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John Essick; Adam Fritsch; Harvey Gould; Beth Parks; Donald Salisbury; Todd Springer; Jan Tobochnik

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John Essick, Adam Fritsch, Harvey Gould, Beth Parks, Donald Salisbury, Todd Springer, and Jan Tobochnik, *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.

Approximate insightful ODE solutions

Sanjoy Mahajan
90(12), p. 887
https://doi.org/10.1119/5.0131531
Rather than only teaching students to solve differential equations—either computationally or analytically—the author suggests that also showing them how to find approximate solutions yields increased insight into physical behavior.

Graphical analysis of an oscillator with constant magnitude sliding friction

V. Roitberg and Alon Drory
90(12), p. 889
https://doi.org/10.1119/5.0073812
Physics instructors are aware that when uniform circular motion is projected onto an axis, the motion is identical to that of an undamped harmonic oscillator. But what if the oscillating mass experiences sliding friction? This paper shows that its motion can be found from the inward spiral of a mass attached to a string that winds around two nails. This analysis technique is simple, powerful, and pedagogically helpful to students interested in understanding motion impacted by frictional forces.

Charging a supercapacitor through a lamp: A power-law RC decay

Michelle L. Storms and Brad R. Trees
90(12), p. 895
https://doi.org/10.1119/5.0065500
The exponential decay of the current in an ideal RC circuit is a standard part of the introductory physics curriculum, but a real circuit involves subtleties not present in an idealized model. Here, the authors present experimental, analytical, and computational results indicating that power law decay of the current (not exponential decay) is found in circuits containing a supercapacitor and a lamp. This power law behavior is ultimately due to the temperature dependence of the lamp's resistance. These are fertile pedagogical grounds, offering instructors the ability to emphasize differences between exponentials and power laws as well as an opportunity to make connections between thermal physics and electronics. Students will benefit from such investigations as they develop skills in refining and updating scientific models.

Exploration of the Q factor for a parallel RLC circuit

J. G. Paulson and M. W. Ray
90(12), p. 903
https://doi.org/10.1119/5.0074843
The series RLC circuit is a staple of undergraduate physics courses. Circuits involving different arrangements of these same components are less well-studied in standard curricula. Such variations, therefore, are excellent candidates for laboratory activities or student projects. The subject of this paper is the parallel RLC circuit, with special attention paid to the quality factor (Q-factor) which quantifies dissipation. When they first encounter it, students may be puzzled by the counterintuitive behavior of this circuit: why does the dissipation decrease when the resistance is increased? This paper describes investigations and analyses that students may perform while attempting to understand this mystery.

A simple electronic circuit demonstrating Hopf bifurcation for an advanced undergraduate laboratory

Ishan Deo and Krishnacharya Khare
90(12), p. 908
https://doi.org/10.1119/5.0062969
Dynamical systems that exhibit Hopf bifurcations provide a rich mathematical playground, but such scenarios are often difficult to realize in the lab. This paper presents a nonlinear electronic circuit that transitions between stable states via a Hopf bifurcation, which can be analyzed with nonlinear equations derived from a repressilator-like transistor circuit in an advanced undergraduate laboratory setting.

The size of the Sun

M.A. Fardin and M. Hautefeuille
90(12), p. 914
https://doi.org/10.1119/5.0081964
Combining dimensional arguments on macroscopic and microscopic scales, this article offers a surprisingly accessible comprehensive overview of stellar structure for beginners in the field. These theoretical ideas could be incorporated into a variety of upper-level undergraduate courses.

An introduction to the Markov chain Monte Carlo method

Wenlong Wang
90(12), p. 921
https://doi.org/10.1119/5.0122488
Monte Carlo algorithms are one of the workhorses for simulating thermal systems. Most practitioners use these algorithms with only a cursory understanding of why they work. Wang provides a pedagogical discussion of the underlying concepts at a level that undergraduate physics majors can follow.

Speed of light measurement with a picosecond diode laser and a voltage-controlled oscillator

Abdulaziz M. Aljalal
90(12), p. 935

https://doi.org/10.1119/5.0104758

Laboratory measurements of the speed of light often require carefully controlled motion over long distances. This paper shows that it can be measured with an uncertainty of 0.03% using a compact set-up with only 150 mm of throw, making use of feedback into a sub-threshold picosecond laser.

Data transmission in a multimode optical fiber using a neural network

Tom A. Kuusela
90(12), p. 940
https://doi.org/10.1119/5.0102369

This paper demonstrates how a neural network can be trained to recognize images that have been scrambled as a result of transmission through a multimode optical fiber. An optical system, which can be easily replicated in most optical instructional laboratories, inputs a two-dimensional image to a step-index fiber and outputs a speckle pattern image at the fiber's end, which is acquired by a digital camera. A simple theory of neural networks is presented and then implemented on the acquired data to model transmission through the fiber, providing pattern recognition with high accuracy. The manuscript will be useful in advanced undergraduate optics courses and discusses many interesting topics, including light propagation in optical fibers and its use in communication, laser speckle patterns, and neural networks as a method for machine learning.

A Bose horn antenna radio telescope (BHARAT) design for 21 cm hydrogen line experiments for radio astronomy teaching

Ashish A. Mhaske, Joydeep Bagchi, Bhal Chandra Joshi, Joe Jacob, and Paul K.T.
90(12), p. 948
https://doi.org/10.1119/5.0065381

The design of a cost-effective radio telescope for use in hands-on training in radio astronomy is presented. The highly efficient and easy-to-build system, which is tuned to detect the 21-cm hydrogen emission line, employs a dual-mode conical horn antenna and off-the-shelf electronic components. Calibration methods are discussed, followed by experimental results acquired using this system to determine the rotation curve as well as structure of the Milky Way galaxy. The antenna is named in honor of Indian physicist and pioneer in radio-wave science Jagadish Chandra Bose. A summary of Bose's work is included in the paper.