI, Middlesex College

This presentation introduces a novel visual tool that would facilitate students learning about Quantum Mechanics in a more inclusive, engaging, and accessible manner. We represent all the potential Quantum States in an atom as rooms ready to be occupied. After presenting room numbers in

terms of quantum numbers and obtaining energy levels from NIST database, a building is displayed representing all the possible states for a particular atom. In this form, Quantum Hotel is like an upside-down Janet periodic table with different labels and descriptions. Several student-centered, hands-on activities related to electron transitions demonstrate the practicality of this visual tool especially for students with limited preparedness for this complicated topic. Quantum Hotel addresses two of the main four challenges identified on 2022 QIST Workforce Development National Strategic Plan such as raising awareness of QIST at K-12 and the undergraduate level and attaining a more diverse QIST workforce.

Session B1: K-12 Quantum Education for Workforce Development

Location: Grand Ballroom A Time: 10–11 a.m. Date: Sunday, January 19, 2025 Moderator: Jon Anderson

B1-01 10:00 AM-10:12 AM | Contributed Talk (12 Minutes) | Teaching Polarization and Interference with the Mach-Zehnder Interferometer in Precollege Quantum Education

Presenting Author: Robert DeLaCruz, Stony Brook University
Additional Author | Dominik Schneble, Stony Brook University
Additional Author | Angela M Kelly, Stony Brook University
Additional Author | Tzu-Chieh Wei, Stony Brook University

This activity was designed for a quantum information science and technology program for precollege students in grades 10-12. Students learned about interference and polarization and applied this knowledge to Mach-Zehnder interferometer (MZI) demonstrations, discussions, and an activity predicting photon behavior. Horizontal and vertical polarizers in the MZI paths served as tags that provided which-way information about the path taken by photons, thus preventing interference in the two output ports. An additional polarizer oriented diagonally re-established interference, with transmitted photons from both pathways having the same diagonal polarization. One the level of a single photon, which-way information is deprived and the photon interferes with itself. An MZI on an optical breadboard with commercial components featured two 50:50 beamsplitters and two mirrors. The incident laser beam was split into two paths and recombined. Students predicted, tested, and discussed the behavior of light with polarizers in various orientations, conceptualizing the transition from a laser beam to the behavior of a single photon. They sketched the predicted paths of light through a series of filters and explained how and why the pattern changed with the addition of polarizers in different configurations. This activity served as a scaffold for students to apply interference and polarization concepts to quantum computing.

B1-02 10:12 AM-10:24 AM | Contributed Talk (12 Minutes) | Quantum Engineering Pre-College Course

Presenting Author: Sean Bentley, Adelphi University

A college credit-bearing course was developed for pre-college students. The course included hands-on experiments covering quantum fundamentals, optics, spin, entanglement, and quantum computing, including programming. Systems studied were modeled in 2-D discrete bases to keep mathematical complexity to simple linear algebra. A guest lecture by a quantum engineer at a quantum computing company allowed the students to learn about various physical implementations, the current status of the field, and the roadmap to move the field forward. The primary goals of the course were to get more students interested in preparing for quantum information-related careers, and to show them the engineering challenges facing current quantum systems to advance which will require more workers at all levels from BS to PhD. The course was developed in part based on information and discussions from a 2021 NSF-funded Quantum Undergraduate Education and Scientific Training (QUEST) program and a subsequent Faculty Online Learning Community (FOLC). Based on lessons learned from the first offering of the course in summer 2024, revisions for the next offering are being developed. It is ultimately planned to develop an undergraduate track for our physics majors to further the goals of the project.

B1-03 10:24 AM-10:36 AM | Contributed Talk (12 Minutes) | Teaching Bell's Inequality in Precollege Quantum Education

Presenting Author: Austin Colon, Stony Brook University
Co-presenting Author | Xinyue Wang, Stony Brook University
Additional Author | Tzu-Chieh Wei, Stony Brook University
Additional Author | Dominik Schneble, Stony Brook University
Additional Author | Angela M Kelly, Stony Brook University

This activity was designed as part of a 25-hour quantum information science and technology program for precollege students in grades 10-12. Students learned about differentiating classical wave behavior and quantum mechanics and applied this knowledge to test Bell's inequality with IBM Composer. The original experiment utilized a pair of entangled particles that traveled through polarized filters to detectors. The probability of the particles hitting these detectors in different orientations can then be famously calculated to a value close to $2\sqrt{2}$, when classically, this calculation should only have a maximum of 2. This laboratory activity is typically reserved for older students due to costly resources such as high-energy lasers, polarization lenses, and photoreceptors. However, IBM Composer —an online circuit editor that connects students directly to one of many quantum computers around the world— may be used to simulate actual entangled particles. Discussion of the practical lab setup, data collection, and analysis provided students with an opportunity to engage with the concepts from a new perspective. By the end of this lab, students familiarized themselves with the tools of IBM Composer by simulating entangled particles and creating circuits to measure and calculate Bell's inequality.

B1-04 10:36 AM-10:48 AM | Contributed Talk (12 Minutes) | Using Infinite Square Well to Teach Concepts in Quantum Information Science

Presenting Author: Vincent Pereira, Freeport School District, Freeport, NY 11520

In this presentation we show how the Infinite Square Well can be used to teach high school students' important concepts in quantum mechanics. A classical particle moving in this potential can be found at a specific position at a specific time. The position of a quantum mechanical particle on

the other hand is invariant with time and the probability distribution of this particle for a certain energy is similar in shape to waves on a string. Thus, the square well gives results that students have encountered in different contexts. Other differences between the classical and the quantum mechanical treatment include specific energies for the quantum mechanical particle. Also, by plotting the wave functions students will realize that they are orthogonal to each other. If the particle is close to absolute zero then the particles will be in the lowest energy state. A laser can be used to excite the particle to another energy level thus generating a qubit.

B1-05 10:48 AM-11:00 AM | Contributed Talk (12 Minutes) | Quantum Education and Workforce Development at an Emerging R2 University: The MTSU Quantum Initiative

Presenting Author: Hanna Terletska, Middle Tennessee State University
Additional Author | Ron Henderson, Middle Tennessee State University
Additional Author | Kavalambramalil George Paulson, Middle Tennessee State University

In this talk, we explore recent initiatives at Middle Tennessee State University (MTSU), an emerging R2 institution, aimed at training the workforce for the second quantum revolution. We highlight the NSF-funded ExpandQISE program, which is designed to educate a diverse group of students in quantum information science (QIS) and prepare them for future career opportunities in this rapidly growing field. We will discuss the development of new academic programs, including a QIS concentration within the physics curriculum, outreach efforts through high school summer camps, and 'train the trainer' workshops to build capacity in quantum education. These initiatives collectively aim to broaden the understanding of QIS across different education levels and communities, fostering the next generation of quantum professionals.

Session B2: Innovations in Course Design

Location: Grand Ballroom B Time: 10–11 a.m. Date: Sunday, January 19, 2025 Moderator: Gillian Ryan

B2-01 10:00 AM-10:12 AM | Contributed Talk (12 Minutes) | Supporting active student learning in a co-taught introductory Astronomy class for non-STEM students

Presenting Author: Melissa Barru, University of Colorado Denver
Additional Author | Andre Calderon, University of Colorado Denver
Additional Author | Ashley Reichenberg , University of Colorado Denver
Additional Author | Parinoz Abdulloeva, University of Colorado Denver
Co-presenting Author | Kathryn R Hamilton, University of Colorado Denver

CU Denver primarily serves non-traditional students; General Astronomy I is an introductory astronomy class mostly populated by non-STEM majors. Because of these two factors, the course can suffer from high rates of student attrition, and low rates of student satisfaction. We, the authors, co-teach a radical General Astronomy I class, where the teaching team, comprised of a junior faculty member, teaching assistant, learning assistants, and grader, demonstrate amongst themselves the community we want our students to embody. Class periods include formal lecture, clicker questions, group problem solving, lecture tutorials and labs. Students are also encouraged to work in groups inside and outside of the classroom. The expanded teaching team can offer over 10 hours of help room support each week and uses their individual strengths to support unique components of the course. Anecdotal evidence from previous semesters suggests higher levels of student engagement in this version of the class, as well as increased feelings of belonging and positive community building. As this class structure continues to be refined, we look to perform formal research on the course structure's impact on student learning and affectation.

B2-02 10:12 AM-10:24 AM | Contributed Talk (12 Minutes) | Hands-On Group Work in Online, Semi-asynchronous Introductory Physics Courses

Presenting Author: Parker Poulos, Kansas State University
Additional Author | Brandi Lohman, Kansas State University
Additional Author | Tim Bolton, Kansas State University

While departments adapted to online courses out of necessity during the COVID-19 pandemic, the return to the classroom has seen some departments slow their efforts to meet the needs of online students. Many online physics curricula focus on the concepts and math without hands-on lab components and student-to-student interactions. The Kansas State University Department of Physics has piloted a new approach to online introductory physics courses with physical lab components and required group work. The course is a hybrid of synchronous and asynchronous content, with a fully asynchronous option for students unable to attend synchronous sessions. We present on the design and implementation of this new approach to online introductory physics courses.

B2-03 10:24 AM-10:36 AM | Contributed Talk (12 Minutes) | Learning Physics using Maple - Creating the Next Generation Textbook Through YouTube

Presenting Author: Scot Gould, Scripps, Pitzer, Claremont McKenna

This talk covers the methods used to create a YouTube channel to educate undergraduate physical science and engineering students and instructors on how to use computation and a computer algebra system to maximize conceptual understanding and minimize mathematical minutia. The "library" (channel) contains over fifty 8-minute to 12-minute "chapters" (videos) organized into several "textbooks" (playlists): Learning Maple Tutorials, Mathematics for Undergraduates, and Learning Physics Using Maple. In each playlist, the videos are ordered to maximize the benefit to the viewer. The videos include links so that viewers can transition between adjacent videos. Most videos follow a similar format. I walk through

the process of typing out the mathematically readable input into a worksheet. This format allows the user to engage in active learning. They can stop the video and enter the relationships themselves. Each video is accompanied by a PDF of a Maple document, which often includes other examples, practice problems and solutions, and troubleshooting help. In the talk, I will discuss the extensive array of information YouTube provides about the interest and viewership of the videos. I will also discuss how to create simple and engaging videos and how to increase interest in your channel more quickly. YouTube.com/@MapleProf.

B2-04 10:36 AM-10:48 AM | Contributed Talk (12 Minutes) | Teaching Scientific Inquiry

Presenting Author: Freek Pols, Delft University of Technology

Additional Author | Peter Dekkers, Delft University of Technology

Conducting experiments is seen as a valuable, if not essential, part of physics education. However, such activities are also costly and time-consuming. Moreover, it is often reported that these activities hardly contribute to the students' content knowledge, nor that they enhance students' view on how science works or teaches them how to plan an inquiry independently. In this presentation, we highlight our approach to teaching scientific inquiry. We elaborate on the various studies conducted on teaching scientific inquiry to 14-16y olds (culminated in the dissertation Development of a teaching-learning sequence for scientific inquiry through argumentation in secondary physics education). In addition to a brief overview of the scientific findings, we provide practical advice and materials that can be directly applied in your own classroom setting.

Session B3: Frontiers in Space Science and Astronomy

Location: Grand Ballroom C Time: 10–11 a.m. Date: Sunday, January 19, 2025 Moderator: Ann Schmiedekamp

B3-01 10:00 AM-10:24 AM | | Using Physics, X-rays, Earth Rocks, and Ash to study the Properties of the Soil on the Moon

Presenting Author: Ahmed Hassan, University of Missouri-Kansas City

Recently, there has been a surge in interest in lunar missions and planning for future human habitats on the moon. Lunar regolith is the top layer of loose dust and rocks on the moon's surface, posing as both a challenge and a valuable resource for future lunar missions. Regarding challenges, lunar regolith can cover solar panels significantly reducing their efficiency. Lunar dust can be also be generated during moon landings, which can lead to navigation errors. On the other hand, lunar regolith is a valuable material that can be used to build structures on the moon instead of bringing construction materials from earth. Before that can happen, the properties of lunar regolith particles need to be well characterized. Recently, NIST has used X-ray tomography to characterize, for the first time, the three-dimensional (3D) shapes of lunar regolith particles from the Apollo missions. We used computational electromagnetic algorithms to calculate these particles' optical and electrical properties and showed significant differences compared to the properties calculated using the simplified shapes typically assumed. Understanding these differences will substantially advance our capabilities in: lunar in-situ resource utilization (ISRU), and designing more efficient electric lunar dust collectors, transporters, and sorters in future lunar missions.

B3-02 10:24 AM-10:36 AM | Contributed Talk (12 Minutes) | Astromerty on close-separation hot and cold double star systems

Presenting Author: Jeffrey Marx, McDaniel College

Additional Author | Anthony Maletta, New Hampshire Astronomical Society

Additional Author | Abdoulie Njie, McDaniel College

In this talk, we will discuss using the Las Cumbres Observatory (LCO) remote telescope array to collect images of close-separation double star systems. By carefully selecting the surface temperature and magnitude of both stars in the system, close-separation double stars can be resolved by imaging the star system in two, standard bandpass filters available to users of the LCO. Although double-star systems are very common, our technique requires specific relationships between the stellar companions, which greatly reduces the number of potential target systems. Our team has begun collecting preliminary images to refine our understanding of the limitations of our approach and establish practical limits on the range of stellar temperatures and magnitudes we can reliably image. The basic physics and techniques of this project make it accessible to undergraduate physics and astronomy students interested in getting involved in a semester or multi-semester-long project. One of the co-authors of this presentation is an undergraduate student who was involved with this project during the summer between his first and second year at McDaniel College.

B3-03 10:36 AM-10:48 AM | Contributed Talk (12 Minutes) | What we have learned from JWST

Presenting Author: Toby Dittrich, Portland Community College

A summary of the initial findings made by the James Web Space Telescope (JWST) that are consequencial to our understanding of astronomy and astrophysics. A whirlwind summary of twelve topics in twelve minutes. Hopefully including 30 second statements from the PI's involved in these twelve discories and observations.

B3-04 10:36 AM-10:48 AM | Contributed Talk (12 Minutes) | The ExoCup

Presenting Author: Tansu Daylan, Washington University in St. Louis

I recently developed and taught a new course, Planets and Life in the Universe, which focused on planetary astrophysics at the upper-undergraduate and graduate level, covering celestial mechanics, observables of exoplanets, planet formation, evolution, and migration, and life as an emergent planetary phenomenon. During the semester, I implemented a series of active learning strategies, including the ExoCup: a knockout tournament between 16 exoplanets, where the exoplanets, championed by the students, competed to win the matches based on their rarity and scientific merit. Before each match, two students presented the competing exoplanets. Other students then contributed further remarks, comments, and clarifica-

tions in an open discussion. Finally, the class voted to determine the winner based on the unique properties of the exoplanet among all confirmed exoplanets. Discussions covered the observables (e.g., transits, radial velocity, imaging, microlensing) and physical properties (e.g., radius, mass, equilibrium temperature) of the exoplanet, its historical significance, atmospheric characterization potential, outstanding research problems it leads to, any rare properties such as spin-orbit misalignment, habitability prospects, and properties of its host star. Overall, the ExoCup was a successful pedagogical experiment, yielding an engaging class activity that effectively synthesized the class material at the end of the semester in an activity with high student enthusiasm and participation.

B4: Citizen Science in the K-12 Physics Classroom - Part 2

Location: Grand Ballroom D Time: 10–11 a.m. Date: Sunday, January 19, 2025 Moderator: Mike Florek

B4-01 10:00 AM-10:12 AM | Contributed Talk (12 Minutes) | Name that Neutrino: Citizen Science Meets Machine Learning at IceCube

Presenting Author: Madeline Lee, Drexel University

Additional Author | Christina Love, Drexel University

The IceCube Neutrino Observatory, located in Antarctica, is designed to detect high-energy neutrinos, which can advance our understanding of astrophysical phenomena. The Name that Neutrino project integrates citizen science and machine learning to classify simulated events from the IceCube detector. Name that Neutrino has participation from thousands of volunteers and the project is available in six different languages. Our first launch in 2023 resulted in over 170,000 classifications and those results yielded insights into the classification capabilities of citizen scientists and how they could inform and work with our current machine learning algorithm. The results also established a basis for the second launch that began in September 2024 which aims to provide better training for volunteers and better event selection for more accurate citizen classifications. Free educational materials will be presented so that Name that Neutrino can be used in high school and undergraduate courses.

B4-02 10:12 AM-10:24 AM | Contributed Talk (12 Minutes) | Implementing Gels in a Nuclear Science Lab

Presenting Author: Katherine Black, Morehead State University

Additional Author | Ignacio Birriel, Morehead State University

In physics labs, students can investigate the attenuation of radiation via the absorption of gamma rays. The standard lab done by students is to measure the mass attenuation coefficient using calibrated absorbers of lead, aluminum, or plastic. We propose the use of medical gels by Humimic Medical. These gels are delivered in one-pound blocks and can be melted and molded to take on any form. Students are required to make their own set of absorbers. They expose the gels to gamma rays, ranging from 0.09 MeV to 1.33 MeV from common radioactive sources, commercially available for physics teaching labs. The density of these gels ranges from 834.3 kg/m3 to 1118.7 kg/m3 and they are commonly used to simulate a wide range of human tissues. We used Cadmium-109, Cesium-137, Cobalt-57, and Cobalt-60 and calculated the mass attenuation coefficients. We discuss our data collection method using a ST-360 Radiation Counter with a GM-35 probe and compare our calculated coefficient values with values of water from the National Institute of Standards and Technology database.

B5: Teacher Share-a-thon

Location: Regency Ballroom A&B Time: 10–11 a.m. Date: Sunday, January 19, 2025 Moderator: Danelle Bugge / Co-Organizer: Meghan DiBacco

B6: Interactive: Implementing NGSS-based Practices in Physics Classrooms

Location: Regency Ballroom C Time: 10–11 a.m. Date: Sunday, January 19, 2025 Moderator: Richard Gelderman

B6-01 10:00 AM-10:24 AM | Interactive (e.g. panel, round table discussion, hands-on activity) | Navigating NGSS: Lessons Learned from Developing a Kinematics Unit

Presenting Author: Richard Slesinski, Syosset High School

This presentation will focus on the process and insights gained while writing a kinematics unit plan incorporating the Next Generation Science Standards (NGSS). The unit plan was created using a ten-step storyline process that included creating an anchor chart, writing enduring understandings, developing essential questions, designing an assessment, and creating a list of phenomena with corresponding learning expectations, experiences and performances. Both the process of creating this unit and the final product will be shared. Attendees will use an 11-point 3D Assessment Screening Tool to evaluate the final assessment, and they will interact with a novel computer simulation that allows students to discover the difference between average speed and velocity. The presenter will share individual lesson plans structured around the 5E student-centered model (Engage, Explore, Explain, Elaborate, Evaluate) and show a video of students testing their solutions to the anchoring problem of predicting where two moving objects approaching each other will meet. This presentation is ideal for high school physics teachers seeking guidance on how to write a unit incorporating NGSS. All lesson plans, resources, and assessments from the complete unit will be available for reference. Participants will leave with practical tools and insights to support their curriculum development efforts.

