



The Paradigms in Physics Project at Oregon State University has reformed the entire upperdivision curriculum for physics and engineering physics majors. This has involved both a rearrangement of content to better reflect the way professional physicists think about the field and also the use of a number of reform pedagogies that place responsibility for learning more firmly in the hands of the students. The junior year consists of short case studies of paradigmatic physical situations which span two or more traditional subdisciplines of physics. The courses are designed explicitly to help students gradually develop problem-solving skills. We have developed many effective classroom activities that are documented on our wiki. Along the way we are also learning what it takes to design and implement large-scale modifications in curriculum and to institutionalize them.

PARADIGMS C

Paradigms (P) & Capstones (C)

The junior year consists of short case studies of paradigmatic physical situations which span two or more traditional subdisciplines of physics. Most have both a classical and quantum base. They are designed explicitly to help students gradually develop problem-solving skills. The senior year consists of more conventional singlequarter lecture classes in each of the traditional subdisciplines of physics. The format is more condensed than in the old, traditional curriculum because the content builds on the examples of the paradigms in the junior year. An overview of our curriculum is shown at right.

CURRICULUM	1		DISSEMINATION
Jr P•Symmetries & Idealizations •Static Vector Fields •OscillationsSr C•Math Methods •E & M	 1-D Waves Spin & Quantum Measurements Central Forces Quantum Mechanics Thermal Physics Optics Lass Mechanics 	Textbooks "Paradigms In Physics: Quantum Mechanics" David H. McIntyre, Corinne A. Manogue, & Janet Tate (Addison Wesley, publication late 2011). "The Geometry of Vector Calculus" Tevian Dray & Corinne A. Manogue physics.oregonstate.edu/BridgeBook (Online text, 2010). "The Geometry of Special Relativity" Tevian Dray physics.oregonstate.edu/coursewikis/GSR (Online text, 2010). "Thermal Physics: Concepts and Practice" Allen Wasserman (Cambridge Press, publication summer 2011).	We http://www.physics.orego This wiki site contains: 1. An introduction and overview of the projects for the 2. Information for institutions interested in adopting of or developing new upper-division curricula of their information about workshops, links to publications, for the new courses, and descriptions of individual 3. Detailed materials for many of the new courses: •Case studies of learning through small group act •Instructor's Guides •Videos of classroom practice •Advice about how to use active engagement stra •Narratives of classroom activities •Textbooks
		EXAMPLES	RE
with a number of and independent S tion from each student, ge-enrollment courses. ady know about a topic ion ented	 middle of the junior year. In a measurent Gerlach spin experiments (Schroeder & from "data" as in real experiments. (Traces in the second secon	idents to begin their exploration of quantum mechanics earlier, in the nent-based approach using a computer simulation of successive Stern-Moore, Am. J. Phys. 61 , 798-805, 1993), students infer the state vector ditional curricula approach these problems backwards: predicting the unknowable wave function.) This spins first approach is the basis of a sith publication expected in late 2011.	 2. The <u>data</u> we use to measure impact incluse problem solving sessions, (2) feedback from advisory board, (4) video tapes of classrop and (6) feedback from wiki users. 3. The <u>methods</u> to collect this data include (1 students, (4) focus groups of students and exams. 4. <u>Key findings</u>: (1) We have identified typical these with explicit active engagement class difficulties in adopting active engagement our wiki to address this. (3) We have iden reasoners (i.e., they do not spontaneously designed activities that require students to problems that students have transferring to develped explicit classroom activities that
<text></text>		• Excel FFT • CUPS FFT • Labview aple activity where students are asked to guess the Fourier coefficient nctions. It is designed to develop students' Fourier intuition and also to pointwise. y(x) $y(x)$	

PEDAGOGY

Types of Active Engagement

Long blocks of class time have allowed us to experiment with different pedagogies which encourage both collaborative ar learning.

- •Small group activities
- •Simulations
- Maple/Mathematica visualization
- Integrated laboratories
- •Kinesthetic activities
- •Small white board questions

Example: Small white board questions

Small whiteboards are used to invite classroom participatio similar to electronic classroom responses systems in large **Examples:**

