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Generic Abstracts

Upper Division Undergraduate

Abstracts Submitted (# 11)

Abstract Title: Classical Dynamics of a Particle in a One-dimensional Exponential Potential 5482

Paper Type: Contributed

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Surprises lurk in the seemingly simple situation of a particle moving in one dimension, with potential energy increasing exponentially with distance from the origin. Force on such a particle also depends exponentially on the position coordinate. Since the magnitudes of potential and restoring force increase monotonically with distance from the origin, the time a particle released from rest takes to reach the origin is expected to show a similarly monotonic dependence on initial distance. The problem can be solved analytically, with the closed-form expression for this travel time involving only elementary transcendental functions. Surprise lies in the fact that this time first grows with the initial distance, reaches a maximum, and then declines for release points farther away. Implications of such a point-of-slowest-return for a classical non-linear oscillator consisting of a particle moving in a symmetrical potential well will be described via computational and analytical models.

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Abstract Title: Divergence of a vector field: Teaching strategies and learning difficulties 5278

Paper Type: Contributed

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It is quite well known that using vector differential operators in physics is challenging for students. In this work, we present an empirical study conducted at the University of Copenhagen that focused on didactic and cognitive aspects of the divergence of a vector field. Our data consist of videotaped lectures from the introductory course on vector calculus and interviews designed to identify students' main difficulties with understanding divergence. The results show that students struggle to connect the two most common definitions of divergence (partial derivatives in Cartesian coordinates and limit of a shrinking volume), rarely associate divergence with flux density and provide several images from fluid mechanics when asked explain the meaning of divergence. Not surprisingly, this is clearly related to the instruction they had.

Conflicts: If possible, please schedule my talk for July 19 or 20.

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No Yes

PER: Student Reasoning--G

Order

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Update

Abstract Title: Entanglement isn't just spin 5480

Paper Type: Contributed

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Schroedinger coined the term "entanglement" in 1935, but it took another 70 years for this vivid and useful word to make its way into most quantum mechanics textbooks. Even today we typically teach entanglement only in the context of spin systems, rarely mentioning the word when we discuss spatial wave functions. Meanwhile, when discussing wave functions of more than one variable, we almost always focus on those that factor into a product of single-variable functions, with no more than a passing mention of the vast variety of nonseparable wave functions. Yet for a two-particle system, these nonseparable wave functions are none other than the entangled states! Therefore, with only a minor modification to our teaching we can accomplish two important goals: avoid the common misconception that all wave functions are separable, and give students a more accessible introduction to entanglement.

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Abstract Title: Faraday Isolators and the Second Law of Thermodynamics 5162

Paper Type: Contributed

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Consider a Faraday isolator: two optical linear polarizers whose transmission axes are oriented 45 degrees relative to each other, between which is located a magnetic rotator that turns the plane of polarization of a beam of light by 45 degrees in the same direction regardless of the direction of propagation of the light. That constitutes a one-way light valve, used to protect lasers from harmful back-reflections. Now place a sample inside a cavity whose walls are made of this stuff. Light gets out but not back in, right? If so, the sample would radiate away all its energy and cool down to absolute zero! How do we save the second law from this catastrophe?

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Abstract Title: Framing Difficulties in Quantum Mechanics 5394

Paper Type: Contributed

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Researchers in student understanding of quantum mechanics have used the Difficulties framework to assess student reasoning, creating long lists of difficulties that span many

topics in quantum mechanics. We seek an underlying structure to these difficulties. Using the lens of epistemological framing, we mapped descriptions of published difficulties into errors in epistemological framing and resource use. We analyzed descriptions of students' problem solving to find their frames, and compared students' framing to framing (and frame shifting) required by problem statements. We found three categories of error: mismatches between students' framing and problem statement framing; inappropriate or absent transitions between frames; and insufficient resource activation within an appropriate frame. Given this framework, we can predict the kinds of difficulties that will emerge for a given problem in quantum mechanics: a possible deeper structure to student difficulties.

You have submitted comments on this item

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No Yes

PER: Student Reasoning--G

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Update

Abstract Title: Highlighting Two Prevalent Student Difficulties in Graduate Level Quantum Mechanics 5322

Paper Type: Contributed

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In our work with Physics graduate students at The Ohio State University, we have examined several prevalent misunderstandings that persist well into graduate level quantum mechanics. Here we focus on two difficulties: drawing bound states in an asymmetric well, and the confusion between symmetry under particle exchange and reflection symmetry (parity). Difficulties in drawing bound states were noted at the graduate level as early as 2008. But we find the asymmetric well reveals a new class of misunderstandings, including the fundamental misuse of axes and symmetry. We note also that students have difficulty interpreting drawings of bound states. The confusion between exchange symmetry and parity is demonstrated with multiple types of student data including quizzes and conceptual assessments. Our efforts suggest that simple awareness of the issue and precision of

language may be sufficient to correct the problem.