The following journal articles and webpages were used as guides when writing this NGSS unit plan for kinematics:

MacIsaac, D. (Ed.). (2019). Paul Anderson site dedicated to NGSS and grade school physics pedagogy. The Physics Teacher, 57(8), 565–565. https://doi.org/10.1119/1.5131131

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B6-02 10:24 AM-10:48 AM | Interactive (e.g. panel, round table discussion, hands-on activity) | Interactively Experiencing the "There Are Two Types" Activity as an Example of NGSS Based Practices

Presenting Author: Richard Gelderman, Western Kentucky University

When Next Generation Science Standards were formulated, the best comment on how things would change was "Students are not only responsible for knowing ideas; they are also responsible for engaging in practices that use the ideas in authentic ways." That was not a new idea in education; however, it is still novel to have it be accepted as the standard across all levels of teaching and administration. During this interactive session, we will work through a wonderful example for sharing the best aspects of NGSS based practices. This example works for all levels of students, functions excellently for all class sizes, and can be expanded or truncated to fit into a wide range of time slots. In the "There Are Two Types" challenge, participants (solo, or in groups) are provided with ten or more vials, each filled with a different liquid. Asked only to keep the lids on, they are given undirected time to experience this resource. When the self-discovery dies down, everyone is provided with the challenge, and the activity unfolds. Please join us to experience how this proceeds for the participants in our session, and then to switch to your teacher hat to debrief how this challenge implements the NGSS based practices.

C1: Beyond Intro

Location: Grand Ballroom A Time: 2–3 p.m. Date: Sunday, January 19, 2025 Moderator: Melissa Eblen-Zayas

C1-01 2:00 PM-2:12 PM | Contributed Talk (12 Minutes) | Efficient Solution for Kepler Orbits Yields Natural Relationship to Quantum Hamiltonians for Intermediate-Level Physics Courses

Presenting Author: Jason Tran, Georgetown University

Additional Author | James Freericks, Georgetown University

Additional Author | Leanne Doughty, Georgetown University

As a more student-friendly approach, decoupling the differential equations typically found in central force problems allows for a simpler, more efficient solution to the orbits of the Kepler problem by removing the need for complex integral analysis. As an additional bonus, the quantization of radial variables uncovers a deeper connection between the Keplerian orbits and quantum mechanical Hamiltonians of hydrogen states, perfect for junior and senior undergraduate physics students. The original idea for this comes from the 1930 textbook Elementare Quantenmechanik by Born and Jordan.

C1-02 2:12 PM-2:24 PM | Contributed Talk (12 Minutes) | Designing and Testing Interactive Online Applets for Upper Level Courses

Presenting Author: Timothy Stiles, Kettering University

Many of the concepts of advanced undergraduate physics courses are abstract and may be difficult for students to visualize. This talk describes the design and initial testing of a suite of interactive online applets aimed at providing understanding of such concepts for students in courses such as junior level mechanics, electromagnetism, and vibration and waves courses. Examples include Lagrangian formulation, principle axes of rotation, nonlinear oscillators, multipole expansion, dipole radiation, Fourier synthesis, drumhead vibration, evanescent waves, and dispersive waves. Each applet includes instructions to the student, example homework problems, and a detailed summary of the physics involved. These applets have been used in courses over the past four years. Data from student interviews and surveys will be presented on the self-reported benefits and disadvantages of using these applets.

C1-03 2:24 PM-2:36 PM | Contributed Talk (12 Minutes) | Curricular Structures in the Undergraduate Physics Major

Presenting Author: Juan Burciaga, Colorado College

In general, the undergraduate physics major incorporates a variety of curricular structures. At the course level, the textbook and course learning objectives are the primary structures that help define the content of the teaching/learning environment. But at the level of the physics major, the most common curricular structure is a catalog of courses. The presentation deconstructs a sample physics major to examine the various curricular structures in order to better discuss the assumptions, expectations and development within the physics major.

C1-04 2:36 PM-2:48 PM | Contributed Talk (12 Minutes) | Supporting and Implementing Research-Based Teaching Practices

Presenting Author: Michael Wittmann, American Physical Society

Additional Author | Sarah McKagan, Alder Science Educaiton Association

Additional Author | Rachel Ivie, American Association of Physics Teachers

The Effective Practices for Physics Programs (EP3) initiative (EP3guide.org) is a collaborative effort between APS and AAPT designed to support

physics departments in improving all aspects of their programs through continued self-reflection. One focus area identified early on for EP3 was providing guidance on teaching practices. Several of the most recently published sections include strategies for how instructional staff can apply research-based teaching and how departments can create cultural structures to support instructional staff in both in-person and online modalities. Additionally, several sections of the guide offer suggestions for how to incorporate research-based teaching in specific types of physics courses, such as introductory and upper-level courses. We will share a brief overview of the EP3 guide, including how the Guide's content will be updated and improved, and how participants can apply the EP3 Guide in their local contexts.
This work is funded in part by NSF grant 1821327.

C1-05 2:48 PM-3:00 PM | Contributed Talk (12 Minutes) | Making Nuclear Magnetic Resonance Resonate with Students: NMR as an Entryway to the Quantum World

Presenting Author: Merideth Frey, Sarah Lawrence College
Additional Author | Colin Abernethy, Sarah Lawrence College
Additional Author | David Gosser, City College of New York
Additional Author | Dedra Demaree, Blue Ridge School

As a quantum mechanical tool with many direct classical analogs, nuclear magnetic resonance (NMR) can provide a valuable entryway to quantum technology and research. This talk introduces a set of research-based active-learning modules developed as part of an NSF-IUSE grant to make the quantum realm more accessible to students by integrating NMR earlier in the undergraduate science curriculum. These modular labs were designed to cover the theory and applications of NMR with flexibility for use in a variety of different courses, classroom environments, and institutions. The developed materials take advantage of the growing capabilities of lower-cost benchtop NMR spectrometers and are also designed to be accessible to faculty and students who do not have direct access to a benchtop NMR spectrometer. This talk will provide an overview of how we have implemented these modules into our undergraduate science curriculum and the positive results in students' confidence, science identity, and expert-like mindsets. We suggest this work may provide a wider and earlier entryway for students to learn about quantum technologies and expand the future quantum workforce.

C2: PER: Student Success

Location: Grand Ballroom B Time: 2–3 p.m. Date: Sunday, January 19, 2025 Moderator: Carolyn Sealfon

C2-01 2:00 PM-2:12 PM | Contributed Talk (12 Minutes) | Self-Study and Success: The Impact of Student Use of Open-Access Resources on Introductory Course Performance

Presenting Author: James Hirons, Texas A&M University
Additional Author | Jonathan D. Perry, The University of Texas at Austin
Additional Author | Tatiana L. Erukhimova, Texas A&M University
Additional Author | Dawson T. Nodurft, Texas A&M University
Additional Author | Scott D. Crawford, Texas A&M University
Additional Author | William H. Bassichis, Texas A&M University

Performance in introductory courses, particularly physics, is often crucial for student success in STEM majors and can impact an individual's tendency to persist in their chosen field. The goal of these large-enrollment support classes is to imbue students with foundational knowledge critical to success in their upper-level STEM courses. To provide students with quality resources and enhance their individual learning experiences, faculty at many universities across the country have worked to develop open-access, self-study materials to help students build conceptual understandings and problem-solving skills. This work explores and measures the impact that these resources have on student success in an introductory, calculus-based electromagnetism course at a large, public, research-intensive university in comparison to some traditional measures of student ability. Data were collected from three fall semesters, 2021-2023, including classroom performance, a conceptual assessment, and relevant university level data to contextualize student background and pre-class abilities. We will present results from regression analysis and discuss how the use of supplemental materials appears to impact students' performance and improvement in the course along with other possible predictors of student performance including demographics and prior preparation. We will also share students' perceptions of these supplemental materials which were gathered through anonymous surveys.

C2-02 2:12 PM-2:24 PM | Contributed Talk (12 Minutes) | Pre-instruction diagnostic tests can help predict probability of obtaining high or low course grades in introductory physics

Presenting Author: David Meltzer, Arizona State University
Additional Author | Dakota H. King, University of Arizona College of Veterinary Medicine

In a study including over 2000 students in 30 distinct introductory physics classes at four universities, we found that administration of certain pre-instruction diagnostic tests allowed reliable prediction of the relative probability of attaining high (top quartile) and low (bottom quartile) course grades for high and low scorers on those tests. The tests used were the Force Concept Inventory, the Lawson Test of Scientific Reasoning, and a mathematics diagnostic test that covered only pre-college mathematics. High (top quartile) scorers on any of the pretests were, on average, about 5 times more likely to get a high course grade than low (bottom quartile) scorers. Low scorers on the pretests were about 4 times more likely to get a low grade than high scorers. This trend was observed to hold in 97% of the 114 cases examined; the probability ratios were 2.0 or greater in 84% of

the cases. Although students' performances on the various pretests were positively correlated with each other, the different tests each had independent predictive power and using multiple test results increased the reliability of the relative probability estimates.
Supported in part by NSF DUE #1504986 and #1914712

C2-03 2:24 PM-2:36 PM | Contributed Talk (12 Minutes) | Comparison of Self-efficacy in Physics Labs, 1st and 2nd semester, Algebra and Calculus-based Sequences

Presenting Author: Jennifer Delgado, University of Kansas
Additional Author | Jessy Changstrom, University of Kansas
Additional Author | Sarah Rush, University of Kansas
Additional Author | Chris Fischer, University of Kansas

We present new results from an ongoing survey of student self-efficacy in introductory physics labs at the University of Kansas. Using data with a sample size of several hundred students per lab course, we find that physics lab self-efficacy generally holds constant in the first semester (mechanics), but improves some in the second semester (E&M) for students of both algebra-based and calculus-based courses. We also find a persistent lab self-efficacy gap between men and women. We further discuss how time spent in the lab as self-reported by students correlates to their self-efficacy.

C2-05 2:48 PM-3:00 PM | Contributed Talk (12 Minutes) | Self Compassion in Physics Classroom.

Presenting Author: Rahmat Rahmat, SCC
Co-presenting Author | Sau Kuen Yam, SCC

Self-compassion is vital for physics students as it promotes both academic success and emotional well-being. Physics often involves challenging concepts and problem-solving, which can lead to frustration or self-doubt. Self-compassion helps students accept that mistakes are part of the learning process, encouraging resilience and a healthier approach to challenges. It also reduces the fear of failure, allowing students to recover from setbacks without harsh self-criticism. By practicing self-compassion, students can prevent burnout by acknowledging the need for rest and self-care, ultimately enhancing their productivity. It fosters a growth mindset, where students view intelligence as something that can improve with effort, helping them persist in the face of difficulties. Additionally, self-compassion improves collaboration and communication with peers, reducing negative comparisons and promoting effective teamwork. Moreover, self-compassion helps students combat imposter syndrome, recognizing their progress and abilities instead of feeling inadequate. Overall, it equips physics students with the emotional tools to navigate the rigor of their studies, supporting both their academic and personal development.

C3: Celebrating the International Year of Quantum Physics with AJP and TPT – Part 1

Location: Grand Ballroom C Time: 2–3 p.m. Date: Sunday, January 19, 2025 Moderator: Beth Parks

C3-01 2:00 PM-2:24 PM | | Grover's Search Algorithm: A Quantum Computing Exercise for Introductory Students

Presenting Author: Jed Brody, Emory University

Quantum computing has generated considerable excitement in the media, and even introductory students may wish to delve into this hot topic. Grover's search algorithm, one of the two most famous algorithms of quantum computing, is typically taught with the full machinery of linear algebra: inner products, outer products, and summation notation. I avoid these abstractions and present the essence of Grover's algorithm at a level appropriate for introductory physics students. No background in quantum mechanics or linear algebra is required. Students can design and run their own circuits on remote quantum processors, for free, via the IBM Quantum website.
Based on "Grover's Search Algorithm: An Approachable Application of Quantum Computing" by Jed Brody and Grant-Christopher Sykes, accepted for publication in The Physics Teacher.

C3-02 2:24 PM-2:48 PM | | The Quantum for All Students and Teachers Project: Sample Activities and the Historical Storyline Linking Them

Presenting Author: Ramon Lopez, The University of Texas at Arlington
Additional Author | Karen Jo Matsler, The University of Texas at Arlington

The Quantum for All Project is a program funded by the National Science Foundation (#2048691) to expand quantum science education in High Schools. The central focus is professional development for teachers, but there is considerable work that goes into developing and validating the instructional materials. In this presentation we provide a general overview of the project. We also provide some details on activities that address specific topics which are included in the Next Generation Science Standards: the electromagnetic spectrum and the dual wave/particle behavior of light. Finally, we discuss a historical storyline that was used with the teachers in the 2024 summer workshop to link several activities dealing with early quantum theory.

C4: Analysis of AP Physics Student Performance on Multiple-Choice Questions

Location: Grand Ballroom D Time: 2–3 p.m. Date: Sunday, January 19, 2025 Moderator: Amy Johnson

C4-01 2:00 PM-2:24 PM | | Student MCQ Performance in AP Physics Mechanics

Presenting Author: Amy Johnson, College Board

In this talk, we will discuss how student performance on multiple-choice questions is analyzed, and how that information can be used to identify student misconceptions as well as common errors and mistakes. This session will specifically discuss student data on question performance from the AP Physics C: Mechanics exam.

C4-02 2:24 PM-2:48 PM | | Student MCQ Performance in AP Physics 1

Presenting Author: Amy Johnson, College Board

In this talk, we will discuss how student performance on multiple-choice questions is analyzed, and how that information can be used to identify student misconceptions as well as common errors and mistakes. This session will specifically discuss student data on question performance from the AP Physics 1 exam.

C5: Interactive: STEP UP! Your Physics Classroom

Location: Regency Ballroom A&B Time: 2–3 p.m. Date: Sunday, January 19, 2025 Moderator: Bree Barnett Dreyfuss

C5-01 2:00 PM-2:48 PM | Interactive (e.g. panel, round table discussion, hands-on activity) | Women in Physics: Uncover Hidden Bias with our Expanded Interactive Lesson

Presenting Author: Bree Barnett Dreyfuss, Amador Valley High School

Co-presenting Author | Elissa Dunn-Levy, Thomas Jefferson High School for Science & Technology, STEP UP

The STEP UP Women in Physics lesson has been expanded to include new interactive tasks in which students make predictions and analyze the actual statistics about who does physics around the world. These new components of the lesson can be done digitally or printed and give students an opportunity to examine data and practice the NGSS Science & Engineering Practice of "Analyzing & Interpreting data" and "Engaging in Argument from Evidence." If you have done the Women in Physics lesson before or are interested in trying it in the future, come to find out about these new aspects of the lesson and try them with your students!

C6: Vertical Articulation from K-8 to HS with the NGSS Science Practices

Location: Regency Ballroom C Time: 2–3 p.m. Date: Sunday, January 19, 2025 Moderator: Mike Florek

This session follows an "unconference" model around the topic of vertical articulation of the Next Generation Science Standards (NGSS) through K-12 classrooms. This model is an opportunity for participants to talk about topics relevant to them. When participants arrive at the session, the moderator will guide the group in deciding on table topics. Movement between table topics will be fluid and anyone is welcome to join this session at any time throughout the hour.

D1: Quantum Education Promotion (QEP): Initiatives and Challenges in Undergraduate Programs – Part 1

Location: Grand Ballroom A Time: 3–4 p.m. Date: Sunday, January 19, 2025 Moderator: Melissa Eblen-Zayas

D1-01 3:00 PM-3:12 PM | Contributed Talk (12 Minutes) | Filling pedagogical or experiential gaps with quantum computing

Presenting Author: Christopher Porter, IBM Quantum

Additional Author | Katie McCormick, IBM Quantum

The buzz around quantum computing over the last decade has been accompanied by a growing body of educational content on the subject. This content has progressed from being for experts, then for professionals, and now even for hobbyists. But much of the content lacks well-defined learning goals or has learning goals that are not tied to existing curricula or courses. IBM Quantum is taking the opposite approach: starting from lessons and learning goals from traditional (pre-quantum computing) courses, and crafting quantum computing activities that help achieve the desired outcomes. The activities are modular, framed in common traditional syllabi, require little coding but accommodate code-savvy learners with optional activities, and come with formative check-in questions and end-of-lesson summative questions. Based on early guidance from instructors, we have crafted a set of Qiskit classroom modules to fit into an undergraduate quantum mechanics course. These modules are designed to help students experimentally realize counterintuitive quantum phenomena, exploring topics like superposition, uncertainty, and hidden variables in the context of Bell's inequality. We are currently field testing this content with partners, and are collecting feedback. The next steps are to refine these modules and extend them to other subjects, such as computer science.

D1-02 3:12 PM-3:24 PM | Contributed Talk (12 Minutes) | Applications of a Fundamental Linear Algebraic Paradigm (FLAP) in Quantum Circuits: A Practical Teaching Pedagogy in Quantum Literacy (QULT)

Presenting Author: Anil Pyakuryal, University of District of Columbia-Community College, Washington, DC 20017.

Additional Author | Peter Plourde, University of District of Columbia-Community College, Washington, DC 20017.

Additional Author | Tatiana Gonzalez, University of District of Columbia-Community College, Washington, DC 20017.

Additional Author | Bushra Ahmad Saeed, University of District of Columbia-Community College, Washington, DC 20017.

Additional Author | Marilyn Hamilton, University of District of Columbia-Community College, Washington, DC 20017.

Quantum Information Science and Engineering (QISE) is a field that combines quantum-physics and information -science in order to process quantum information using digital circuits. Such technology has led to the development of advanced applications such as Quantum Computation, Quantum Communication and Sensing. In general, literacy and awareness in Quantum is essential to train the technical professionals needed for the anticipated crisis of the work-force in Quantum technology. However, a learning process for such technology has become a challenging task for the beginners in Quantum. As an alternative to the commonly used time-consuming algorithmic [A] models, one can easily demonstrate the quantum information processing using linear algebraic mathematical [M] models, to simulate the operation of logic-gates in digital Quantum circuits. Therefore, M-guided circuit (M-C) model could have a potential edge over the M-guided algorithmic (M-A) model in the learning process of the beginners by overcoming various algorithmic constraints. Such practices have been recommended from the randomized surveys performed on industrial professional participants in Quantum World-Congress, 2024. Survey has suggested proportional incorporation of interdisciplinary-fields such as linear-algebra (28.3%), circuit-design (25.8%), programming (23.3%), and qualitative Quantum-Physics (18.3%) respectively, in heuristic-model of course structure and teaching pedagogies in the elementary QISE programs and its applications such as Quantum-Literacy.