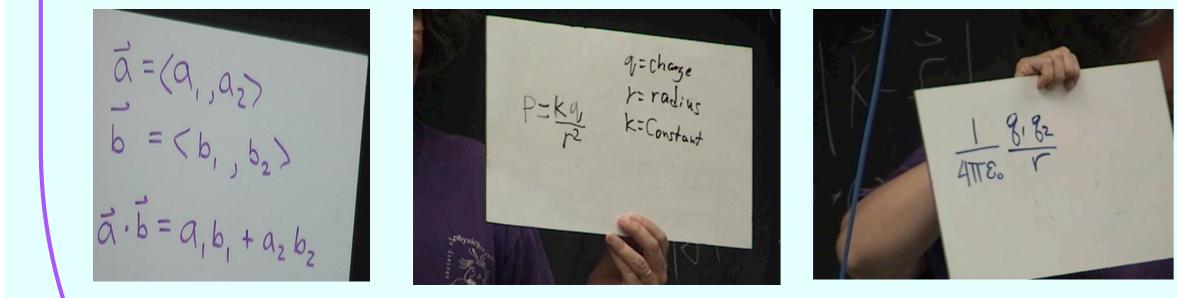
Review: Ask students to write down what they already **Recall:** Ask students to recall a specific formula

Compute: Ask students to perform a short calculation

Apply: Ask students to apply what you've just presen

Translate: Ask students to express something in a ne

Next Step: Ask students to do the next step in a deriv



ACKNOWLEDGEMENTS

PARADIGMS IN PHYSICS - OREGON STATE UNIVERSITY **REVISING THE UPPER-DIVISION CURRICULUM**

	EXAMPLES)
Early Quantum Mechanics		
Our rearrangement of content allows students to middle of the junior year. In a measurement-base Gerlach spin experiments (Schroeder & Moore, / from "data" as in real experiments. (Traditional of results of experiment from "knowing" the unknow new textbook on quantum mechanics, with public	sed approach using a c Am. J. Phys. 61 , 798-8 curricula approach thes vable wave function.)	computer si 05, 1993), se problem This spins
Oven Analyzer Magnet Counter		$ -\rangle$
Fourier Activities Fourier analysis is integral to several of the enhance student learning.	Paradigms courses, a	and we use
C C	<u>Tool</u>	<u>Outco</u>
Guess coefficients	Maple	 Intuiti
Calculate coefficients (paper & comp)	Paper, Maple	Mathe
Transform impulse response	Excel FFT	Dual
Periodic system mode frequencies	CUPS FFT	Norm
• FFT experiments •	Labview	 Aliasi
The plots shown below are from a Maple active a simple linear combination of sine functions.	It is designed to dev	
make sure they know how to add functions po	ointwise. y(x)	$ \begin{array}{c} $
Maple coding:		$\begin{array}{c} v \\ 3 \\ 2 \\ 2 \\ 1 \\ 2 \\ 1 \\ 1 \\ 2 \\ 1 \\ 1 \\ 2 \\ 1 \\ 1$
$y(x) = 4\sin x \left(1 - \cos x\right) - 4\sin^3 x$	guess	
Fourier series: $y(x) = \sin x - 2\sin 2x + \sin 3x$	difference	
National Science Foundation		Oregon Sta

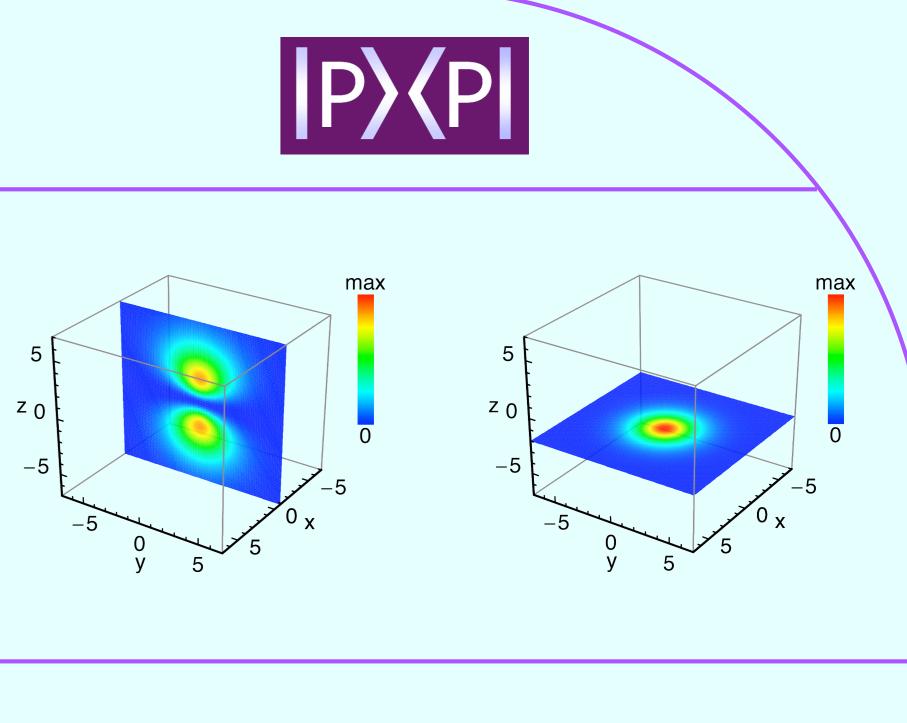
•DUE-9653250, 0231194, 0618877 •DUE-0088901, 0231032



