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Joseph Amato ; John Essick; Claire A. Marrache-Kikuchi ; Beth Parks ; Donald Salisbury ; Todd Springer

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Joseph Amato, John Essick, Claire A. Marrache-Kikuchi, Beth Parks, Donald Salisbury, and Todd Springer, *Editors*

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These brief summaries are designed to help readers easily see which articles will be most valuable to them. The online version contains links to the articles.

Letters to the Editor

Kirk T. McDonald, https://doi.org/10.1119/5.0088991
John Houlihan, https://doi.org/10.1119/5.0086631
S. Deser, https://doi.org/10.1119/5.0080405
90(4), p. 247

Please enjoy these letters-to-the-editor and consider writing one yourself. I'd love to hear from you.

Guest editorial: Updating our language to help students learn: Mechanical energy is not conserved but all forces conserve energy

Lane Seeley, Stamatis Vokos, and Eugenia Etkina
90(4), p. 251
https://doi.org/10.1119/5.0067448

A call to change the language we use when teaching introductory mechanics.

Universal functions

Sanjoy Mahajan
90(4), p. 253
https://doi.org/10.1119/5.0088966

This month's Back of the Envelope column illustrates how plotting the right combination of variables can beautifully illustrate physical laws.

Balloon-borne two-channel infrared spectral photometer for observation of atmospheric greenhouse effect by undergraduates

Gerard T. Blanchard, Fawaz A. Adesina, William Cole Belkwell, James R. Dyess, Victoria A. Frabbiele, Conor S. McGibboney, and Ryan D. Rumsey
90(4), p. 256
https://doi.org/10.1119/10.0009284

The greenhouse effect is a crucial parameter of climate change, but it is difficult to exhibit in tabletop experiments. This paper proposes a student project that, by launching Arduino-based radiation sensors in a balloon, measures that the radiation emitted by the Earth and its atmosphere towards space has an effective temperature that decreases with altitude. They also measure the effects of water and CO_2 absorption. This undergraduate project could be adapted for ground-based experiments and can also serve as a practical illustration of Planck's law.

The analog computer: Beyond the museum artwork, a tool for studying linear and nonlinear systems

Marcello Carlà
90(4), p. 263
https://doi.org/10.1119/10.0009634

There was a time when physicists would argue whether analog or digital computing would win out as the more useful technology. Remember, in 1969, NASA used analog and hybrid (analog computers controlled by digital electronics) computers for simulations and (some) flight control in the Apollo 11 mission! This era is now gone, but analog computers are still an interesting pedagogical tool, as this manuscript shows. In particular, educators can introduce undergraduate students to operational amplifiers-based electronic circuits that constitute the building blocks for analog computing: the summing node, the integrator, and the multiplier module. From there, solutions for linear and non-linear oscillators can be derived, thus relating electronic circuits to more general physics problems.

How physics textbooks embed meaning in the equals sign

Dina Zohrabi Alaee, Eleanor C. Sayre, Kellianne Kornick, and Scott V. Franklin
90(4), p. 273
https://doi.org/10.1119/10.0009096

Experts in physics may take for granted many steps in the problem-solving process that have become deeply ingrained after years of practice. These concepts may not be part of a traditional physics course, but, nevertheless, they might need to be taught. One such concept, often taken for granted, is the meaning of the equals sign. In this article, readers will find a categorization scheme of many possible meanings that are encoded into an equals sign in physics. This article will be of interest to educators wanting to gain a fresh perspective on the difficulties their students may face when trying to interpret mathematical formulae.

Simulation led optical design assessments: Emphasizing practical and computational considerations in an upper division physics lecture course

Vincent M. Rossi
90(4), p. 279
https://doi.org/10.1119/5.0064138

Computation-based simulations in an optics course allow students to gain practical experience in optics at the same time that they develop coding skills. The author has developed a sequence of computational exercises that take students from an introductory level (in both optics and coding) to the design and simulation of optical systems such as spectrometers and polarization-imaging microscopes. These exercises are described in the paper, and the author shares the full set of assignments in the accompanying online supplementary material.