D1-03 3:24 PM-3:36 PM | Contributed Talk (12 Minutes) | Quantum Counter-Revolution

Presenting Author: Ian Redmount, Saint Louis University

For over a century ``modern physics''--encompassing quantum mechanics and Einsteinian relativity--has been presented as a revolutionary, transcendent departure from classical predecessors. This has engendered ideas such as that physics, and by extension all of science, advances by being completely rewritten in a sequence of revolutions, and that it belongs in an inaccessible, almost mystical realm of ideas. These notions adversely impact both the teaching and the pubic acceptance of physics and science in general. A more useful approach would recognize that quantum mechanics bears exactly the same relation to classical mechanics that wave (physical) optics bears to ray (geometric) optics, just as Einsteinian relativity is the expansion of Newtonian mechanics to accommodate a finite invariant speed. All these developments are best to be understood as natural evolutions of the classical physics which has gone before.

D1-04 3:36 PM-3:48 PM | Contributed Talk (12 Minutes) | Open source software package for quantum mechanics

Presenting Author: Eric Majzoub, University of Missouri - St. Louis

We present an open-source software package for performing quantum mechanical calculations in finite dimensional Hilbert spaces. The package, "qm-maxima" is built for the Maxima computer algebra system (CAS). Maxima is a powerful, open-source CAS that students can download for free. The qm-maxima package provides tools and definitions for solving a variety of problems including calculating the probability of outcomes of Stern-Gerlach experiments for any spin, working with the angular momentum (|j,m> representation) of states, building tensor products of states, computing Clebsch-Gordan coefficients by manually walking up and down the ladder of states, computation of density matrices, and working with entangled states, among others. The software is powerful enough to solve many problems at the graduate level as well. The presentation will demonstrate how students can use and benefit from these tools.

D2: PER: Science and Math

Location: Grand Ballroom B Time: 3–4 p.m. Date: Sunday, January 19, 2025 Moderator: Aaron Titus

D2-01 3:00 PM-3:12 PM | Contributed Talk (12 Minutes) | Nikola Tesla in Science Textbooks in the Canadian Education System

Presenting Author: Farook Al-Shamali, Athabasca University

Additional Author | Matthew Yaguchi

Additional Author | Angela Beltaos, Athabasca University

Additional Author | Gustavo Carrero, Athabasca University

Nikola Tesla is considered one of the greatest inventors in modern history, described as "the man who invented the 20th century". He is honored by naming the magnetic flux density unit the "tesla", which is one of only 19 units named after scientists in the International System of Units (SI). Science textbooks mention a number of scientists when their work is related to a given topic and frequently include a biographical note with a picture. Conveying an accurate narrative of the evolution of scientific ideas developed by physicists should allow young generations to better understand the scientific process and motivate future scientists. In this work, we study the representation of Nikola Tesla in the span of other prominent physicists and their achievements in a sample of textbooks spanning the Canadian education system (elementary, secondary, and university levels). The analysis reveals significant variations in representations based on textbook levels, with first year introductory physics textbooks having most coverage, followed by high school level material. There are also differences among individual scientists, with some receiving significant coverage, while others appear to be under-represented, even when a unit is named after them (such as Nikola Tesla).

D2-02 3:12 PM-3:24 PM | Contributed Talk (12 Minutes) | Student Understanding of Xeno's Dichotomy Paradox in Multiple Representations

Presenting Author: Daniel Marsh, Missouri Southern State University

Additional Author | Rabindra R. Bajracharya, Missouri Southern State University

Xeno's dichotomy paradox describes an imaginary process where someone in theory could move a fixed distance in a first step. After that they move half their first distance in a second step. They move one-half the second distance in their third step, and continue to make successively smaller and smaller steps, and so on. Fischbein (1978) questioned students about this paradox in a survey. He observed that most of the students believed the process would never end and a majority believed that the process would also cover an infinite distance. The potential infinity of the

process appears to present a cognitive obstacle to the student's understanding of the limit concept. We have investigated the student understanding of this paradox by a questionnaire that presents this process in five different representations, namely: a conceptual representation, an analytical representation as a series of successively smaller displacements, an analytical representation as a geometric series, a tabular representation, and a graphical representation. We found that the finite value of the limit is much easier for the students to observe in some of the different representations. We analyze the results using a novel analytical framework called representational transformation (RT). We will discuss the instructional aspects of the RT approach.

D2-03 3:24 PM-3:36 PM | Contributed Talk (12 Minutes) | Investigating Student Perceptions of Negative Signs in Transformed Calculus-based Physics course

Presenting Author: Kazi Aatish Imroz, The Ohio State University

Additional Author | Geraldine Cochran, The Ohio State University

Introductory, calculus-based physics courses at numerous institutions rely heavily on prior mathematical skills and often include prerequisite and corequisite math courses. This may create new or exacerbate existing inequities among admitted students. We intend to provide support in developing mathematical skills and quantitative literacy in introductory physics courses by restructuring the syllabus. To assess student skills and gains in quantitative literacy during the course, we will administer the Physics Inventory of Quantitative Literacy (PIQL), developed by Brahmia et al. This inventory tests the quantitative reasoning of students which is the skill necessary to make a connection between mathematical symbols and physical quantities to make sense of the instructions delivered while learning physics. In this presentation, we will share our analysis of student performance on the PIQL given as a pre- and post-survey at a public university in the Southcentral region of the US. Particularly, we will be looking into the questions that require interpreting the negative sign, a symbol that creates recurring confusion among students in introductory physics due to its numerous implications.

TEAM Acknowledgement: The preliminary findings presented are from a larger study by the Transforming Introductory Physics Sequences to Support All Students (TIPSSS) Network.

Funding Acknowledgement: This work is supported in part by National Science Foundation Award# 2403512. The findings and opinions present are that of the authors and do not necessarily reflect the views of the National Science Foundation.

D2-04 3:36 PM-3:48 PM | Contributed Talk (12 Minutes) | Deeper Understanding Through Problem Posing

Presenting Author: Michael Peterson, Triangle Math and Sci Academy

Research findings suggest that many students tend to ask infrequent and superficial questions, which hinders their ability to deepen their understanding and acquire new knowledge. This pilot study (N=15) asked whether having students pose their own problems to examine would have an effect on their understanding. The instructor guided the students from structured problems to having students posing their own problems for each unit. To assess the effects of problem posing on understanding, students were evaluated on Advanced Physics Calculus released force multiple choice and free-response questions. Bayesian machine learning was used to determine the network of influencing factors. The network results suggest that problem posing, with an arc strength of 0.54, supported free-response questions. Problem posing also influenced the total achievement with an arc strength of 0.82, with one being the maximum. While these results are intriguing, the study needs to be expanded with a larger sample size and broader content assessment.

D3: Celebrating the International Year of Quantum Physics with AJP and TPT – Part 2

Location: Grand Ballroom C Time: 3–4 p.m. Date: Sunday, January 19, 2025 Moderator: Beth Parks

D3-01 3:00 PM-3:24 PM | | Introducing quantum mechanics with a two-mode Mach-Zehnder Interferometer: basic concepts of quantum physics and properties of single photon states

Presenting Author: Benoit Chalopin, Université de Toulouse, France

Additional Author | Gauthier Rey, Université de Toulouse, France

Additional Author | Renaud Mathevet, Université de Toulouse, France

Additional Author | Sébastien Massenot, Université de Toulouse, France

The wave function approach is mostly used as the first formalism of quantum mechanics as it is most relevant for physicists aiming at understanding physical and chemical systems at the microscopic level. However, the rapid development of Quantum Information (QI) compels educators to teach quantum mechanics to new types of students, especially future quantum engineers who will work outside of academic laboratories. Quantum optics can easily provide low-dimensional spaces required for QI, and can therefore be used to introduce the foundations and postulates of quantum mechanics. Exploiting the students' intuition about the concept of photons, we can use the fact that, up to the detection, the single photons actually behave exactly as their classical counterpart, that is the optical mode which supports it.
I will present how a simple Mach-Zehnder interferometer experiment can be exploited in this regard. Results can be intuitively interpreted and used to understand the postulates and introduce the more abstract formalism of states and transformation useful for quantum information.

D3-02 3:24 PM-3:48 PM | | Decoherence, Entanglement, and Information in the Double-Slit Experiment

Presenting Author: Frederick Strauch, Williams College

Richard Feynman famously characterized the double-slit experiment as containing "all of the mystery of quantum mechanics." The standard discussion, however, does not include entanglement, which Schrödinger had called "the characteristic trait of quantum mechanics." In this talk I

will consider how more of the mystery of quantum mechanics can be captured by modifying the double-slit experiment so that the passage of an electron is monitored by the deflection of a proton. A quantitative treatment, suitable for undergraduates, will be presented, with the aim of understanding decoherence, entanglement, and the information gained by measurements in this classic experiment.

D4: Embracing the Dark Side: Teaching Light Pollution Concepts to K-16

Location: Grand Ballroom D Time: 3–4 p.m. Date: Sunday, January 19, 2025 Moderator: Tracy Hodge

D4-01 3:00 PM-3:24 PM | | Educating K-16 Students About Light Pollution

Presenting Author: Jennifer Birriel, Morehead State University

Light pollution is now recognized as a pervasive form of human generated pollution, rather than simply a problem for the astronomical community. Publications such as "National Geographic" and programs like the National Park Service's "Night Sky Rangers" represent important informal education efforts. However, the physics education community is uniquely positioned to reach large numbers of young people: those who will ultimately influence and/or inform public policy. We discuss opportunities to engage students with light pollution from the disciplines of astronomy, biology/environmental science, engineering, and physics. Students from K-16 can participate in Citizen Science programs and hands-on-learning curricula as part of course work in astronomy, biology, or physics. Motivated students can pursue projects documenting light pollution as part of science fair projects or undergraduate research experiences. We conclude with the potential opportunities to use light pollution as a service-learning vehicle in undergraduate courses as well.

D4-02 3:24 PM-3:36 PM | Contributed Talk (12 Minutes) | Using a Sky Quality Meter to Measure Light Trespass at the Berea College Pinnacles

Presenting Author: Tracy Hodge, Berea College

Additional Author | Adrienne Beggs, University of Kentucky / Kentucky Transportation Center

I report on a novel use of the Sky Quality Meter (SQM) to measure light trespass at the Berea College Pinnacles. As part of her senior capstone project, one of our students measured the brightness under the tree canopy as a function of distance from the parking lot under a variety of sky conditions (clear, cloudy, partly-cloudy). The student was able to demonstrate that lights from the parking lot had a signifcant impact on the luminance at a distance of up to 200 m within the forest, compared to nights when the lights were turned off. Future work includes continuing to monitor the light pollution at the Pinnacles under different light and seasonal conditions, as well as installing a permanent SQM-LE unit at the site.

D5: PTRA Presents Make, Take, Learn, Do

Location: Regency Ballroom A&B Time: 3–4 p.m. Date: Sunday, January 19, 2025 Moderator: Nina Morley Daye

This session is sponsored by the Pre-High School Committee and hosted by PTRAs. Come and get a variety of ideas for things you can make for a small investment of money and time. Students can make many of these items. These can be used to teach physics concepts at a variety of levels. Each item will have the instructions available and is linked to the NGSS.

D6: AP Physics: Revised Course and Exams for 2024-2025

Location: Regency Ballroom C Time: 3–4 p.m. Date: Sunday, January 19, 2025 Moderator: Amy Johnson

POSTER SESSION II:

Location: Midway West Time: 4–5 p.m. Date: Sunday, January 19 Sponsor: AAPT

Astro Poster Session II

POS-SUN-C302 | Poster Presentation Traditional | An Earth to Jupiter Ion Engine Ladder through the Asteroids

Presenting Author: Joseph West, Indiana State University

Additional Author | Daniel Bailey, Indiana State University

Additional Author | Dalton Bogdon, Indiana State University

A new algorithm is introduced to perform a circle-to-circle orbital transfer using only ion engines in an iterative process, analogous to climbing the rungs of a ladder. Ion rocket engines are generally much more efficient than their chemical powered counterparts but have orders of magnitude

lower thrust. The iterative nature of the new maneuver accounts for the low level of thrust. A significant reduction in the complexity and mass of the drive system, and a large increase in fuel efficiency is attained by using only ion engines. The full time and fuel requirements for a hypothetical mission to move the NASA Pathfinder satellite between the L1 Lagrange points of Earth and Jupiter using the new algorithm and a traditional chemical powered are compared. The iterative nature of the ion version of the mission could also visit asteroids of interest between Mars and Jupiter as the satellite "climbs the rungs of the ladder." All results are in simple analytic form, and suitable for use in a college level course in mechanics.

POS-SUN-C304 | Poster Presentation Traditional | Integrating Place-Based Education & Service Learning in Community College Astronomy Courses

Presenting Author: Roger Hart, Community College of Rhode Island

Additional Author | Kateline A Pereira, Community College of Rhode Island

Additional Author | Michael J Gryss, New Bedford High School

Additional Author | Ilana M Vertullo, Bridgewater State University

Service-learning (SL) and place-based education (PBE) blend community-focused activities with reflective learning, helping students connect course content to real-world locations. These approaches enhance understanding, promote civic responsibility, and positively shape students' perceptions of science. General education astronomy courses, often taken by non-science majors, provide unique opportunities to integrate meaningful, hands-on experiences of science learning. We show that, in "The Solar System" astronomy course, both SL and PBE can take many forms that can engage students with scientific practices. Our projects, (1) PBE by involving students measuring skyglow in their local areas and comparing it to readings from the college campus and (2) SL by hosting sky/stargazing sessions for the general community, both which foster local connections and improving astronomical understanding. However, having general education students complete their own science investigations that can connect to astronomy course learning outcomes can also be implemented, increasing student agency. Based on the GEAS project for astronomy laboratory exercises, (3) a student-driven SL investigation of plastic mass, along with water quality, from their hometown beaches, and how these concepts connect to astronomy course outcomes. Our demonstrated activities align with specific astronomy student learning outcomes where students demonstrate their understanding of the scientific process by actively engaging in scientific practices.

POS-SUN-C306 | Poster Presentation Traditional | Modern Eddington Experiment 2024

Presenting Author: Toby Dittrich, Portland Community College

The Modern Eddington Experiment (MEE) started in 2017 by utilizing modern telescopes and digital CCD cameras to acquire deflected stars. There were two successful parties Berry/Dittrich (and four students) in Oregon and Don Bruns in Wyoming. The success that Don Bruns obtained gave him the Chambliss Astronomy Award. The Berry/Dittrich execution was not as successful but did achieve determination of the Einstein Coefficient, which demonstrated that the experiment is possible with students. The MEE2024 project was organized, and there was a total of thirteen telescope camera stations at three locations across the path of the April 8 eclipse. The seven stations in Texas were clouded out, but the six stations in central Mexico had modest success, despite the clouds from a subtropical jet stream. They captured several hundred stars on thousands of plates with about 500 GB data in the 4.5 minutes of totality. The team of professors, amateur astronomers and twenty students once again proved that this experiment is very hard to perform but with planning, training, calibration and practicing procedures during totality the Einstein Coefficient can be determined. This second success beckons the call for an even greater execution for the August 2, 2027, and recruitment of the MEE2027 team.

Cross-Disciplinary Poster Session II

POS-SUN-D402 | Poster Presentation Traditional | Use Energy to Estimate the Greenhouse Gasses Associated with Food

Presenting Author: James Panzer, Energy and Equity Project and John Jay High School

The poster will showcase a lesson for high school students that enables students to understand food as a form of energy, and allows them to draw their own conclusions as to what kind of foods are better for the environment. Students are introduced to common energy formulas in an engaging way as they perform a physical task and calculate the energy expenditure. Then students use dimensional analysis and fact-checking to estimate the amount of greenhouse gasses released in the atmosphere due to their food choices. In this lesson, students discover for themselves the various impacts on our environment that food and the food industry has, and are given a chance to dive into the complexities of cultures, disadvantaged peoples, and the roles of different stakeholders in the complex processes that it takes to get food on the table. At the same time, they learn how to work with the formulas for kinetic energy, gravitational potential energy, etc. UN Sustainable Development goals are used as a framework for student's individual concerns. This work is supported by the Energy and Equity Project under NSF Award #1936601.

POS-SUN-D404 | Poster Presentation Traditional | Incorporating community engagement and social justice through air quality monitoring

Presenting Author: Joseph Kozminski, Lewis University

Additional Author | Nuvia Hernandez, Lewis University

Additional Author | Michael Jarvis, Lewis University

A team from Lewis University and community partner Warehouse Workers for Justice are deploying an air quality monitoring network in environmental justice (EJ) communities in the Joliet and Canal Corridor in Will County, IL. This urban area southwest of Chicago has much heavy industry, refineries, natural gas-fired power plants, and increasing numbers of warehouses. This area is also located on a major transportation and shipping corridor with several interstate highways and major rail lines, a ship canal, and the largest inland container port in North America. This air quality monitoring network uses PurpleAir sensors to measure PM2.5 (particulate matter under 2.5 microns) concentrations in the air. The air

quality measurements from these sensors is continuously updated on the PurpleAir website and is publicly available for use by the community. The goals of this project are to educate the public, including students, about air quality and the health risks due to poor air quality and to provide data for use in educational settings (K-12 and college), for local decision-making, and for climate and environmental advocacy and action planning. This poster will discuss the air quality network and climate vulnerability in the area and show how data collected by the sensors can be used. This work is supported in part by an Environmental Protection Agency ARP Grant Number 5X00E03355 through sub-award from Warehouse Workers for Justice. 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 Environmental Protection Agency.

POS-SUN-D406 | Poster Presentation Traditional | Going Off Track

Presenting Author: Thomas Gibbons, Retired from Eastern Iowa Community College District

One way to go a little off track and add information about physics related topics not in an official curriculum is through the problems and examples we choose to illustrate the main course content. An obvious subject for such problems is climate change. It is clearly related to physics but is not likely to be part of an official curriculum. But if the course contains the ideal gas law, then that can be used to calculate the density of carbon dioxide molecules in the atmosphere. This suggests it is more likely for outgoing photons to encounter a CO2 molecule than it would seem from just quoting its concentration of about 0.04%. Various specific heat problems can also relate to climate change. Some groups have recently loudly tried to promote the flat earth idea. Whether they are serious about it or not, they certainly spread a lot of misinformation. Their idea of physics is so far off the mark that efforts to correct it could make certain physics topics extremely interesting. Examples such as the ones mentioned here will be included in the posters.

