PARADIGMS PROJECT — MULTIPLE ENTRY POINTS

OREGON STATE UNIVERSITY

Paradigms in Physics Project

The Paradigms in Physics Project at Oregon State University has reformed the entire upper-division 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. We have developed many effective classroom activities and we are also learning what it takes to design and implement large-scale modifications in curriculum and to institutionalize them.

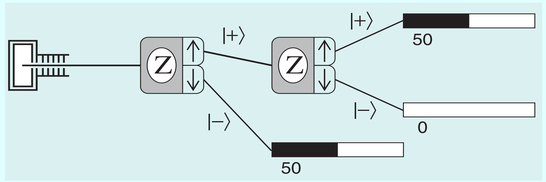
Vector Calculus Bridge Project

There is a "vector calculus gap" between the way vector calculus is usually taught by mathematicians and the way it is used by others. This material is essential for physicists and some engineers due to its central role in the description of electricity and magnetism. This project seeks to bridge the gap by emphasizing geometric visualization and multiple representations.

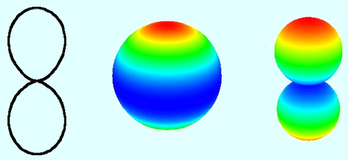
QUANTUM MECHANICS TEXTBOOK

We are writing an upper-division quantum mechanics textbook, to be published by Pearson Education. Features of the textbook include:

- Content rearrangement: early introduction of the postulates with spin as the central example.
- A measurement-based approach where students infer the wave function from "data" as in real experiments. (Traditional curricula approach these problems backwards: predicting the results of experiment from "knowing" the unknowable wave function.)
- Natural incorporation of student engagement activities, especially computer simulation of successive Stern-Gerlach experiments (Schroeder & Moore, Am. J. Phys. **61**, 798-805, 1993) and Maple/Mathematica visualization.
- Emphasis on the role of eigenstates in diverse contexts and time dependence.
- Incorporation of modern topics (*e.g.* Bell's inequalities, neutrino oscillations, quantum computing).



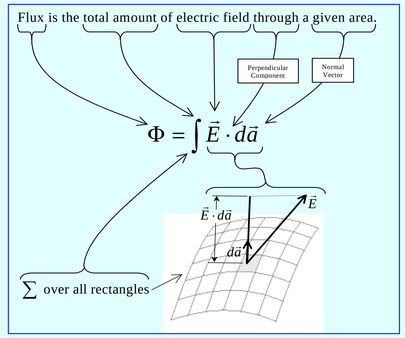
Spins applet



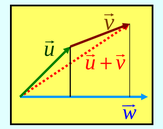
$Y_{10}(\theta,\phi)$ polar plot, color plot, and combined plot

THE GEOMETRY OF VECTOR CALCULUS

We are writing an informal text emphasizing the geometry of vector calculus and its application to electromagnetism, for use in both math and physics courses.



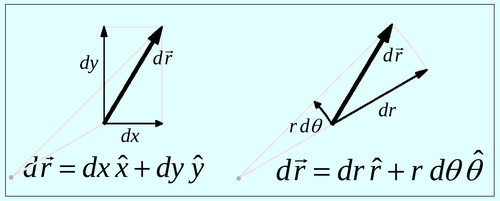
Multiple representations



Geometry of the dot product

$$df = \vec{\nabla} f \cdot d\vec{r}$$
$$ds = |d\vec{r}|$$
$$d\vec{S} = d\vec{r}_1 \times d\vec{r}_2$$

Vector differentials



Adapted coordinates and basis vectors

DEVELOPMENT TEAM

Design Team

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Partners

The main focus of our current work is the dissemination of our materials to other institutions. We are always looking for other institutions to test our materials and to partner with us in their further development. If you are interested, please contact us!

Texas A&M APPEAL project:
Jairo Sinova, Peter McIntyre, Vince Rossi, Tracy Rossi
Open Source Physics project (OSP):
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Ithaca College:
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Central Washington University:
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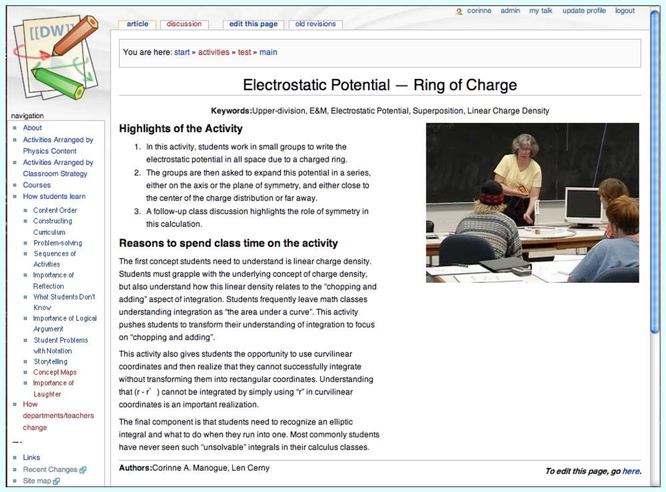
ONLINE DISSEMINATION OF ACTIVITIES

Our materials will be available online, both through the National Science Digital Library (NSDL) and our own website.

The website will include:
- Case studies of learning through small group activities
- Instructor's Guides
- Videos of classroom practice
- Advice about how to use active engagement strategies.

Types of Active Engagement
- Small group activities
- Simulations
- *Maple/Mathematica* visualization
- Integrated laboratories
- Kinesthetic activities
- Small white board questions

Activity Topics
- E & M
- Quantum Mechanics
- Waves
- Thermal Physics
- Vector Calculus
- Linear Algebra
- Classical Mechanics
- Optics



RESULTS

Websites

http://www.physics.oregonstate.edu/paradigms
http://www.physics.oregonstate.edu/portfolioswiki
http://www.math.oregonstate.edu/bridge

Publications

1. D. H. Mcintyre, J. Tate, and C. A. Manogue, *Integrating Computational Activities into the Upper-Level Paradigms in Physics Curriculum at Oregon State University*, Am. J. Phys. (to appear).
2. T. Dray and C. A. Manogue, *The Geometry of the Dot and Cross Products*, JOMA **6**, June 2006.
3. C. A. Manogue, K. Browne, T. Dray, and B. Edwards, *Why is Ampère's law so hard? A look at middle-division physics,* Am. J. Phys. **74**, 344-350 (2006).
4. T. Dray and C. A. Manogue, *Bridging the Gap between Mathematics and the Physical Sciences*, in **Preparing Future Science and Mathematics Teachers**, eds. D. Smith and E. Swanson, MSU, Bozeman, 2005, pp. 39-41.
5. T. Dray and C. A. Manogue, *Using Differentials to Bridge the Vector Calculus Gap*, College Math. J. **34,** 283-290 (2003).
6. T. Dray and C. A. Manogue, *Spherical Coordinates*, College Math. J. **34**, 168-169 (2003).
7. C. A. Manogue and K. S. Krane, *The Oregon State University Paradigms Project: Re-envisioning the Upper Level*, Physics Today **56**, 53-58 (2003).
8. C. A. Manogue, P. J. Siemens, J. Tate, and K. Browne (Department of Physics) & M. L. Niess and A. J. Wolfer (Department of Science and Mathematics Education), *Paradigms in Physics: A New Upper-Division Curriculum*, Am. J. Phys. **69,** 978-990 (2001).
9. D. H. McIntyre, *Using Great Circles to Understand Motion on a Rotating Sphere*, Am. J. Phys. **68**, 1097 (2000).

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•Hutchcroft Fund

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•Noyce Visiting Professorship