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PER: Student Reasoning--G

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Update

Abstract Title: Is There Room for Computation in Undergraduate Physics Courses? 5413

Paper Type: Contributed

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In making the case for the integrated inclusion of computation into virtually every undergraduate physics course (I think it should be done!), I am often confronted with the (very reasonable) protest that there is critically important material that would have to be dropped in order to accommodate computer problem-solving and all the attending programming platform baggage. I believe that there is, in reality, much that can be dropped from the traditional typical undergraduate physics course, especially upper level ones, to make room for the important marketable skill-building benefits of computation, without profoundly betraying the students' undergraduate physics preparation. Indeed, computation can, in many cases, provide better access to physical principles than a purely analytical approach. I will briefly describe a prototypical example, from the realm of quantum mechanical scattering, of a topic whose traditional mode of instruction should be dropped in favor of a computational treatment.

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No Yes

Technologies--G

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Update

Abstract Title: Learning About Liouville’s Theorem with ODE Solver Algorithms 5230

Paper Type: Contributed

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In this talk we will discuss a way to teach students about algorithms for solving systems of ordinary differential equations while also teaching them about Liouville’s Theorem. One way of stating Liouville’s theorem is that in conservative systems the dynamics of the system preserves the area of a region of phase space. Liouville’s theorem can be illustrated by using the Maxima computer algebra system to implement the non-symplectic Euler algorithm and the symplectic Euler-Cromer algorithm for the case of a 1D simple harmonic oscillator. The Euler-Cromer algorithm preserves the phase space area occupied by an ensemble of particles, while the Euler algorithm results in an increasing phase space area. This result is closely connected to the fact that the Euler-Cromer algorithm conserves the average energy over each oscillation while the Euler algorithm results in an increasing average energy. The numerical errors in the Euler algorithm behave like a driving force, effectively adding energy to the system and making the algorithm unstable. These examples help students learn that not all ODE solver algorithms are equally good while also helping students develop a qualitative understanding of Liouville’s theorem.

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Abstract Title: Modeling heat transfer in undergraduate Thermal Physics 5218
Paper Type: Contributed
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Students learn early on that Q=mc Delta T; the EFFECT of heat transfer is to change the temperature of an object. It is not unreasonable to also expect students to learn that the conduction of heat is CAUSED by a temperature difference between two objects; Fourier's law of heat conduction, dQ/dt = k A dT/dx. By combining these two equations, I will describe how students can build and use models of increasing sophistication--starting with paper and pencil and ending with computer simulations--in order to understand the phenomenon of heat transfer.

Footnotes: This project is funded by NSF IUSE grant DUE-1525062.

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Abstract Title: Multiple-Choice Assessment for Upper-division Electrodynamics 5352

Paper Type: Contributed

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Multiple-choice assessments are a standard tool for achieving reliable measures of certain aspects of students' conceptual learning in large introductory physics courses. It is harder to develop a multiple-choice assessment for upper-division physics because it involves greater emphasis on assessing students' reasoning in addition to their conceptual knowledge. A coupled-response format employed by the multiple-choice CUE (Colorado Upper-division Electrostatics) diagnostic has achieved great success. We further investigate this new testing format in upper-division electrodynamics content. Our goal is to preserve the insights afforded by the existing open-ended assessment, the CURrENT (Colorado UppeR-division ElectrodyNamics Test), while exploiting the logistical advantages of an objectively gradable instrument. We present the development, scoring, and preliminary analysis of validity and reliability of this multiple-response version of the CURrENT.

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No Yes

PER: Evaluating instructional strategies--G

Order

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Update

Abstract Title: The Effectiveness of “Pencasts” in undergraduate curriculum 5397

Paper Type: Contributed

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Pencasts are videos of problem solving with narration. Pedagogically, instructors can use

pencasts to model problem solving for their students, uploading the videos for students to watch outside of class. Alternately, students can create pencasts to illustrate their own problem solving to the instructor or to their peers. In this talk, we describe the use of pencasts in an upper-division Electromagnetic Field course usually taken by junior or senior physics majors. For each homework students created and submitted pencasts of ordinary homework problems several days before the problem set was due. We compare students' performance in the class (grades for pencast submission excluded) with the pencast submission rate. Students who submit more pencasts do better in the course. We conclude with some practical suggestions for implementing pencasts in other courses.

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No Yes

PER: Student Reasoning--G

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Date Last Updated: February 4, 2011