Intro & Beyond Poster Session II

POS-SUN-E504 | Poster Presentation Traditional | Pedagogy courses for preparing teaching assistants at University of Washington

Presenting Author: Kazumi Tolich, University of Washington

Guiding students using Socratic questioning or during open-ended activities can be challenging. Providing well over 1000 students with consistent instruction, when the labs and tutorials of the introductory courses at University of Washington are led by approximately 40 graduate or undergraduate teaching assistants each quarter, makes it even more challenging. Over three decades, the introductory physics courses have been running tutorials where students actively work on conceptual problems, and teaching assistants are expected to employ Socratic questioning. Three years ago, our introductory labs went through an overhaul making them more focused on student decision-making and investigation. Given the changes in our labs, to better prepare the teaching assistants and improve uniformity in instruction, we developed two pedagogy courses: one for the graduate teaching assistants, and the other for undergraduate teaching assistants. Each course has two parts: one is where teaching assistants go through the tutorial and lab activities themselves and prepare themselves to teach upcoming sessions, and the other is where we discuss general pedagogy with topics such as: Socratic questioning, learning objectives, grading, classroom management etc. I will discuss the details of how these pedagogy courses evolved over the last three years, what worked and what didn't.

POS-SUN-E506 | Poster Presentation Traditional | Effects of including AI output along with a traditional exam question

Presenting Author: Timothy McCaskey, Columbia College Chicago

In my course on waves and sound, I have started giving exam questions where part of the task to use and evaluate AI output produced from part of the question. AI often recognizes what concepts are in play but often (1) uses different notation or formulations of the ideas than I present in class and (2) makes arithmetic errors. By including that AI output, I can see how students respond to and critically evaluate it. In this poster, I will show examples of students finding AI errors appropriately, missing the errors completely, or in rare cases, seeing the incorrect output and then discounting their own correct work.

POS-SUN-E508 | Poster Presentation Traditional | Experiences with an Introductory Quantum Information Course

Presenting Author: Daniela Topasna, Virginia Military Institute

In the effort of advancing quantum information at the undergraduate level, an introductory course has been created that exposes students to basics of controlling information using principles of quantum mechanics. Students practice qubit manipulation on a quantum circuit simulator and using an educational quantum computer. Other topics include materials used for qubit fabrication; career opportunities related to quantum computing and quantum information science and technology; the importance of the interdisciplinary aspect of the field; and latest advances and projected developments. This presentation describes how the course has been implemented and what were the opportunities and challenges that came about from developing and teaching the course.

POS-SUN-E510 | Poster Presentation Traditional | Circuit Simulators: Reducing Barriers for Beginners in Quantum

Presenting Author: Patrick Hall, Univ of the District of Columbia

Additional Author | Peter M Plourde, Univ of the District of Columbia

Co-presenting Author | Anil Pyakuryal, Univ of the District of Columbia

To comprehend Quantum Information Science (QIS) and its applications, fundamental knowledge is needed in engineering digital circuits [C], scripting algorithms [A], developing linear algebraic models [M], and applying elementary Quantum Physics [P], termed the "CAMP model." Due to the lack of experience in various types of computer programming languages, beginners often struggle to develop programs for designing quantum circuit models. In addition, frequent updates in evolving frameworks with cloud-based quantum computing platforms (CBQCPs), such as Qiskit and PennyLane, also require users' periodic attention. Furthermore, performing real-time quantum computation with CBQCPs is also very time-consuming. These problems are the primary barriers for the beginners learning QIS and its applications. However, our study found that

browser-based quantum circuit simulators (BBQCSs), such as QRydDemo and Quirk, were more effective than CBQCPs in addressing these problems. We also compared the fidelity and probabilistic accuracy of BBQCSs against CBQCPs by examining the outcomes of several types of quantum applications such as Bell state circuit design, quantum teleportation, and prime factorization using Shor's algorithm. The graphical interfaces, built-in tutorials, and minimal setup in BBQCSs enabled the beginners to design various types of quantum circuits and understand their applications efficiently within a reasonable amount of time.

POS-SUN-E512 | Poster Presentation Traditional | Cultivating Practical Skills and Core Knowledge in Photonics for STEM Majors

Presenting Author: Douglas Petkie, Worcester Polytechnic Institute

We will detail the design and activities of a sophomore/junior-level photonics course tailored for STEM majors. The course aims to equip students with essential knowledge and practical skills for undergraduate research, workforce entry, and graduate studies. Key topics include an overview of optics, optical waveguides (fibers and photonic integrated circuits), propagation, coupling, light sources, and detectors. The course incorporates demonstrations and simulations to provide context-rich in-class worksheets and homework problems. Through course projects, students explore photonics-based applications and career opportunities, linking course content to current technological advancements.

POS-SUN-E514 | Poster Presentation Traditional | SUPER STEM Honors Program at Randolph College: Student Wellbeing

Presenting Author: PETER SHELDON, Randolph College

Additional Author | Sarah Sojka, Randolph College

Additional Author | Meghan Halbrook, Randolph College

Randolph College instituted a recruitment and retention program funded by three NSF S-STEM grants with different themes that has contributed significantly to the success of our STEM students. We have significantly increased the numbers of our science graduates, particularly in physics and engineering. This comprehensive STEM honors program is SUPER: Step Up to Physical Science and Engineering at Randolph. It includes a summer transition program, first-year living-learning community, mentoring, career services, tailored seminars, and enhanced academic support services. The newest iteration of the NSF S-STEM grant focuses on mental wellness and inclusiveness. We will discuss the programs and services we have implemented, and will share any research results that we have about effectiveness.

This project is supported by the National Science Foundation under Grant No. DUE-2029082. 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.

K-12 Poster Session

POS-SUN-B202 | Poster Presentation Traditional | Implementing the Patterns Physics Curriculum in a 12th Grade Independent School

Presenting Author: Ben Gillen

The Portland Metro STEM Partnership has created a three year course sequence pulling from teacher generated content and curated open-content materials. It is designed for 9th grade students to leverage their own experimental curiosity to make data-informed predictions about a range of phenomena. I attended their workshop in Portland during July 2024, and have since implemented their curriculum into my 12th grade physics classes at the Seattle Academy of Arts and Sciences. The difference in target vs. applied grade has necessitated changes in the curriculum, and I have adapted projects to better fit the needs of my students. I am presenting on these changes, and the feedback that I have received from my students during the Patterns Physics implementation.

POS-SUN-B204 | Poster Presentation Traditional | Quantum instruction for Elementary Students

Presenting Author: Jose Soto, Richard J. Daley Academy

As a first time STEM based developer of curricula, breaking from the "stereotypes" that society has created in relation to what Science is becomes the point of entry to a successful implementation of Quantum Instruction for elementary grades. Integrating current science standards and aligning them with higher order investigative approaches to learning can provide students a window to future careers in the field of STEM.

POS-SUN-B206 | Poster Presentation Traditional | Examples of Integrated AI Literacy in the Physics Classroom

Presenting Author: Lisa Carpenter, OpenZebra + ZebraEd

Student-facing AI is making its way into classrooms as students are increasingly using AI to assist them in learning and exploring all subject areas. It is quickly becoming our responsibility to teach students how to use generative AI safely, equitably, and productively. I share examples of lessons that integrate AI literacy concepts with traditional physics objectives. From generating custom chatbots to engineering prompts to analyzing bias and accuracy in model outputs...these lessons are designed to spark student engagement with AI in ways that foster critical thinking while complimenting physics objectives.

POS-SUN-B208 | Poster Presentation Traditional | Energy and Equity Portal

Presenting Author: Gareth Kucinkas, Seattle Pacific University/EF Academy

Energy is a foundational concept of physics and plays an integral role in a web of sociocultural realities, economic issues, and public policies. The Energy and Equity Portal supports high school teachers in teaching a robust model of energy, grounded in the NGSS, and also intentionally constructed to support engagement with current sociopolitical issues. Using the resources and community provided in the Portal, teachers explore energy learning as a means for promoting discussions of energy justice and energy equity globally and in our local communities. By developing a model of energy in physics that is fully aware of how science is sociocultural, teachers and students create science concepts informed by their

cultural worlds and educational priorities. Check out the classroom-ready teaching tools and enjoy a dynamic and compassionate professional learning community!

POS-SUN-B210 | Poster Presentation Traditional | Using Vernier Video Analysis to Investigate Motion in High School Physics Projects

Presenting Author: Meghan DiBacco, Katy ISD - Cinco Ranch High School

This session explores the integration of Vernier Video Analysis software into high school physics projects to deepen students' understanding of motion. The project follows a structured three-part approach designed to support students learning. The session will cover each part of the project in detail, showcase examples of student work produced throughout the process, and key takeaways.

POS-SUN-B212 | Poster Presentation Traditional | The Contemporary Physics Education Project

Presenting Author: Margaret Norris, Black Hills State University

| Howard Matis

| Michael Barnett

| Lynn Cominsky, Sonoma State University | Cindy Schwarz, Vassar College | Samuel Lightner

The Contemporary Physics Education Project (CPEP) is a non-profit organization consisting of educators and physicists with an interest in inspiring students through contemporary physics topics. CPEP materials present the current understanding of the fundamental nature of matter and energy, incorporating the major research findings of recent years, and updated as new discoveries are made. The colorful charts, posters and other products distributed by CPEP began with the Fundamental Particles and Interactions chart and continues today with the latest endeavor, a poster on Quantum Information. Other products are in the areas of Fusion: A Fundamental Energy Source, History and Fate of the Universe, Nuclear Science and Gravitation.

POS-SUN-B214 | Poster Presentation Traditional | Conceptual Physics for the 21st Century High School

Presenting Author: John Suchocki, Conceptual Academy, PBC

High school physics teachers face increasing demands while resources and support diminish. This challenge calls for modernizing proven approaches like Paul G. Hewitt's Conceptual Physics, which has delighted students and teachers worldwide since the 1970s through its accessible approach to physics fundamentals. We present a digital platform that integrates a streamlined version of Conceptual Physics with interactive videos, serving both as a teacher authoring tool and student electronic field journal. The platform includes NGSS/TEKS standards alignment, Bluetooth sensor integration, and AI-powered tutoring and teacher support. This solution maintains Hewitt's proven pedagogical approach while providing teachers with modern tools for effective physics instruction.

Labs Poster Session II

POS-SUN-F602 | Poster Presentation Traditional | Non-standard units in introductory physics labs

Presenting Author: Christopher Aubin, Fordham University

Additional Author | Jan C Bierowiec, Fordham University

Additional Author | Jackson Saunders, Fordham University

When students perform experiments in introductory labs, they usually use SI units for measurements, especially when measuring a well-known quantity (such as the acceleration of an object in free fall, g). In such cases, they find ways to confirm their results without a proper error analysis because their result is "close enough" to the correct answer. Masking the correct answer by using a non-standard system of units can encourage students to be more careful when ascertaining if their results are valid. Such a technique is common in nuclear and particle physics research, and in this poster we discuss a way to define a new unit of length so that g has a value not known to the students. To make this a more scientifically engaging experience, the lab takes place over two lab periods, where during the second period we run a "conference" where the students are guided in coming up with a consensus among the group as to what the accepted value of g is in these units.

POS-SUN-F604 | Poster Presentation Traditional | The Scientific Graphic Organizer for Lab Work

Presenting Author: Freek Pols, Delft University of Technology

To better align assessment and learning goals for practical work, without increasing the teacher's workload, we developed the scientific graphic organizer (SGO). The SGO can be considered a pre-structured but simplified lab journal that in many cases allows to replace the practical's worksheet as well as students' written report. I will elaborate on the educational value of the SGO, discuss its elements, and report on the practical implementation and preliminary results of research into, and with the SGO.

POS-SUN-F606 | Poster Presentation Traditional | Making Nuclear Magnetic Resonance Resonate with Students: Integrating NMR into the Undergraduate Curriculum

Presenting Author: Merideth Frey, Sarah Lawrence College

Additional Author | Colin Abernethy, Sarah Lawrence College

Additional Author | David Gosser, Sarah Lawrence College

Additional Author | Dedra Demaree, Blue Ridge School

Nuclear magnetic resonance (NMR) is an important tool used in the modern STEM workforce. The recent development of inexpensive benchtop NMR spectrometers offers great opportunities for undergraduate institutions to give their students relevant research skills with this essential tech-

nique. Through the support of an NSF-IUSE grant, we have established an interdisciplinary and cross-institutional team to develop, assess, and disseminate curricular material that integrates NMR into the undergraduate science curriculum. We have been developing and testing curricular materials consisting of lab modules and associated instructional guides and online resources. As we focus on dissemination in the coming year, we would like to assess the implementation of these materials and their effectiveness in different institutional environments, with or without direct access to an NMR system. If you or any faculty colleagues may be interested in implementing any of our materials, please scan the QR code on the poster for the contact form. The NMR curricular materials developed in this work are freely available at https://sites.google.com/view/makingnmr/home.

POS-SUN-F608 | Poster Presentation Traditional | Photoelectric Effect Lab Experience using Fixed Pairs of Light-emitting Diodes

Presenting Author: Samuel Sampere, Syracuse University

Additional Author | Eric A Schiff, Syracuse University

Light-emitting diodes (LEDs) are useful for creating an introductory lab experience that illustrates important features of the photoelectric effect as well as the properties of photodiodes. We have developed a simplifed implementation of this lab experience by exploiting the higher powers of low-cost LEDs. For our experience, six fixed pairs of aligned LEDs are used with differing colors: red-red, red-green, red-blue, green-green, green-blue, blue-blue. A variable low-voltage power supply and a minimal cost digital multimeter are needed in addition. The experiments confirm that only the blue diode will create photocurrents in all three LEDs used as absorbers. Green photodiodes create photocurrents in only the green and red LEDs, and a red photodiode creates a photocurrent only in a red LED. All of these are elementary aspects of the photoelectric effect. The experience also gives hands-on experience with the fact that an LED is both a source and a detector of light, as well as insight into the relationship of voltage and color.

POS-SUN-F610 | Poster Presentation Traditional | Advanced Laboratory Investigation of Particle Accelerator Magnetic Field Analogs via Experiment, Simulation, and Theory

Presenting Author: Kelley Sullivan, Ithaca College

Additional Author | Antara Sen, Northwestern University

Additional Author | M C Sullivan, Ithaca College

With exciting news continually reported from the LHC, including the recent conclusive experiment regarding the mass of the W boson, accelerator physics is of key interest to undergraduate students. We present a low-cost, versatile intermediate-to-advanced laboratory experiment that draws students in with the promise to learn more about accelerator magnetic fields. Students are kept engaged through adaptations that can focus exploration on CAD design and 3D printing, theoretical derivations, simulations to visualize and calculate the magnetic field, or experimental data-taking and analysis. Students investigate the behavior of magnetic fields exterior to the common quadrupole, octupole, and sextupole magnet configurations used in particle accelerators to guide and focus the beam path. In the far-field limit, the lowest order multipole term should dominate the magnetic field behavior, such that the magnetic field is proportional to 1/r^(l+2), where l is the multipole order. We find excellent agreement between theoretical, simulated, and experimental results that verify this expected behavior. Our apparatus is simple, and we encourage the use of Python to simulate the magnetic fields and Phyphox, a freely available smartphone app, to collect data. This ensures accessibility by keeping costs low and allowing for the laboratory to be completed remotely or in person.

TYC Poster Session

POS-SUN-A152 | Poster Presentation Traditional | OPTYCs CPDW Program – Year 3

Presenting Author: Thomas O'Kuma, Lee College

Co-presenting Author | Paul (Joe) Heafner, Independent Scholar

Co-presenting Author | Kris Lui, OPTYCs and AAPT

OPTYCs is The Organization for Physics at Two-Year Colleges (https://optycs.aapt.org). Part of the OPTYCs mission is to provide Continuing Professional Development Workshops (CPDW) and Tandem Meetings for TYC physics faculty across the country. In this poster, we will summarize the workshops that occurred during year 3 so far. We will also highlight workshops at the current meeting, any currently scheduled future workshops and the 2025 Tandem Meeting. We will also invite TYC physics colleagues and others to submit ideas for workshop content (https://optycs.aapt.org/user/Contact.cfm). CPDW is open to all with an emphasis for TYC faculty. OPTYCs is supported by NSF-DUE-2212807.

POS-SUN-A154 | Poster Presentation Traditional | Physics and Engineering Collaboration in Research-Based Learning

Presenting Author: Jennifer Grote, Illinois Central College

Co-presenting Author | Vijayalakshmi Varadarajan, Illinois Central College

At Illinois Central College, a two-year undergraduate institution, Physics and Engineering disciplines have been employing Research-Based Learning strategies and collaborating between disciplines to improve student learning through these strategies. This study explores the effectiveness of Research-Based Learning methods in enhancing student learning across different disciplines. Specifically, it examines how students in an introductory engineering course and an introductory physics course engage with and benefit from research projects. Student research projects were tailored to enhance student motivation, knowledge organization, and goal-directed application of skills. Instructors provided focused feedback to help students adjust learning approaches and become self-directed learners. Student projects utilized resources provided by the NASA Community College Network (NCCN) initiative. The poster will discuss the performance outcomes of students involved in these Research-Based Learning activities and analyze the impact of this approach on their learning experiences.

POS-SUN-A156 | Poster Presentation Traditional | Supporting new TYC faculty with OPTYCs New Faculty Development Series– Cohort 2

Presenting Author: Krista Wood, University of Cincinnati Blue Ash
Additional Author | Brooke Haag, Pathstream
Additional Author | Dwain M Desbien, Estrella Mountain Community College
Additional Author | Tom O'Kuma, Lee College

The Organization for Physics at Two-Year Colleges (OPTYCs) and American Association of Physics Teachers (AAPT) present a 16-month experience designed specifically for Two-Year College (TYC) Physics Faculty in their first six years of TYC teaching. This New Faculty Development Series (NFDS) will support new TYC physics faculty incorporating student-centered active learning, and research-based instructional strategies. NFDS is an exceptional opportunity that provides new TYC Physics Faculty (1) a foundation in Physics Education Research (PER) with online discussions, (2) a 3-day Immersion Conference to engage in PER-based instructional and inclusive strategies, (3) online mentoring throughout the implementation phase, and (4) a 2-day Commencement Conference in conjunction with a National AAPT Conference. Cohort 2 will be Spring 2025 – Summer 2026. This NSF-funded program provides a community to support you and travel funding for the Immersion and Commencement Conferences!

This project is supported by AAPT and funded by NSF-DUE-2212807.