The Development Team

FACULTY: Corinne A. Manogue David H. McIntyre **Janet Tate** Tevian Dray Emily Van Zee **Barbara Edwards** David Roundy Allen L. Wasserman Philip J. Siemens

William M. Hetherington Henri J. F. Jansen Kenneth S. Krane Albert W. Stetz William W. Warren, Jr. Yun-Shik Lee Ethan Minot **Dedra Demaree** Elizabeth Gire (postdoc)



ate University •Department of Physics •College of Science •Academic Affairs



Mount Holyoke College •Hutchcroft Fund



/ebsite

gonstate.edu/portfolioswiki

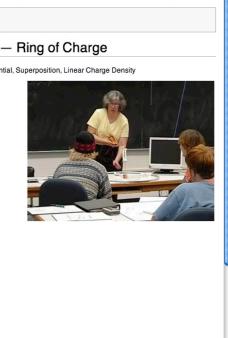
the interested public. our curriculum eir own, including ns, detailed syllabi al activities.

activities

trategies

A A	You are here: start » activities » test » main
	Electrostatic Potent
navigation	Keywords:Upper-division, E&M, Electrostatic
About	Highlights of the Activity
Activities Arranged by Physics Content Activities Arranged by Classroom Strategy Courses How students learn = Content Order = Constructing Curduum	 In this activity, students work in small groups to write the electrostatic potential in all space due to a charged ring. The groups are then asked to expand this potential in a series, either on the axis or the plane of symmetry, and either close to the center of the charge distribution or far away. A follow-up class discussion highlights the role of symmetry in this calculation.
= Problem-solving	Reasons to spend class time on the activity
Sequences of Activities Importance of Reflection What Students Don't Know Importance of Logical Argument Student Problems	The first concept students need to understand is linear charge density. Students must grapple with the underlying concept of charge density, but also understand how this linear density relates to the "chopping and adding" aspect of integration. Students frequently leave math classes understanding integration as "the area under a curve". This activity pushes students to transform their understanding of integration to focus on "chopping and adding".
with Notation Storytelling Concept Maps Importance of Laughter How	This activity also gives students the opportunity to use curvilinear coordinates and then realize that they cannot successfully integrate without transforming them into rectangular coordinates. Understanding that (r - t') cannot be integrated by simply using "r" in curvilinear coordinates in an important collision.
departments/teachers change	coordinates is an important realization. The final component is that students need to recognize an elliptic integral and what to do when they run into one. Most commonly student have never seen such "unsolvable" integrals in their calculus classes.
Links Recent Changes 6	Authors:Corinne A. Manogue, Len Cerny

here: start » activities » test » m Electrostatic Potential — Ring of Charge Keywords: Upper-division, E&M, Electrostatic Potential, Superposition, Linear Charge Dens ghts of the Activity is activity, students work in small group e center of the charge distribution or far aw this calculation. ons to spend class time on the activity



To edit this page, go here.

ESULTS

are (1) textbooks on Quantum Mechanics, Vector odynamics; (2) a wiki web site with curricular materials r understanding of student reasoning in upper division

clude (1) interviews of students during think-out-loud from adopting faculty, (3) feedback from our national room activities, (5) feedback from textbook reviewers,

(1) surveys, (2) classroom videotapes, (3) interviews of and adopters, and (5) copies of student homework and

ical difficulties with student reasoning and addressed lassroom materials. (2) We have identified typical faculty ent strategies and have included multiple resources on entified that students at this level are not harmonic Isly transition between algebra and geometry). We have to change representations. (4) We have identified g their mathematics expertise to physics and have nat require students to bride this gap.

ublications

Understand Motion on a Rotating Sphere, American

and K. Browne (Department of Physics) & M. L. Niess e and Mathematics Education), Paradigms in Physics: A can Journal of Physics 69, 978-990 (2001).

Pregon State University Paradigms Project: Reoday **56**, 53-58 (2003).

erentials to Bridge the Vector Calculus Gap, College

nd B. Edwards, Why is Ampere's law so hard? A look at nal of Physics, 74, 344-350 (2006).

ogue, Integrating Computational Activities into the Upperat Oregon State University, American Journal of