Continuous gravitational waves in the lab: Recovering audio signals with a table-top optical microphone

James W. Gardner, Hannah Middleton, Changrong Liu, Andrew Melatos, Robin Evans, William Moran, Deeksha Beniwal, Huy Tuong Cao, Craig Ingram, Daniel Brown, and Sebastian Ng
90(4), p. 286
https://doi.org/10.1119/10.0009409
In the past few years, we have all been thrilled by the "chirps" detected by LIGO and other gravitational wave (GW) observatories. These tiny signals are generated by binary systems containing black holes and/or neutron stars in the brief moments before their coalescence. The same observatories are also searching for *continuous* GWs, signals that are nearly constant in frequency and persist for years, emitted by non-spherical spinning neutron stars. The authors describe a tabletop Michelson interferometer–a mini-GW detector–that uses sound vibrations to perturb its interference pattern in a manner similar to GW detection. They then introduce the Viterbi algorithm, a signal processing technique used by GW observatories to detect signals that drift slowly in frequency, and demonstrate its effectiveness using their tabletop apparatus. Finally, the authors review a number of signal-processing techniques, employing their apparatus as an "optical microphone" to demonstrate each technique's effectiveness in recovering speech and music in noisy environments. The apparatus can be used as a demonstration of GW detection for non-specialists, or, with an added emphasis on signal processing, in physics, engineering, or cross-disciplinary classes.

Relativistic spin-0 particle in a box: Bound states, wave packets, and the disappearance of the Klein paradox

M. Alkhateeb and A. Matzkin
90(4), p. 297
https://doi.org/10.1119/10.0009408
This informative relativistic supplement to an introductory undergraduate course in quantum mechanics introduces the Klein-Gordan wave solution as a single particle wave function. With the interpretation of negative energy states as representing anti-particles, one gains a recognition of the scalar product as representing charge density, and this constitutes a first step toward quantum field theory. Indeed, the Klein paradox itself, with its production of an amplified current incident on a single potential energy barrier, has as yet neither a sound theoretical basis nor experimental grounding regarding the behavior of bosons confined to a classical potential well. In addition, students will appreciate the multiple scattering analysis that leads to a classical particle interpretation.

Energy-mass equivalence from Maxwell equations

Alejandro Perez and Salvatore Ribisi
90(4), p. 305
https://doi.org/10.1119/10.0009156
Einstein's equation expressing the relationship between mass and energy, $E = mc^2$, is perhaps the most famous equation in physics. Historically, the relationship between mass and energy predated the equivalence principle, one of the cornerstones of general relativity. In this article, the equivalence principle is used to derive Einstein's most famous equation. Even though it did not come about this way historically, the exploration of this connection can still be pedagogically useful for those interested in special relativity, general relativity, and the connection between the two.

Phase plot of a gravity pendulum acquired via the MEMS gyroscope and magnetic field sensors of a smartphone

T. Splith, A. Kaps, and F. Stallmach
90(4), p. 314
https://doi.org/10.1119/10.0009254
With a smartphone serving as the bob of a gravity pendulum, the pendulum's time-dependent angular displacement and velocity are produced from data acquired from the phone's gyroscope and magnetometer sensors via the *phyphox* app. Experimental phase-space plots from the analysis of these data are presented, along with fits to the expected theoretical curves. This experiment is suitable as a lecture demonstration as well as an instructional laboratory experiment. Detailed instructions on how to adopt the experiment are provided in the supplementary material.

Marinated eggs: An engaging quantitative demonstration of diffusion

Carson Emeigh, Hyeonggeun (Luke) Bak, Dilziba Kizghin, Haipeng Zhang, and Sangjin Ryu
90(4), p. 317
https://doi.org/10.1119/5.0062178
Many cultures feature foods in which a flavored sauce is infused into hard-boiled eggs. The authors use eggs soaked in red food coloring to show that this process follows Fick's law of diffusion, creating a fun and engaging demonstration or laboratory exercise for undergraduates.