POS-SUN-A158 | Poster Presentation Traditional | What's New with the PICUP Initiative

Presenting Author: Andrew Morrison, Joliet Junior College
Additional Author | Marcos D. Caballero, Michigan State University
Additional Author | Larry Englehart, Francis Marion University
Additional Author | Walter Freeman, Syracuse University
Additional Author | Rachel L. Ivie, American Association of Physics Teachers
Additional Author | Marie Lopez del Puerto, University of St. Thomas

The Partnerships for Integrating Computation into Undergraduate Physics (PICUP) initiative aims to enhance computational education in undergraduate physics programs. This comprehensive project provides workshops, webinars, and community-building activities to support faculty in integrating computational methods into their teaching. Project activities that are of interest to physics educators include: Distributed Institutes for Computational Education (DICE) workshops, Summer Leadership Institutes for Computational Education (SLICE) workshops, demonstration workshops at national meetings, virtual workshops, webinars, and a virtual capstone conference. Through these activities, the PICUP initiative is building a sustainable, inclusive community of educators dedicated to integrating computation into undergraduate physics curricula.

QM Quantum Activities for the Classroom

Location: Regency Ballroom A&B Time: 11 am–12 p.m. Date: Monday, January 20, 2025 Moderator: Jason Sterlace

QM-01 10:12 AM-10:24 AM | Interactive (e.g. panel, round table discussion, hands-on activity) | Heisenberg's Laser

Presenting Author: Kenneth Cecire, University of Notre Dame
Additional Author | Michael Wadness, Medford High School

Using little more than a laser pointer and some vernier calipers, teachers and students can empirically demonstrate and derive the Heisenberg Uncertainty Principle. We will look at how it works and actual experimental results. This laboratory activity is suitable for high school and undergraduate physics classes.

QM-02 11:24 AM - 11:48 AM | Interactive (e.g. panel, round table discussion, hands-on activity) | Intuitive Quantum Activities for Secondary School Classrooms

Presenting Author: Luis Mendoza, Fermilab

In recent years there has been an increased interest in the development of the field of Quantum Information Science (QIS); this field uses the laws of quantum mechanics for storing, transmitting, manipulating, and measuring information. To aid in the development of this field it is important to start introducing concepts of QIS at the middle and high school levels. With this goal in mind it is necessary to develop further resources at the middle and high school levels. In this session we will showcase some hands-on activities developed at Fermilab to help introduce the concepts of measurement, superposition, and entanglement to middle and high school classrooms and work to see how these activities could be integrated into a science curriculum. These same activities can also be used in an introductory quantum mechanics course for undergraduate students.

E1: Frontiers of Quantum Research 1: Quantum Sensing and Measurement

Location: Grand Ballroom A **Time:** 1:30–2:20 p.m. **Date:** Monday, January 20, 2025 **Moderator:** Nathan Powers

E1-01 1:30 PM-1:54 PM | | Quantum diamond sparkles

Presenting Author: Chong Zu, Washington University

Diamond is not just a perfect gemstone. The tiny imperfections inside diamond can be turned into ultrasensitive nanoscale quantum sensors which can offer brand-new lenses to see through intricate phenomena spanning from atomic and molecular objects to events on a grand scale. In this talk, we will start with an overview of quantum sensing technologies based upon spin defects (e.g. nitrogen-vacancy centers) in diamond. We will then discuss our recent efforts at WashU to employ these diamond sensors for a wide range of applications covering condensed matter physics, biomedical imaging and geoscience. If time permits, we will present some of our results on developing a new generation of quantum sensors beyond diamond, specifically in two-dimensional materials.

E1-02 1:54 PM-2:18 PM | | Quantum sensing with time travel

Presenting Author: Kater Murch

Could it be possible to send a quantum sensor back in time with the optimal settings in hindsight? That could be very useful if you wanted to orient a telescope in the right direction, or more simply orient a spin to be pointing in the right direction to get the maximum possible rotation from some previously unknown magnetic field. Turns out the answer is yes, due to a mathematical equivalence between closed timelike curves - hypothetical chronology-violating trajectories of particles allowed by general relativity - and certain algorithms for manipulating quantum entanglement. I'll explain our experiments that demonstrate this fascinating connection and how we can optimally set the orientation of a detector in hindsight and effectively send it back in time.

E2: Supporting Students and Faculty: TYCs

Location: Grand Ballroom B **Time:** 1:30–2:20 p.m. **Date:** Monday, January 20, 2025 **Moderator:** Wayne Manrakhan

E2-01 1:30 PM-1:42 PM | Contributed Talk (12 Minutes) | Launching Knowledge: Engaging Non-Physics Students in a Hands-On Rocket Lab Experience

Presenting Author: Jonathan Engelman, Kettering College

This hands-on rocket lab is designed for students enrolled in a one-semester introductory college physics course and can be adapted for higher level courses. The activity provides a practical application of fundamental physics concepts such as Newton's laws of motion, conservation of energy, and basic mechanics. By building and launching small model rockets up to 1000 feet in the air, students directly engage with the principles they study in the classroom, deepening their understanding through real-world experience. The lab activity emphasizes collaboration, problem-solving, and critical thinking, allowing students to experience the scientific process from hypotheses to experiment and analysis. Throughout the semester, students learn how to calculate trajectories, altitudes, energy, and forces that may be in play during a rocket's flight. The culmination of the lab involves a final launch day, where students choose one of three motors, launch their rocket with an altimiter to gather data, collect their rocket, and then make calculations based on altimeter data. This activity not only reinforces key concepts but also inspires students by connecting theoretical knowledge to tangible, exciting outcomes. The experience is taylored to non-physics/engineering majors, offering an accessible yet challenging introduction to the practical side of physics.

E2-02 1:42 PM-1:54 PM | Contributed Talk (12 Minutes) | Enhanced student support in introductory Physics courses motivated by OPTYCs Leadership Institute

Presenting Author: Wayne Manrakhan, Harford Community College

The OPTYCs Leadership Institute (LI) was created to develop the next generation of two-year college physics faculty leaders. I was selected as a member of the first cohort of this program and participated in the first Summit during the 2024 AAPT Winter Meeting. The training and feedback from mentors resulted in the design of a Leadership Project based on enhancing curriculum and student support in the non-calculus introductory physics courses I teach. This includes adapting OER materials for the courses and designing active learning assignments based on my core leadership strengths. I also instituted holding some of my semester's office hours at the college's Learning Center and plan on using peer tutors during discussion sessions in Spring 2025. I will report on the efficacy of these changes and evaluate feedback from students.

E2-03 1:54 PM-2:06 PM | Contributed Talk (12 Minutes) | A Mathematician Teaches Gen-Ed Algebra-Based College Physics: Challenges, Successes, Observations

Presenting Author: Chris Oehrlein, Oklahoma City Community College

Since returning to campus after the pandemic, and even in the few years before, it was difficult to find adjuct physics professors who were willing and could teach on-campus courses during the day. What happened when a mathematics professor, who normally taught calculus, differential equations, and statistics, was asked to teach the algebra-based, non-majors Physics I? What challenges did the professor encounter? What techniques from the math courses were successful in the physics course? What other observations did the professor have about the similarities and

differences between math and physics courses, about the structure of a general education physics course with a lab, and about the relationship between modern college math pathways and general education physical science courses?

E2-04 2:06 PM-2:18 PM | Contributed Talk (12 Minutes) | Fostering student inquiry through CUREs

Presenting Author: Chitra Solomonson, Green River College

Students who participate in undergraduate research experiences (UREs) improve their academic performance and professional skills, and more strongly identify with and persist in STEM disciplines1. In fact, URE participation is more reliably correlated with college completion than most other "high impact" practices advised for postsecondary institutions2. UREs especially benefit students from populations that are historically underrepresented in our STEM workforce. Course-based undergraduate research experiences (CUREs) are a well-established means to deliver UREs at community colleges, where faculty members are expected to devote most of their time to traditional classroom instruction and thus do not have time to mentor undergraduates in extra-curricular projects. In addition, introducing research in the classroom ensures that all students are given the opportunity to pursue a research question. This talk will focus on the preliminary CUREs (pre-CUREs) developed in the Calculus-based Physics sequence. In a pre-CURE, students ask their own question and work in teams to answer the question. The CUREs get progressively more complex through the three-quarter sequence. During the last quarter, students have fabricated their own organic solar cells and compared the relative efficiency of these cells. The talk will also describe the ongoing efforts in the state of WA to build undergraduate research in the curriculum.

1.Gentile, J., Brenner, K., & Stephens, A. (Eds.) (2017) Undergraduate research experiences for STEM students: Successes, challenges, and opportunities. Washington, DC: The National Academies Press.

2. Johnson, S.R. & Stage, F.K. (2018). Academic engagement and student success: Do high-impact practices mean higher graduation rates? The Journal of Higher Education, DOI: 10.1080/00221546.2018.1441107.

3. This work is funded by NSF awards 1141339, 2307048 and 2212807.

E3: PICUP: Ideas for Integrating Computation into Physics Courses

Location: Grand Ballroom C **Time: 1:30–2:20 p.m.** **Date: Monday, January 20, 2025** **Moderator: Doug Petkie**

E3-01 1:30 PM-1:42 PM | Contributed Talk (12 Minutes) | PICUP's 5-year plan to help YOU integrate computation into your Physics course

Presenting Author: Marie Lopez del Puerto, University of Saint Thomas

Co-presenting Author | Andrew Morrison, Joliet Junior College

In this talk we will share PICUP's 5-year plan to grow and sustain the community of faculty engaged in integrating computation into their Physics courses. We will conduct regional workshops at locations around the country and an annual national Summer Leadership Institute for Computational Education in Physics (SLICE). We will report on two regional workshops that were conducted in Fall 2024 in Chicago and the Twin Cities, and present details on the first SLICE which is planned for Summer 2025.

This project is supported in part by NSF grants DUE-2337052 and DUE-2337054.

E3-02 1:42 PM-1:54 PM | Contributed Talk (12 Minutes) | Integrating Computation Through Coding as a Calculator

Presenting Author: Aaron Titus, North Carolina State University

Additional Author | Ruth Chabay, North Carolina State University

Additional Author | Bruce Sherwood, North Carolina State University

Additional Author | Steve Spicklemire, University of Indianapolis

If a teacher or department wants to integrate computation into a physics course, how should they do it? We suggest starting by teaching students to write code for all calculations for in-class activities, homework, and exams. This has the following advantages over a calculator: (1) students can find and fix errors without repeating all the steps in the calculation; (2) students define variables and write calculations symbolically; (3) students quickly become comfortable writing, reading, and debugging code; and (4) students believe they can code and believe it is relevant to the course. A significant key for students adapting this new way of doing calculations is to allow them to use it for tests. We will make recommendations, including how to securely allow VPython as a calculator on tests.

E3-03 1:54 PM-2:06 PM | Contributed Talk (12 Minutes) | Revolutionizing Physics Education with SIMPHY

Presenting Author: Themistoklis Chronis, University of Alabama in Huntsville, Department of Physics and Astronomy

Additional Author | Mahesh Kurmi, SIMPHY

Traditional teaching methods in undergraduate and high school physics often struggle with concept visualization and employ abstract and disengaging methodologies. Additionally, limited access to real-world experimentation due to costs, safety protocols, and time constraints exacerbates these challenges. Over approximately seven years, Mr. Mahesh Kurmi and the SIMPHY team (https://simphy.com) have developed a unique platform that directly addresses and overcomes the inherent problems in teaching e.g. Newtonian mechanics, circuitry, electromagnetism, and geometrical optics. Using SIMPHY, instructors can create tailored simulations that match their specific learning objectives, without any knowledge of coding. For more complex needs, simulations can also be created using SIMPHY's dedicated editor that supports JavaScript. SIMPHY is available on Windows, MacOS, and Linux-based operating systems. In addition, Dr. Chronis of UAH has also successfully implemented SIMPHY in all UAH in-person and online physics laboratory sessions. This allows students to not only study actual hands-on experiments from a distance but also to gradually introduce more complex scenarios through SIMPHY. All these simulations can be shared via the default SIMPHY file format or through an API. For more information visit (https://simphy.com) or contact@simphy.com For SIMPHY-related Physics curriculum design and support Dr. Themis Chronis tc0025 at uah.edu

E3-04 2:06 PM-2:18 PM | Contributed Talk (12 Minutes) | Transforming Physics Education with a Collaborative Research Approach: A Case Study on Air Pollution

Presenting Author: Rudra Aryal, Franklin Pierce University, Rindge, NH
Additional Author | Brett Nutting, Franklin Pierce University, Rindge, NH
Additional Author | Isabella Williams, Franklin Pierce University, Rindge, NH
Additional Author | Angel Gomez, San Jacinto College South, Houston, TX
Additional Author | Madhu Gyawali, San Jacinto College South, Houston, TX

This study explores the impact of collaborative learning to improve physics education through a project focused on aerosol data analysis. Students from a general physics course analyzed NASA's Aerosol Robotic Network (AERONET) data at four Houston-area stations: University of Houston, Dragon_Clinton, Dragon_Deer_Park, and Dragon_Searook Park. The time series of aerosol optical data is compared with the nitrogen dioxide (NO2) records, which are in-situ surface measurements from the US Environmental Protection Agency (EPA) Air Quality System. The project involved creating graphical abstracts, writing research articles, and examining interactions between solar radiation and aerosols. Students from Franklin Pierce University, NH, and San Jacinto College South, TX, collaborated, developing critical problem-solving skills and enhancing their understanding of aerosol particle dynamics, including scattering, absorption, and size distribution. This interdisciplinary approach provided insights into seasonal variations and sources of aerosols, bridging physics concepts with environmental science. Students improved their research and mathematical proficiency by collaborating on scientific writing, data analysis, and working with others, enhancing their academic growth. The collaborative, analytical, and research-based project assigned to students stimulated their enthusiasm and interest in physics as they gained confidence in presenting their findings. These results demonstrate that incorporating additional real-world projects into the physics curriculum can deepen students' comprehension and motivation.

E4: AI in Physics Education

Location: Grand Ballroom D Time: 1:30–2:20 p.m. Date: Monday, January 20, 2025 Moderator: Steve Spicklemire

E4-01 1:30 PM-1:54 PM | | From Analogies to Assessments: Using AI in teaching and learning of Physics

Presenting Author: Amogh Sirnoorkar, Purdue University

Generative Artificial Intelligence (AI) has recently garnered significant attention due to its remarkable ability to engage with multimodal data and generate sophisticated responses. In light of these capabilities, educators are increasingly exploring how this technology can revolutionize classroom learning. In this talk, I will provide an overview of the latest research trends on the use of AI in physics education, highlight practical strategies for integrating AI into physics classrooms, and discuss the ethical implications of AI in educational environments. Drawing from my ongoing work, I will share examples such as the development of "three-dimensional learning assessments" using prompt engineering, how AI can help students create analogies for complex concepts, and the features of scientific inquiry in AI-generated responses.

E4-02 1:54 PM-2:06 PM | Contributed Talk (12 Minutes) | The Creation of an Asynchronous Modern Physics Course: Preliminary Results

Presenting Author: Clifton Massey-Noel, The University of Texas at Arlington
Additional Author | Atharva Dange, The University of Texas at Arlington
Additional Author | Ramon Lopez, The University of Texas at Arlington

Prior research performed by the physics education group at The University of Texas at Arlington has validated the use of active learning techniques and the 'flipped' classroom modality in a Modern Physics course. The new prevalence of remote learning tools makes asynchronous lectures more practical, and generative AI (i.e., ChatGPT) may be used to emulate peer-to-peer interaction. We assess whether these advances may be leveraged to make asynchronous learning at least equally as effective as a traditional lecture version of this specific course. We will discuss the development of a fully online asynchronous Modern Physics course, deployed entirely through Canvas, with custom questions generated using ChatGPT. Preliminary results from the asynchronous course are discussed, with an emphasis on how course modality affects student performance and satisfaction. The deployment of an OpenAI custom GPT 'chatbot', and an evaluation of its effectiveness, are described in a companion presentation.

E4-03 2:06 PM-2:18 PM | Contributed Talk (12 Minutes) | Investigating the Role of Generative AI in Enhancing Student Engagement and Performance in an Asynchronous Physics Course.

Presenting Author: Atharva Dange, University of Texas at Arlington
Co-presenting Author | Clifton W. Massey-Noel, University of Texas at Arlington
Additional Author | Ramon E Lopez, University of Texas at Arlington

The use of asynchronous online learning in physics courses demands innovative approaches to maintain student engagement and improve learning outcomes. This study explores the use of Generative AI (GenAI) in an asynchronous Modern Physics course to enhance student problem-solving and academic performance by integrating GenAI tools into the course. The first use is to develop questions for homework and practice exams using Student Learning Objectives (SLOs) to ensure alignment with course goals. The process involved editing the AI-generated questions for accuracy and clarity. Second, we created Study Buddy Bot (an AI trained on modern physics content and common student misconceptions) to simulate student-like interactions and have aimed to simulate a peer-to-peer experience, helping students engage more deeply with the content. We will present preliminary findings on how these tools impact student engagement and performance, with a focus on AI's potential to improve learning outcomes in virtual environments.

E5: Women+ and Gender Minorities in Physics: A Roundtable Discussion

Location: Regency Ballroom A&B Time: 1:30–2:20 p.m. Date: Monday, January 20, 2025 Moderator: Sarah Johnson

Come to this roundtable discussion about women+ and gender minorities in the field of physics. This will be a "safe space" for women+ and gender minorities to come together to discuss their lived experiences, barriers they have encountered, and how they have persevered. We hope that this chance to speak with others especially helpful for those that may be the only woman+ or gender minority in their departments, programs or labs.

E6: Teaching the Introductory Physics for Life Sciences (IPLS) Course

Location: Regency Ballroom C Time: 1:30–2:20 p.m. Date: Monday, January 20, 2025 Moderator: Juan Burciaga

E6-01 1:30 PM-1:54 PM | | Introducing mathematical modeling in the life sciences: from the whiteboard to the bench

Presenting Author: Shankar Mukherji, Washington University in St Louis

Among the greatest shifts in the modern life sciences is the rapid adoption of computation and theory to achieve insight into the inner workings of complex biological and biomedical phenomena. The tools now finding their way into disciplines ranging from molecular biology to the clinic span from purely statistical methods to the building of mechanistic models to capture biological interactions at diverse length and complexity scales. It is incumbent on us to prepare both life and physical science students to be able to tackle these quantitative problems at the interface of biology and physics. Here I will describe recent efforts we have taken to introduce both core physics concepts, typically but not exclusively from statistical mechanics and thermodynamics, and more general mathematical modeling techniques to undergraduates both in formal lecture-style class settings as well as alongside demanding biophysical experiments. I hope to catalyze discussion on the best way to balance teaching to a room made up of biologists, physicists, and engineers that both fosters rigor while still maintaining the high levels of enthusiasm that students in these diverse disciplines have for reaching across disciplinary boundaries.

E6-02 1:54 PM-2:18 PM | | Enabling students to achieve successful careers in Medical Physics

Presenting Author: Michael Altman, Washington University in St. Louis

Medical physics is a multi-disciplinary field combining elements of medicine, physics, engineering, with careers in clinical, academic, industrial, and/or regulatory settings. The field can appeal greatly to physics students who seek ways to use their talents and skills to directly help people and see the positive impact of their work with more immediacy. However, many students who may be interested in entering the field do not learn about the it until very late in their academic training. This can leave students who would otherwise find the field compelling without requirements, skills, and experiences to facilitate them being able to pursue the field further. Accredited medical physics graduate programs, increasingly the primary entrance pathway to the field, are frequently small and have become increasingly selective and competitive. Providing students a strong foundation to make them compelling candidates for medical physics programs can be pivotal to their success in finding a pathway to the field. This foundation includes both helping students gain a basic awareness and understanding of the field as well as to know what skills and experiences they can pursue at both the high school and collegiate levels to make themselves highly competitive candidates for medical physics programs.

E6-03 2:18 PM-2:30 PM | Contributed Talk (12 Minutes) | Measuring soil respiration: High-tech and low-tech

Presenting Author: Spencer Perry, Indiana University

While soil respiration is typically discussed as part of life science courses, it can also serve as a launch point and/or anchoring phenomenon for teaching physics. These might include conservation of matter, energy flow, and as a critical component of carbon sequestration when discussing climate change. This hands-on poster presentation will show two methods of measuring soil respiration flux using resources available in many science departments. One method will be high-tech and the other will be low-tech.

F1: Frontiers of Quantum Research 2: Quantum Materials

Location: Grand Ballroom A Time: 2:30–3:20 p.m. Date: Monday, January 20, 2025 Moderator: Nathan Powers

F1-01 2:30 PM-2:54 PM | | Atomically Thin, Infinite Possibilities: The World of 2D Materials

Presenting Author: Xi Wang, Washington University in St Louis

Two-dimensional (2D) van der Waals materials, with their atomic-scale thickness, provide a unique platform for exploring and engineering novel quantum materials. By stacking and twisting these layers, we can create heterostructures exhibiting exotic electronic, optical, and magnetic phenomena not observed in bulk materials. Our research group investigates the fundamental properties of 2D materials and develops strategies to fabricate and characterize novel quantum materials. We are particularly interested in exploring their potential for quantum optoelectronics and topological quantum materials. By harnessing the versatility of 2D materials, we aim to contribute to the advancement of quantum technologies and revolutionize fields such as electronics, energy, and information science.

F1-02 2:54 PM-3:18 PM | | Strongly correlated topological materials

Presenting Author: Sheng Ran, Washington University in St Louis

Quantum materials with both strong correlations and nontrivial band structure topology can have novel physics properties that do not exist in the non-correlated counterparts. Kondo lattice systems have emerged as promising platforms for such strong correlated topological systems. In this talk, I will present our recent experimental exploration along this direction. In one case, we found intrinsic anomalous Hall effect that seems to break the Fermi liquid scaling relation. In another case, we have discovered a candidate for topological Kondo insulator.

F2: Culture-based Approaches to Physics Education – Part 1

Location: Grand Ballroom B Time: 2:30–3:20 p.m. Date: Monday, January 20, 2025 Moderator: Clausell Mathis

F2-01 2:30 PM-2:54 PM | | Contesting the boundaries of physics teaching: What it takes to transform physics education toward justice-centered ends

Presenting Author: Jasmine Jones, University of Illinois at Chicago

The underrepresentation of Black Americans in physics has been persistent for so long that it seems to have constrained physics educators' collective imagination when it comes to conceptualizing and pursuing equity in physics teaching and learning. Drawing on a teacher research study that foregrounds justice-centered physics teaching, this research pushes past the "equity as access" narrative toward more expansive visions of equity and justice by reimagining physics education as a liberatory praxis. Accordingly, this study explores the complexities that emerged while expanding the boundaries of physics learning to embrace a justice-centered curriculum through a Youth Participatory Science (YPS) project. Taught in the context of a freshman physics course at an urban public high school, this YPS project engaged students in designing solar energy systems for an African-American community historically harmed by environmental racism. Specifically, this study investigates the ways in which canonical physics knowledge dialectically interacts with interdisciplinary knowledge throughout the defining, investigating, and intervening phases of the YPS cycle. The critical understandings constructed from this study frame what it takes to repurpose physics teaching and learning for environmental justice, specifically emphasizing the agentic pedagogical and curricular decisions teachers must negotiate to transform physics education for liberatory purposes.

Jones, J. (2024). Contesting the boundaries of physics teaching: What it takes to transform physics education toward justice-centered ends. Science Education, 1–19. https://doi.org/10.1002/sce.21862

F2-02 2:54 PM-3:18 PM | | Researcher and Teacher perspectives on integrating cultural resources in physics learning through formative assessments

Presenting Author: Andrea Wooley, Michigan State University

Co-presenting Author | John Kelly, Tennessee State University

Additional Author | Clausell Mathis, Michigan State University

Additional Author | Ian Neuhart, Michigan State University

Existing studies on transforming physics classrooms to include student culture have focused on pedagogy, curriculum and teacher identity. We aim to direct our focus towards students by developing formative assessments that prompt students to use their cultural resources as they relate to the physics concepts covered in class. Assessment items were administered to students in calculus based introductory physics classes at a HBCU and written responses were collected. We analyze student responses to identify their use of cultural resources, conceptual understanding and epistemological stances that allow them to bridge between their personal culture and physics culture. In this presentation, a lead researcher will discuss the assessment development process and analysis of select student responses to assessment items. A teacher/researcher will discuss their own motivation for implementing these changes, their impressions of how students' thinking has shifted, and how their instruction has developed over the course of this study.

F3: PICUP: Integrating Computation and Experiment

Location: Grand Ballroom C Time: 2:30–3:20 p.m. Date: Monday, January 20, 2025 Moderator: Marie Lopez del Puerto

F3-01 2:30 PM-2:42 PM | Contributed Talk (12 Minutes) | Singing Buddha Bowls and Wine Glasses: Modal Analysis of Found Objects

Presenting Author: Duncan Carlsmith, University of Wisconsin-Madison

Learn how to scan a singing Buddha bowl or wine glass with your phone and perform modal analysis, and then "play it."

F3-02 2:42 PM-2:54 PM | Contributed Talk (12 Minutes) | Integrating Computation with MicroPython and sensors

Presenting Author: Zengqiang Liu, Saint Cloud State University

MicroPython is a version of Python that runs on microcontroller boards, small electronic boards that work like a computer but with much smaller sizes and much less onboard resources. Besides not requiring installing Python on a computer to run Python, you can connect a MicroPython board to all kinds of sensors that you can't with a computer. This makes learning the Python programming language a fun journey alongside with hands-on learning of basic sensors and electronics. MicroPython runs on a number of common microcontroller platforms, which makes it very

easy to get one's hands on. Before making a selection though, one may need to weigh the pros and cons of each platform. I will introduce MicroPython and a number of popular microcontroller boards that run MicroPython. Then I will discuss how to choose a MicroPython board based the level of support, the amount of onboard resources, cost, and any specific project needs. I will also discuss how an instructor might integrate computation with MicroPython in lectures and labs.

F3-03 2:54 PM-3:06 PM | Contributed Talk (12 Minutes) | Enhancing the e/m Experiment with Simulation

Presenting Author: Karen Camarda, Washburn University

Additional Author | Brian Thomas, Washburn University

In a common experiment done in undergraduate labs, students calculate the charge-to-mass ratio of the electron by measuring the diameter of electrons' circular trajectory in the magnetic field between a pair of Helholtz coils. Several approximations are made in the calculation, including the magnetic field the electrons move in, and ignoring the width of the Helmholtz coils. We have developed a Python program to simulate the experiment that allows students to explore the effects of these approximations. We will report on our experience having students use the code to better understand the sources of error in this laboratory exercise.

F3-04 3:06 PM-3:18 PM | Contributed Talk (12 Minutes) | Integrating Computation and Experiment: Coupled Oscillators with Smart Carts

Presenting Author: Nicholas Nelson, California State University, Chico

Contemporary physics is generally done via a collaborative combination of mathematical and physical theory, laboratory experiment and techniques, and computational analysis and modeling. Upper-division physics courses have traditionally been siloed into only one of these three categories. The integration of these three pillars of science has been recognized as highly valuable, yet is not often done. The ICEP (Integrating Computational and Experimental Physics) project seeks to enable this integrating. Here we present a low cost, accessible module for a junior/senior-level classical mechanics course which provides a numerical and experimental integration to the standard analytical exploration of coupled harmonic oscillators. Using Smart Carts, springs, and an inclined track we demonstrate the ability to observe normal modes of oscillations for arbitrary arrangements of spring constants and masses, which can be calculated numerically using eigenvalue and eigenvector packages commonly available in most linear algebra libraries.

F4: 21st Century Physics and Astronomy in the Classroom – Part 1

Location: Grand Ballroom D Time: 2:30–3:20 p.m. Date: Monday, January 20, 2025 Moderator: Shane Wood

F4-01 2:30 PM-2:42 PM | Contributed Talk (12 Minutes) | Signal Extraction and Noise / Pressure Correction in Cosmic Ray Flux Analysis During CME Events

Presenting Author: Kristian Qirko, New Trier

Additional Author | Monika Alfredeen

Additional Author | Anna Halwax

Additional Author | Rex Paster

Additional Author | Evangeline Selking

Additional Author | Zoya Siddiqi

Our study was conducted using ten detectors located around the United States, and we have been collecting cosmic ray flux data since 2018. Six detectors are in IL, two are in Hawaii, one is in South Dakota, and one is in Minnesota. We focused on the coronal mass ejection (CME) event from May 10-12, 2024. In preparation for the analysis, we reduced noise by correcting for the effects of barometric pressure on flux. The pressure corrections employed measurements during a quiescent period in April. We applied the corrected flux to the May event. Noise-corrected results

F4-02 2:42 PM-2:54 PM | Contributed Talk (12 Minutes) | The Characterization of Cosmic Ray Muon Flux Changes Due to Coronal Mass Ejections

Presenting Author: Zoya Siddiqui, Downers Grove South High Schookl

Co-presenting Author | Evangeline Selking, Downers Grove South Highschool

Additional Author | Rex Paster, Rochelle Zell Jewish High School

Additional Author | Kristian Quirko, New Trier High School

Additional Author | Sydney Stapleton, Downers Grove South High School

Additional Author | Maya Zacks, New Trier High School

This study explored the change in cosmic ray muons flux by global Quarknet detectors, following the coronal mass ejection (CME) events of May 2024. These events showed significant changes from the normal constant muon flux levels. We analyzed the onset time and recovery of flux to the baseline values before the CME events. The structure of the recovery was noted. Insights from our analysis aim to enhance our understanding of muon flux behavior during CME events.

F4-03 2:54 PM-3:06 PM | Contributed Talk (12 Minutes) | My introduction to the NASA HEAT Project as a novice astrophysist

Presenting Author: Jeff Hengesbach, Estrella Mountain Community College

Having become a NASA HEAT ambassador in spring 2024, this talks shares some of my experiences related to the NASA Heliophysics Education Activation Team (NASA HEAT). It is a program providing resources to learners of all ages, including a Framework for Heliophysics Education

and a Heliophysics Resource Database. This extensive database is organized to help guide educators in finding everything they need to bring curated heliophysics resources, including NASA data, videos, activities, lesson plans and more, into a variety of learning spaces. As a novice astronomer and astrophysist, this talk seeks to inform others of the resources and opportunities available through this program.

F5: Interactive: Technology in the Physics Classroom

Location: Regency Ballroom A&B Time: 2:30–3:20 p.m. Date: Monday, January 20, 2025 Moderator: Bob Brazzle

F5-01 2:30 PM-2:54 PM | Interactive (e.g. panel, round table discussion, hands-on activity) | Beyond the Textbook: Redefining Physics with AR/VR Adventures

Presenting Author: Nicole Heaver, Ottawa Elementary School District

Dive into the transformative power of augmented and virtual reality (AR/VR) in revolutionizing physics education. In this session, our panel of experts will showcase immersive, lifelike lab experiences that enhance student learning while addressing the limitations of traditional classrooms. This session will highlight the implementation of AR/VR in middle and high schools to deliver evidenced-based instruction resulting in increased student engagement, motivation, and academic achievement. Explore innovative, student-centered activities that make complex and often dangerous or expensive concepts—from refraction simulations to satellites in circular orbit to laws of motion —safe and engaging. Discover how AR/VR supplements existing K-12 physics curriculum, making learning both interactive and unforgettable.

F6: IPLS Poster Session

Location: Regency Ballroom C Time: 2:30–3:20 p.m. Date: Monday, January 20, 2025 Moderator: Juan Burciaga

Poster Presentation Traditional | IPLS Students Visualizing Forces and Torque Parameters

Presenting Author: Nancy Beverly, Mercy University

IPLS students preparing for careers in professions that use biomechanics such as physical therapy, kinesiology, or exercise science, need to be able to visualize the forces that act on the body, particularly involving muscle torque, in diverse scenarios. For example, in the traditional course, students are provided with pictures of forces and lever arms from which they calculate some unknown quantity. A more effective transfer is achieved with the addition of the initial skill of visualizing the forces and lever arms for themselves. It turns out that visualizing torque forces and lever arms on the human body is challenging for most students. Curricular materials have been developed that provide student practice and assessment of this skill.

Poster Presentation Traditional | Post Secondary IPLS Student Understanding of a Bouncing Ball

Presenting Author: Dan Young, University of Delaware

Additional Author | Liam McDermott, University of Connecticut

Additional Author | Andrew Mason, University of Central Arkansas

Additional Author | Rebecca Lindell, Tiliadal STEM Education: Solutions for Higher Education

Understanding why a ball bounces may seem easy to students; however, they often struggle to accurately predict what will happen in the system. The ball-bouncing system presents a challenge for students, especially ones for whom creating toy models is new, as this system is one which they most likely will have prior experience and expectations for the results. As part of a larger study, we asked nearly 70 students in introductory physics for life sciences classes to answer the following question: when you drop ball and let it bounce, how high does it bounce? In this poster, we present the results of thematic analysis of these student responses and detail the complex learning mechanisms which come from examining a relatively “simple” problem.

G1: Innovation in the Physics Classroom

Location: Grand Ballroom A Time: 3:30–4:20 p.m. Date: Monday, January 20, 2025 Moderator: Bob Brazzle

G1-01 3:30 PM-3:42 PM | Contributed Talk (12 Minutes) | Seeing Virtually: An Exploration into Teaching E&M in Augmented Reality

Presenting Author: Matthew Anderson, San Diego State University
Additional Author | Janet Bowers, San Diego State University
Additional Author | Dustin Thoman, San Diego State University
Additional Author | Elizabeth Flynn, San Diego State University
Additional Author | Adrian Larios, San Diego State University
Additional Author | India Wishart, San Diego State University

We are researching the use of augmented and virtual reality for teaching physics concepts in three dimensions: electric fields, magnetic fields, and electromagnetic waves. One reason that students struggle in introductory physics classes is that certain conceptual phenomena are difficult to visualize and manipulate in one's mind. For example, vector fields, the right-hand rule, solenoids, and electromagnetic waves are challenging concepts in their own right and even more so when presented using static, two-dimensional imagery. We hypothesize that students' understanding for these topics will be enhanced if they are able to interact with objects in a virtual 3D environment. We have developed three such environments in which students are able to view the phenomena from multiple angles, interact with components to explore parameters of the model, and, most importantly, converse with other students or an instructor who is also interacting within the environment. The physics and education researchers from SDSU have partnered with Altoura, whose innovative platform enables us to create collaborative experiences during which students can digitally interact with realistic, 3-D renderings of E&M physics phenomena. We will do a live demo and discuss our current findings. The presentation will focus primarily on the tech innovation of teaching with virtual reality, and less so on the physics education research results. I will present the augmented reality live, but also be available after the talk for hands-on demos. This seems very well suited for the "Innovation in the physics classroom" topic for this winter meeting. (I will also likely present the education results more fully at the next PER meeting.) Thanks for your consideration.

G1-02 3:42 PM-3:54 PM | Contributed Talk (12 Minutes) | Spacetime effects here on Earth: Moving beyond global time

Presenting Author: Phil Fraundorf, University of Missouri at Saint Louis

We make the case here that we live in a very relativistic world, with for example: (a) car speedometers that register proper-velocity with no lightspeed upper limit, (b) inertial, centrifugal & gravitational forces linked to differential-aging, and of course (c) magnetism, powered by length-contraction, that makes electric motors & even light possible. If you use or experience any of these things, your world is being colored by an everyday link between space & time. Moreover use of "traveler-point variables", like frame invariant proper time τ, proper-acceleration α, and synchrony-free proper-velocity $w \equiv \delta x/\delta\tau = \gamma v$, open up a way to quantify high-speed kinematics (including acceleration) and dynamics (including local "geometric forces") in terms of physical units that naturally recognize the local distinction between space and time, and are especially easy to apply with one space & one time dimension.

G1-03 3:54 PM-4:06 PM | Contributed Talk (12 Minutes) | Vivan's travelogue: Tales told by an interstellar traveler.

Presenting Author: Phil Fraundorf, University of Missouri St. Louis
Co-presenting Author | Chathuri Silva, McDonnell Center for Space Sciences, Washington University
Co-presenting Author | Phil Chrostoski, Sandia National Laboratory, Livermore CA

Extraterrestrial materials in the laboratory can have amazing stories to tell. For example the story told by a micron-sized sphere extracted from the meteorite Murchison, and formed in the neighborhood of an AGB star like that which created the carbon nuclei inside you, may provide a way to tie together scientific detective work that ranges over processes in labs here on earth, through the history of our solar system, and the adventures of particles in the interstellar medium, to atom-scale events that took place during solidification in a carbon star's photosphere. In addition to tying atom-scale observations on earth with atom-scale processes in stars via the scientific method, classroom spinoffs from this story might include analysis of the particle size limit on radiation pressure ejection from star systems, and use of on-line transmission electron microscope simulators to do detective work on the size and arrangement of graphene sheets in a frozen carbon droplet.

G2: Culture-based Approaches to Physics Education – Part 2

Location: Grand Ballroom B Time: 3:30–4:20 p.m. Date: Monday, January 20, 2025 Moderator: Clausell Mathis

G2-01 3:30 PM-3:54 PM | | How do teachers talk about justice-centered issues when designing physics curricula?

Presenting Author: Katarzyna Pomian Bogdanov, Northwestern University

Science learning environments have been shaped by Eurocentric ideologies that center science as a set of culturally neutral and color-blind systems (McGee, 2020) which science teachers are often reluctant to acknowledge (MoralesDoyle, 2021). However, current reforms in the US are asking science teachers to teach in more justice-oriented ways. This requires shifts in teachers' approaches, which can be challenging for them to accomplish (NRC, 2012). This study investigates how three teachers discuss issues of racial and social justice as they work to co-design science curricula alongside researchers. I employ the curricular values framework which characterizes design dilemmas as moments when a design team

encounters multiple ways in which they can proceed with the design process and identifies curricular values that underlie criteria used to make design decisions (Pomian Bogdanov, 2022). I identify design dilemmas that center on issues of racial or social justice to characterize how teachers approach designing for more justice-centered physics classrooms. Through unpacking dilemmas in teachers' ideas and approaches, I find ways that teachers may shift their understanding and approaches to designing curricula to be more justice-centered.

G3: PICUP: Integrating Computation in Upper-Level Courses

Location: Grand Ballroom C Time: 3:30–4:20 p.m. Date: Monday, January 20, 2025 Moderator: Marie Lopez del Puerto

G3-01 3:30 PM-3:42 PM | Contributed Talk (12 Minutes) | Integrating Jupyter Notebooks into a Methods of Mathematical Physics Course

Presenting Author: Kathryn Hamilton, University of Colorado Denver

Integrating computation into physics courses can prove to be challenging, particularly in a course like Methods of Mathematical Physics. This course is typically taken by students who have just completed the introductory physics sequence, with the aim of introducing the mathematical tools which are required in their upper-division courses like Quantum Mechanics, Thermodynamics, and Electromagnetic Theory, and reinforcing previously acquired mathematical skills. In this presentation I will describe how I have integrated computation into a Methods of Mathematical Physics course taught at the University of Colorado Denver through the use of Jupyter Notebooks. The Notebooks are made available to students for every class period, and provide reinforcement and visualization of the mathematical concepts covered in class, but also require the students to interact with and manipulate code. Examples include calculating the sum of a finite series using a for loop, the visualization of different orders of Taylor Series approximations, and calculating limits of functions using the SymPy library. Student perceptions of the Notebooks will be discussed, as will planned future improvements in their implementation and content.

G3-02 3:42 PM-3:54 PM | Contributed Talk (12 Minutes) | Integrating Python Computation in Classical Mechanics

Presenting Author: Nathan Frank, Augustana College

Classical Mechanics is among the most challenging courses for students in an undergraduate physics curriculum. The mathematical rigor combined with difficult concepts provides ample challenge to any student along with the teacher who guides them. Recent changes in our department's course offerings increased the emphasis on coding throughout the curriculum. Coding is a key skill set that physics majors and other STEM disciplines need. However, integrating coding assignments in Classical Mechanics is a particular challenge given the context of the course. Activity design needs to accommodate a variety of Python coding backgrounds and achieve course learning goals. Activities build upon one another to help the students learn enough to complete a computational modeling project instead of a final exam. Course activities, projects, and challenges will be presented.

G3-03 3:54 PM-4:06 PM | Contributed Talk (12 Minutes) | Computational astrophysics for students who like stars (but are less sure about coding)

Presenting Author: Sean O'Neill, Pacific Lutheran University

I will present an ensemble of computational exercises arranged around the subject of stellar astrophysics. Running python codes using the web-based platform trinket.io, our upper-level physics students gained valuable exposure to standard numerical analysis and data processing techniques with applications to both theoretical and observational astronomy. Specifically, the exercises focused on: integrating the equations of stellar structure to model star density/temperature/pressure profiles, direct simulation of scattering in stellar cores and atmospheres, determining the relative distances to real star clusters from color-magnitude diagrams, and estimating pulsar periods by constructing power spectra of observed light curves.

G4: 21st Century Physics and Astronomy in the Classroom – Part 2

Location: Grand Ballroom D Time: 3:30–4:20 p.m. Date: Monday, January 20, 2025 Moderator: Shane Wood

G4-01 3:30 PM-3:42 PM | Contributed Talk (12 Minutes) | Modeling Techniques and Misconceptions Analysis on Inquiry-Based Planetarium Activities

Presenting Author: Emma Rasmussen, Brigham Young University

Additional Author | Adam Bennion, Brigham Young University

Additional Author | M Jeannette Lawler, Brigham Young Universtiy

Inquiry-based learning presents unique challenges in astronomy education, as the night sky is not typically available during traditional teaching hours. However, planetariums offer an ideal setting for implementing inquiry-based activities, fostering deeper understanding by allowing students to explore astronomical concepts interactively. Typically, planetariums are used to supplement lectures or demonstrations, but we have developed five interactive activities designed to engage students directly. These activities encourage students to investigate their own knowledge and confront misconceptions while displaying reasoning and modeling skills. By transforming the planetarium into an inquiry-driven learning space, we aim to bridge the gap between passive learning and active exploration. In this presentation, we will share the design of these activities, along with an analysis of student outcomes. Our evaluation focuses on student reasoning, the models they construct, misconceptions identified, and overall enjoyment.

G4-02 3:54 PM-4:06 PM | Interactive (e.g. panel, round table discussion, hands-on activity) | Workshop and Discussion: Seminars to Incorporate non-technical skills into the physics curriculum, Devised at Marquette University

Presenting Author: Karen Andeen, Marquette University

As physics educators, one of our main goals is to ensure that our students become successful physicists in a variety of career paths. However, becoming a successful physicist requires many skills that are often not explicitly taught in the physics classroom, including working together in teams to develop new ideas, gathering and presenting information to a variety of audiences, applying for jobs, and being strong and inclusive allies for colleagues from all backgrounds. The Joint Task Force on Undergraduate Physics Programs suggests in their Phys-21 report that these skills be more explicitly addressed within the physics curriculum to better prepare our physics graduates. At Marquette University in Milwaukee, WI, we have recently revised our physics curriculum. Using the suggestions made in the JTUPP-Phys-21 report, we designed six new 1-credit seminar courses, taught one per semester over three years. These seminars focus on explicitly teaching these non-technical skills that our physics graduates need to succeed. At AAPT in New Orleans 2024, we presented the structure of these six seminars and gauge of their initial success. This year we will take a deeper dive into the detailed content of these seminars.

G6: Physics with Phones – Waves and Sound

Location: Regency Ballroom C Time: 3:30–4:20 p.m. Date: Monday, January 20, 2025 Moderator: Dan Burns

LLNL scientist Dave Rakestraw has developed an extensive and detailed curriculum centered on the use of smart phones and low-cost materials. Dan Burns has teamed with Dave to conduct Physics with Phones workshops for teachers (both in-person and online). This session will introduce participants to the Physics with Phones curriculum using several hands-on lab activities. The activities will be selected to enhance topics such as waves and sound. The activities are appropriate for high school and introductory college physics classes. They use free phone apps such as PhyPhox and The Physics Toolbox. Materials will be provided and there will be phones to borrow. The Physics with Phones curriculum can be accessed at this website: https://st.llnl.gov/sci-ed/Physics-with-Phones

H1: Quantum Education Promotion (QEP): Initiatives and Challenges in Undergraduate Programs – Part 2

Location: Grand Ballroom A Time: 8–8:50 a.m. Date: Tuesday, January 21, 2025 Moderator: André Bresges

H1-01 8:00 AM-8:24 AM | | Developing and supporting an interdisciplinary quantum information science and technology minor at RIT

Presenting Author: Ben Zwickl, Rochester Institute of Technology, School of Physics and Astronomy

A key element in developing a quantum workforce is helping engineering, computing, and science majors learn the foundational concepts of quantum science and their applications to technology. Understanding these concepts and applications prepares students to use their primary expertise toward quantum science and engineering and engage in future learning. In 2022, Rochester Institute of Technology started an interdisciplinary minor in Quantum Information Science and Technology (QIST). I will describe the rationale, design process, structure, and challenges we have faced. Some strengths include a balanced emphasis on quantum computing and other areas of quantum technology. We also include many "classical" courses that either prepare students to work on hardware (e.g., optics, microfabrication) or application areas impacted by quantum (e.g., cybersecurity, AI). The minor requires modest resources and provides an expandable platform as more quantum courses become available. Some of the challenges to broad student participation surface around aligning the minor with existing course requirements, inflexible curricula in some majors, and perceptions that quantum computing involves too much physics.

H1-02 8:24 AM-8:48 AM | | How National User Facilities Can Motivate Education In Quantum Science

Presenting Author: Hendrik Ohldag, LAwrence Berkeley National Laboratory

When we think about quantum science, we think about science at very small lengthscales or short timescales. We also think about an area of physics that is in its detail only relevant to a rather small group of specialized scientists. However, the reality parrticualr at large scale user facilities, where users from diverse scientifc backgrounds come together to study their samples using technqiues that are not available at their home institutions, shows, that quantum sciecen impacts every researcher. At microsopy centers, nano fabrication centers, synchrotrons or neutron sources graduate students are gaining deep insight into the electronic, atomic and crystallographic structure of their samples. They experience how small changes on the atomic level can drastically change the macroscopic properties that they observe in their lab at their home institution. For this reason an ealry close collaboration between undergraduate institutions and user facilties is crucial. Our existing experience with the various summer internship programs is already very encouraging, however, their reach is limited. For this reason a more concerted effort with regular summer schools or even short visits to local user facilties is critical. Apart from gaining imporatnt insight It can also demostrate to students how important team work in science is.

H2: Enhancing Diversity, Equity and Inclusion

Location: Grand Ballroom B Time: 8–8:50 a.m. Date: Tuesday, January 21, 2025 Moderator: Susan White

H2-01 8:00 AM-8:12 AM | Contributed Talk (12 Minutes) | Broadening Participation through REU Programs

Presenting Author: Valarie Bogan

The Office of Diversity and Inclusion (ODI) at the National Radio Astronomy Observatory (NRAO) seeks to address systemic injustices in multiple ways. ODI has several student programs, educational initiatives and institutional partnerships intentionally designed to broaden participation of underrepresented populations in STEM fields. In this talk I will provide an overview of our student programs, particularly the NAC, NINE, RADIAL, and SpectrumX. These programs follow innovative models that offer undergraduate students summer research and training experiences, long-term mentoring, and on-going support. Finally, I will briefly describe the related institutional partnerships that provide BIPOC students and mentors with technical resources, research opportunities and mentorship training for student success.

H2-02 8:12 AM-8:24 AM | Contributed Talk (12 Minutes) | Simons–NSBP Scholars Program: Experiences from the first five years

Presenting Author: Kasey Wagoner, North Carolina State University

The Simons-NSBP Scholars Program [SNSP] started in 2020 in response to many NSBP undergraduates losing their summer research opportunities. Since its inception, the SNSP has had a positive impact on a large number of undergraduate Black physicists. It has also grown from fully virtual projects, to fully in-person projects at three institutions. While the SNSP has experienced many successes, it has also encountered multiple challenges. This talk will describe the SNSP, some of its victories, and some of its struggles.

H2-03 8:24 AM-8:36 AM | Contributed Talk (12 Minutes) | Physics Wonder Girls Program: Celebrating Eleven Years of Supporting Middle and High School Girls in STEM

Presenting Author: Roberto Ramos, Saint Joseph's University

On the occasion of its 11th anniversary, the Physics Wonder Girls Program continues to stimulate and sustain interest in physics among middle and high school girls. We report and reflect on the activities, programming, and milestones of the camp. This year, the free Physics summer program supported 32 participants selected from a pool of high-performing students in the Philadelphia-New Jersey-Maryland region in an intensive week-long immersive program held at Saint Joseph's University in Philadelphia. Participants from 23 distinct schools mostly came from diverse, underserved communities. The camp theme was renewable energy and campers built and tested solar-powered fidget spinners, solar cars, solar trackers, solar cookers, wind turbines, and used infrared cameras to audit energy loss. Campers received free kits including a digital multimeter. They interacted with physics and STEM majors who serve as crew, women physicists and engineers, toured R&D and manufacturing facilities of a multinational food company, presented "Equity-in-Energy" poster sessions about women physicists, and gave capstone presentations of their favorite energy projects. Past camp graduates returned to the camp as STEM professionals and college students, this time as speakers. I report on the products of the camp, status of graduates, program assessments, and the future direction of the program.

H3: Labs/Apparatus

Location: Grand Ballroom C Time: 8–8:50 a.m. Date: Tuesday, January 21, 2025 Moderator: Jason Sterlace

H3-01 8:00 AM-8:12 AM | Contributed Talk (12 Minutes) | Inexpensive Setup for kHz-Range Digital Data from Underdamped LRC Circuits

Presenting Author: Bob Brazzle, Jefferson College

I've developed a lab activity for my Introductory University Physics course in which students study an underdamped LRC circuit (though there is no physical resistor; only the intrinsic resistance of the other circuit components, which they calculate). I currently use a 1980's vintage analog oscilloscope, mylar film (nonpolar) nF-range capacitors and mH-range inductors. These generate oscillation frequencies in the ~5kHz to ~100kHz range. Training students to use this equipment is time consuming, and maximizing measurement precision requires attention to detail. Meanwhile, I've been trying to find inexpensive nonpolar capacitors with larger capacitances, and inductors with larger inductances, to generate low-frequency oscillations (in the Hz to tens of Hz range), so that we can use our PASPort voltage-current sensors to get digital data. The main problem is high internal resistance causing complete damping in fewer than three complete cycles. I recently discovered Pasco's high-frequency voltage and current sensors and the oscilloscope mode of the 550 interfaces. In this presentation, I will discuss my digital data using this equipment and how to help students interpret the data using a ternary energy diagram.

H3-02 8:12 AM-8:24 AM | Contributed Talk (12 Minutes) | Using the Pendulum to teach concepts in Physics

Presenting Author: Joe Wyatt Jr, me

Pendulums are important in teaching lab procedures and the consepts of vectors, potential energy, kinetic energy, work, velocity, acceleration and, circular motion. In my pendulum lab, students first learn to time the period of a pendulum using only a stopwatch. They must develop a method to time the period of a pendulum so that they can make 5 consective measurements of the period that average to the actual value of the period of the pendulum and that the difference between the highest and lowest value does not exceed 0.02 of a second. They then measure the period of pendulums of various lengths and plot the values on a graph. Students then plot the calculated values on the same graph for comparison. Students are encouraged to explain any deviations of the collected data from the calculated values. Student are then taught how to calculate the potential energy

of a given pendulum as a function of the length of the pendulum and the angle of deflection. This enables them to calculate the velocity, tangental acceleration, tension acceleration, and kinetic energy at any point in its swing. These skills are then used in solving problem sets in the future that involve pendulums.

H4: Physics Degree Variations

Location: Grand Ballroom D Time: 8–8:50 a.m. Date: Tuesday, January 21, 2025 Moderator: Joseph Ganem

Some physics departments, to increase the number of majors and broaden the appeal of physics, offer variations on the traditional physics degree. Some examples are tracks, interdisciplinary majors, 3-2 agreements, and applied physics degrees. This discussion will share ideas, experiences, and outcomes for these various programs.

H5: Interactive: Visualizations in the Physics Classroom

Location: Regency Ballroom A&B Time: 8–8:50 a.m. Date: Tuesday, January 21, 2025 Moderator: Marianna Ruggerio

H5-01 8:00 AM-8:24 AM | Interactive (e.g. panel, round table discussion, hands-on activity) | Motion Diagram Manipulatives

Presenting Author: Kristin Pierce, Mehlville School District

Motion diagrams are a great tool for teaching about velocity and acceleration without using graphs. They are especially useful for visualizing the relationship between direction of motion and direction of acceleration. Join other teachers in using a hands-on manipulative to teach this useful subject.

TAKEAWAYS: 1. Velocity and acceleration can be taught qualitatively instead of quantitatively; 2. Using manipulatives reaches all different kinds of learners—verbal, visual, and kinesthetic; and 3. Giving students different ways to learn the same topic helps to reach more students.

H6: Physics with Phones – Magnetism

Location: Regency Ballroom C Time: 8–8:50 a.m. Date: Tuesday, January 21, 2025 Moderator: Dan Burns

LLNL scientist Dave Rakestraw has developed an extensive and detailed curriculum centered on the use of smart phones and low-cost materials. Dan Burns has teamed with Dave to conduct Physics with Phones workshops for teachers (both in-person and online). This session will introduce participants to the Physics with Phones curriculum using several hands-on lab activities. The activities will be selected to enhance second semester topics in Magnetism. The activities are appropriate for high school and introductory college physics classes. They use free phone apps such as PhyPhox and The Physics Toolbox. Materials will be provided and there will be phones to borrow. The Physics with Phones curriculum can be accessed at this website: https://st.llnl.gov/sci-ed/Physics-with-Phones

I1: Unlikely Pairing with Physics

Location: Grand Ballroom A Time: 9–9:50 a.m. Date: Tuesday, January 21, 2025 Moderator: Beverly Trina Cannon

I1-01 9:00 AM-9:24 AM | Contributed Talk (12 Minutes) | The Physics of Dragonflies: Science Outreach Catalyst Kits

Presenting Author: Maia Chandler, Swarthmore College, Society of Physics Students

Science Outreach Catalyst Kits (SOCKs) are boxes of exploratory physics and science activities designed for undergraduate Society of Physics Students chapters to use in outreach presentations. Each kit includes demonstration materials, a comprehensive manual, resources for presenters, and physics explanations for three age groups: elementary school, middle school and the general public, and high school. This year's SOCK contains demos that utilise more commonplace materials to increase accessibility. SOCKs seek to introduce students of different ages to physics concepts in the world around them. As such, this year's theme is dragonflies. Dragonflies can fly backwards, control each wing individually, have near 360-degree vision, and can see UV light. All kinds of equations go into understanding their different modes of flight–hovering, gliding, and taking off, and the flight patterns and efficiency of dragonflies inspire new technologies. Dragonflies come in a remarkable range of colours, some hues produced from light scattering and layers of cuticle that produce thin-film interference. In short, dragonflies are several physics concepts packed into one creature. This outreach kit aims to spark interest in physics and build connections to other disciplines.

I1-02 9:24 AM-9:36 AM | Contributed Talk (12 Minutes) | Unearthing Newton: Exploring Industrial Heritage with Physics as a Guide

Presenting Author: Marty Johnston, Marty Johnston

Additional Author | Nathan Gaus, University of St. Thomas

Additional Author | Will Tuma, University of St. Thomas

This presentation explores the application of physics in understanding the functionality of early technologies and the competitive advantages that specific designs contributed to the market. These interdisciplinary projects in industrial archeology engage students with history, architecture, and

engineering as we use physical artifacts, patents, historical records, and physics to unravel the story of our industrial heritage. In this talk I will provide an overview of our investigations of novel industrial tramways and parabolic cranes, the real shape of a loaded suspension bridge, and the development of pneumatic locomotives while highlighting the central role that students play in the process.

I1-03 9:36 AM-9:48 AM | Contributed Talk (12 Minutes) | Physics is Fun! Using Social Media to Communicate STEM

Presenting Author: Caleb Bonyun, Massachusetts Institute of Technology

In this talk I will discuss the seemingly odd pairing of physics and social media. Physics has a bad reputation as being difficult, boring, and intimidating. I use short format video content to show the world that physics is actually interesting and fun! There are negative sides to the use of social media, however I say that students will be in that space regardless, so we should al also be in that space with educational content! With just over 1.7 million followers across three platforms I have created a platform where STEM outreach can be done on a truly large scale. In this talk I will discuss some of the basics on how I make short form content, how the algorithms work, and how anyone can make educational content for their classroom or for the world.

I2: PER: Upper-level and Graduate Education

Location: Grand Ballroom B Time: 9–9:50 a.m. Date: Tuesday, January 21, 2025 Moderator: Doug Petkie

I2-01 9:00 AM-9:12 AM | Contributed Talk (12 Minutes) | Shared Resources in Student Understanding of Spherical Unit Vectors in Upper-division E&M, A Case Study

Presenting Author: Ying Cao, Drury University

Additional Author | Brant Hinrichs, Drury University

We are interested in better understanding ways that students collaborate to solve conceptual physics problems in the context of spherical unit vectors in upper-level E&M, especially problems that have been shown to be difficult for students to solve individually on their own, but which groups of students have been more successful at. We apply the framework shared resources to examine cases students collaborated effectively--first one student activated a conceptual resource and expressed it, then another student took up that idea, and finally the whole group together used that idea to move forward with the problem. In our provisou work, we reported our methodology and the results from one group interview to illustrate one shared resource we identified and the role it played in helping students collaboratively solve the conceptual problem in that context. In this paper, we present more examples from different students to verify our theory and analysis. Our goal is to construct a more complete set of typical, sharable resources in students' understanding of spherical unit vector and suggest implications for instruction.

I2-02 9:12 AM-9:24 AM | Contributed Talk (12 Minutes) | Developing a Department-level Retention Rate for Physics Graduate Programs

Presenting Author: Bill Bridges, Kansas State University

Additional Author | Christopher Overton, University of Georgia

Additional Author | Nicholas T Young, University of Georgia

Additional Author | Jacquelyn J Chini, Ohio State University

Additional Author | Rachel Henderson, Michigan State University

Additional Author | James T Laverty, Kansas State University

Student retention has historically been a point of research interest in understanding how healthy a program is. While this has been largely conducted for undergraduate students, there is significantly less information for graduate programs. We are interested in a measure that can effectively capture a physics graduate program's rate of students earning a graduate degree. This work expands on our previous study identifying measures of national retention of physics programs, resulting in a measure agreeing with historical rates of students earning a PhD at 50%. We propose now a measure of institutional physics graduate student retention utilizing data collected by the American Institute of Physics. From this study, we find that there are variations in retention rates among physics departments, which could help to motivate further investigations into the connection that physics graduate program requirements have on student retention.

I3: Approaches to Intro Physics

Location: Grand Ballroom C Time: 9–9:50 a.m. Date: Tuesday, January 21, 2025 Moderator: Nathan Powers

I3-01 9:00 AM-9:12 AM | Contributed Talk (12 Minutes) | Promoting Good Student Habits via Weekly Formative Quizzes

Presenting Author: Kathleen Harper, Case Western Reserve University

Additional Author | Kurt R. Rhoads, Case Western Reserve University

In the 2022-23 academic year, we introduced low-stakes formative quizzes to the large lecture section of an introductory course. At the beginning of the weekly lecture, students answer a couple of short questions based on the previous week's material. The quiz is then quickly discussed before proceeding with new topics and students are encouraged to use it as a learning experience. They receive a modest amount of credit for making a reasonable attempt. The presentation will focus on the implementation details, including how the format of the quiz was modified in the fall of 2024 to promote more metacognitive reflection by students. We will also share results of efforts to assess the impact of this tool.

I3-02 9:12 AM-9:24 AM | Contributed Talk (12 Minutes) | Transparency in University-level Introductory Physics

Presenting Author: Amy Furniss, University of California Santa Cruz

Transparent course structure is an intentionally inclusive design which provides students a complete view of course content, activities and assessments up front. This explicit layout enables students more focused content interaction, leads to lower overall anxiety and provides for a broadened understanding of concept connection. I will present an example of transparent course design as applied to the year-long Introductory Physics sequence for bio-adjacent majors at University of California Santa Cruz. Within this fine-grained transparent design, between 120 and 140 module-specific learning outcomes are directly tied to components of the course such as reading, homework, slides, in-class activities, active learning sessions, laboratory experiments, quizzes and midterms. A summary of the key components of implementation, as well as observed qualitative outcomes will be provided.

I3-03 9:24 AM-9:36 AM | Contributed Talk (12 Minutes) | A Cat and a Squirrel as Physics Educators: Supplementing an Intro Physics Textbook with Comics

Presenting Author: Roger Freedman, University of California, Santa Barbara

Additional Author | Juan Manuel Ramírez de Arellano, Tecnológico de Monterrey, Campus Ciudad de México

Student misconceptions in physics are numerous, robust, and challenging to overcome. To help students confront and conquer these, the new 16th edition of University Physics by Young and Freedman (Pearson, in press) includes a suite of 44 "Caution Cartoons" that we have created, each designed to address a particular misconception or conceptual stumbling block. (RAF is one of the original group that helped start the San Diego Comic-Con in the 1970s; JMRdeA is both a professional cartoonist and a physicist.) These "Caution Cartoons" use the same cast of characters as our "Physics Comics and Stories" comics (which we presented at the Summer 2023 and Winter 2024 meetings). We will detail the process of creating these cartoons, show several examples, and describe progress on new chapters of "Physics Comics and Stories."

I3-04 9:36 AM-9:48 AM | Contributed Talk (12 Minutes) | The Trouble with Significant Figures

Presenting Author: Larry Smith, Snow College

Additional Author | John S Denker

While dealing with uncertainty is an important skill, the method of significant figures (also known as significant digits) is a particularly poor way to do it. The method is inconsistent and often fails. There are approaches for dealing with and reporting uncertainty that are more correct and are easier for teachers and students.

I4: Cultivating Community in Physics Classes

Location: Grand Ballroom D Time: 9–9:50 a.m. Date: Tuesday, January 21, 2025 Moderator: Carolyn Sealfon

We all use various strategies to cultivate inclusive communities in our classes, from icebreakers to applied improv games to collaborative activities. What approaches do you use in different contexts, class sizes, and class formats (e.g. online versus in person)? What can we learn from each other? How can we adapt approaches to our situations? What conditions allow inclusive learning communities to form? Bring your experiences, ideas, and curiosity, and let's share and discuss.

I5: STEP-UP Lesson – Interactive Session

Location: Regency Ballroom A&B Time: 9–9:50 a.m. Date: Tuesday, January 21, 2025 Moderator: Bree Barnett Dreyfuss

I5-05 9:00 AM-9:48 AM | Interactive (e.g. panel, round table discussion, hands-on activity) | Designing your Classroom for Inclusive Physics with STEP UP

Presenting Author: Bree Barnett Dreyfuss, Amador Valley High School

Co-presenting Author | Elissa Dunn-Levy, Thomas Jefferson High School

Reflecting on the STEP UP program's Everyday Actions Guide, participants will analyze sample images and videos of physics classrooms through the lens of creating a welcoming and inclusive space for all students. Participants will reflect on their own spaces and discuss with others what they notice about the sample classrooms. After learning more about different spaces for learning physics, participants will reflect on changes they can make to their own learning environments. Teachers of all levels and amounts of experience are encouraged to come to this interactive discussion.

I6: Let Them Teach: Undergraduates doing Informal Science Programs

Location: Regency Ballroom C Time: 9–9:50 a.m. Date: Tuesday, January 21, 2025 Moderator: Toni Sauncy

There is growing evidence for how providing opportunities for undergraduate physics students to plan and present informal science education programs can benefit their educational experience. These programs ultimately bring positive benefits to physics programs. If developing the plans and tools for programs to engage students in public outreach seems daunting, this interactive session is for you! Join with some folks who bring best practices and touch on the realities of time and money. Be prepared to try some tested outreach activities so you can go home inspired and equipped with ideas to let your undergrads teach!

J1: Innovations in Cross-Disciplinary Connections

Location: Grand Ballroom A Time: 10–10:50 a.m. Date: Tuesday, January 21, 2025 Moderator: Beverly Trina Cannon

J1-01 10:00 AM-10:12 AM | Contributed Talk (12 Minutes) | Incorporating Interdisciplinary Topics into Introductory Physics Courses

Presenting Author: Blane Baker, William Jewell College

Introductory physics courses offer opportunities to include interdisciplinary topics that impact society and the everyday lives of citizens. In this talk, several of these topics will be discussed, along with details of how to incorporate them into course-work. Discussions will cover background material, classroom activities, problems sets, and critical thinking prompts. Exam-ples include climate change, lithium-ion batteries, nuclear reactors, energy, and quantum dots. Some attention is given to the broader implications of these topics such as how they have contributed to and influenced our economy and society.

J1-02 10:12 AM-10:24 AM | Contributed Talk (12 Minutes) | The Importance of Introducing New Physics Students to the Philosophy of Science

Presenting Author: John Cordell, Fort Worth Country Day School

This talk will discuss the importance of introducing students to the philosophy of science in their introductory physics classes. I will discuss the ideas of enlightenment science and philosophers, Hume's problem of induction, the Raven Paradox, and the ideas of Karl Popper, Thomas Kuhn, and Imre Lak\s class, for example: What is the truth of such information? How might our ideas change in the future? What are the goals of the field of physics as a whole? My goal will be to convince other educators to incorporate some philosophy into their curricula to help their students gain a better understanding of physics.

J1-04 10:36 AM-10:48 AM | Contributed Talk (12 Minutes) | Information from the 2024 Intergovernmental Panel on Climate Change (IPCC) Report That Can Be Used in Your Classroom

Presenting Author: Frank Lock, Climate Reality Project

This talk will provide participants with information about the 2024 IPCC report and how it might be used with your students. As confirmed by the World Meteorological Organization, 2023 was the hottest year on record, with particularly startling extremes in ocean temperatures. Extreme weather events and wildfires ceased to be just part of future projections(1). Students should be aware of these challenges, and how to deal with them.

J2: Increasing Diversity & Persistence in Physics: A Data-Driven Approach

Location: Grand Ballroom B Time: 10–10:50 a.m. Date: Tuesday, January 21, 2025 Moderator: Gordon Ramsay

J2-01 10:00 AM-10:24 AM | | Where do we start?

Presenting Author: Susan White, American Institute of Physics

Additional Author | Raymond Y. Chu, American Institute of Physics

Additional Author | Jordana Oman, American Institute of Physics

We will examine what physics bachelor's degree recipients say influenced their decision to major in physics. Almost 70% say informal exposure to science (e.g. museums, NASA) influenced their decision, and almost 60% report that their experience with high school physics influenced them. Are there gender differences in influences? Not every physics bachelor's degree recipient starts their education at a four-year institution; about 13% of recent physics bachelor's degree recipients started at a two-year college (TYC). Students who started at a TYC were less likely to have taken AP or advanced physics courses in high school. In fact, 40% of those earning a bachelor's degree in physics who did not take physics in high school started their undergraduate education at a TYC. We will take a brief look at the availability of high school physics, and we will preview the results from the OPTYCs survey of TYCs.

J2-02 10:24 AM-10:48 AM | | Staying or leaving: A 5-year study of physics major persistence

Presenting Author: Anne Marie Porter, American Institute of Physics

What drives undergraduate students to persist in or drop a physics major? To answer this question, staff members at AIP Statistical Research conducted a 5-year longitudinal study between 2018 and 2023. We surveyed 3,917 students in the first week of their introductory college physics course and asked whether they wanted to major in physics. We surveyed the respondents considering a physics major annually for 5 years. We compared the experiences of students who graduated with a physics degree and students who lost interest in a physics major. Among the students who left physics, most dropped physics during their first two years due to other interests or issues within physics courses, and they were more likely to report lower self-efficacy and less positive department climates. Underrepresented students who left physics reported less supportive relationships with physics professors and peers.

J3: Quantum Education for Workforce Development

Location: Grand Ballroom C **Time: 10–10:50 a.m.** **Date: Tuesday, January 21, 2025** **Moderator: James Freericks**

J3-01 10 AM-10:12 AM | Contributed Talk (12 Minutes) | How to use quantum computing to illustrate important single quantum experiments for quantum instruction

Presenting Author: James Freericks, Georgetown University

As physics departments determine how best to modernize their instruction to better prepare students for the quantum workforce, they often struggle with needing to remove old content to include newer content. In this talk, I will describe how more modern instruction can be employed to enhance traditional instruction, especially in spins-first paradigms. The key point is that quantum computers available via the cloud are ideal platforms for simulating many experiments used in quantum instruction that are either impossible, or quite difficult to implement as lecture demonstrations or advanced laboratory experiments. We have already investigated the Stern-Gerlach analyzer, analyzer-loop, Bell experiments, delayed choice experiments, two-slit experiment with or without detectors, Mach-Zehnder interferometer and delayed choice variants with polarizers, simple models of decoherence, Rabi oscillations, and Hahn spin-echo. While free access to the cloud can be time-consuming for some examples, much can be done that allows students to both learn quantum computing basics, develop intuition about single-quantum experiments, and reinforce Dirac notation and how it is used to describe state preparation and measurement for these examples.
This work was supported by the Air Force Office of Scientific Research and the McDevitt bequest at Georgetown University.

J3-02 10:12 AM-10:24 AM | Contributed Talk (12 Minutes) | Quantum state tomography of two-photon polarization states and its application to study decoherence.

Presenting Author: Benoit Chalopin, Université de Toulouse, LCAR, France
Additional Author | Nicolas Ombredane, Université de Toulouse, LCAR, France
Additional Author | Mélissa Kleine, Université de Toulouse, LCAR, France
Additional Author | Alban Leschallier-De-Lisle, Université de Toulouse, LCAR, France
Additional Author | Sébastien Massenot, Université de Toulouse - ISAE, France
Additional Author | Renaud Mathevet, Université de Toulouse, LCAR, France

Teaching experiments with two-photon entangled polarization states are increasingly popular for graduate and under-graduate students. They are commonly used to illustrate entanglement, and to perform a simpler version of the Nobel-prize winning violation of Bell's inequalities experiments. With our students, we have completed this type of experiments with photonic state tomography. It allows a full characterization of two-photon polarization states in a 4-dimensional Hilbert space through the 4-by-4 density matrix from which the probability outcome of any measurement can be calculated. It requires more measurement steps as well as advanced post-treatment of data with reconstruction algorithms such as maximum likelihood. This has been an ideal way for our students to get a better grasp on the complex mathematical object that is the density matrix or density operator. Additionally, it can be used to quantify the limitation in the generation and manipulation of a specific quantum system, by quantifying the purity and the entanglement of the two-photon state. Finally, we have inserted a depolarization plate at several locations in the optical paths to simulate decoherence and measure its effect on the two-photon entangled state.

J4: Rethinking the Undergraduate Physics Curriculum

Location: Grand Ballroom D **Time: 10–10:50 a.m.** **Date: Tuesday, January 21, 2025** **Moderator: Joseph Kozminski**

Through surveys and online and in-person discussion groups, the AAPT REV-UP Working Group has gathered input from the community regarding concerns about the undergraduate physics curriculum and suggestions for changes. The input received to date will be reported followed by small group discussions by attendees to comment on prior input and/or to provide new ideas and concerns.

J5: Retain and Renew: PD Strategies for Teacher Growth

Location: Regency Ballroom A&B **Time: 10–10:50 a.m.** **Date: Tuesday, January 21, 2025** **Moderator: Spencer Perry**

J5-01 10:00 AM-10:12 AM | Contributed Talk (12 Minutes) | K-12 STEM and Physics Teacher Retention from a Federal Perspective

Presenting Author: Janet Kahn, Albert Einstein Distinguished Educator Fellowship, Department of Energy

Co-presenting Author | Charles Wang, Albert Einstein Distinguished Educator Fellowship, Department of Energy

Can programs and advocacy for policy support at the federal level have a positive impact on teacher retention? Two Einstein Fellows will discuss the issues with STEM teacher shortages and retention from the perspective of the federal goverenment. We will explore causes of physics and other STEM teacher low retention rates, and the ways that the agencies and federal government might improve the situation. Financial compensation and loan support are important but do not address teacher burn-out and issues of low efficacy. The Albert Einstein Distinguished Educator Fellowship Program, run by the Department of Energy, places Fellows with federal agencies and on Capitol Hill. We will present our findings from half a year in Washington.

J5-02 10:12 AM-10:36 AM | | Bringing Teachers Together with Food, Physics, and Fun

Presenting Author: Duane Merrell, Brigham Young University

Co-presenting Author | Adam Bennion, Brigham Young University

In this session we will present a program we are running at BYU that brings preservice teachers, novice teachers, and veteran teachers together to collaborate, network, and improve their teaching. We have found that short workshops that focus on real needs, provide materials, and allow teachers to network in meaningful ways give teachers from all levels of expertise real value. We hope to discuss with those present the strategies they have found effective in their own communities as we consider how to build up new teachers and energize the veterans. Please come with ideas to share and be ready for a productive conversation.

J5-03 10:36 AM-10:48 AM | Contributed Talk (12 Minutes) | Creating Successful Professional Development Programs

Presenting Author: Kristine Lui, OPTYCs

Additional Author | Dwain Desbien, Estrella Mountain Community College

Additional Author | Sherry Savrda, OPTYCs

Additional Author | Rachel Ivie, AAPT

During the past two years, The Organization for Physics at Two-Year Colleges (OPTYCs) has ramped up multiple programs for professional development. While these are aimed at two-year college faculty, we have had participation from high school teachers, professors from four-year institutions, and graduate students. In this presentation, we will highlight some of our programs and share what we have learned about creating relevant and engaging events for professional growth. OPTYCs is funded by NSF-IUSE-2212807.

J6: Embodying Physics

Location: Regency Ballroom C **Time: 10–10:50 a.m.** **Date: Tuesday, January 21, 2025** **Moderator: Carolyn Sealfon**

Wellness and mindfulness act as buzz words these days, often seen as separate from physics. Yet we know they are important, and everything is related to physics! Join us to explore how we can integrate physics, teaching, and wellness in a new light. Wear comfortable clothes and be prepared to practice simple motions. We will experience together ways to integrate the clarity and rationality of basic physics with wellness practices such as mindfulness and tai chi, and discuss how we can apply these insights in our classes.