Supporting Education with Online Computational Physics Resources

Distance Education and Online Learning in Physics Workshop
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American Center for Physics, College Park, MD

Wolfgang Christian Davidson College, US

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The relations between content, pedagogy and technology are complex and nuanced. Technologies often come with their own imperatives that constrain the content that has to be covered and the nature of possible representations. So it may be inappropriate to see knowledge of technology as being isolated from knowledge of pedagogy and content.

(Mishra and Koehler 2006)
Online Open Source Physics Resources

Open Source Physics (OSP) provides curriculum resources that engage students in physics, computation, and computer modeling. Computational physics and computer modeling provide students with new ways to understand, describe, explain, and predict physical phenomena. This workshop explores Physlets, EJS, and the ComPADRE OSP Collection.

- Physlets are small interactive Java applets that are designed for the teaching physics in a web-based environment. **Physlet Physics** contains a collection of over 800 items spanning the introductory physics sequence. Every chapter of Physlet Physics contains three quite different Physlet-based exercises: Illustrations, Explorations, and Problems.

- **Easy Java Simulations** encourages modeling and authoring with basic programming. EJS removes many of the complicated tasks involved in integrating computation into the classroom allowing students and teachers to focus on the science. The EJS environment allows learners to explore new physics and to test the limitations of the models being used.

- The **OSP Collection** is a ComPADRE repository where EJS models and OSP-based curricular materials can be organized and shared.
Physlet Physics on ComPADRE

Chapter 1: Introduction to Physlets

Illustrations
- 1.1: Static Text Images Versus Physlet Animations
- 1.2: Animations, Units, and Measurement
- 1.3: Getting Data Out

Explorations
- Exploration 1.1: Click-Drag to Get Position.
- Exploration 1.2: Input Data, Numbers.
- Exploration 1.3: Input Data, Formulas.

Problems
- Problem 1.1: Use a caliper to measure different objects.
- Problem 1.2: Getting data from an animation to a graph.
- Problem 1.3: Drag the Monster Truck.

Mechanics TOC
Overview TOC

Distance Education & Online Learning
The Davidson College Physics Department has adopted the open source Moodle platform as its preferred course management system. Not only does this platform provide well organized course content for students, it encourages collaboration and provides an opportunity for outreach.

The Moodle course management system allows instructors to organize materials from multiple sources and reassemble them into a personalized course.
Computational Physics

College-level teaching should reflect current research and professional practice and computation provides many excellent topics. Every undergraduate physics major should know about computational physics, including essential algorithms, minimal level of programming experience, and computational ways of thinking.

- Differential equations and ODE numerical algorithms: Newtonian orbits and N-body orbits. Molecular dynamics
- PDEs and boundary value problems: Laplace and Poisson equations.
- Stochastic models and Monte Carlo algorithms: Ising model and demon algorithm
- Chaos theory: Logistic map and double pendulum
- Projects of the student’s choice.
Student Projects (shared filing cabinet)

- **Hyperion Orbit** (J. Barrick)
- **Lightning** (S. Castle)
- **Lattice gas** (B. Gautier)
- **2D Traffic Flow** (F. Healy)
- **Lorentz Gas** (S. Keller)
- **Fractals** (S. Mohammed)
- **Forest Fires** (M. Mohorn)
- **Catastrophe Theory** (D. Glassman)
- **Javelin Throw** (P. Wall)
PHYSICS 200: Computational Physics
Spring 2013

Instructor: Wolfgang Christian  Office: Dana 142  Tel: 704-894-2322
Tutorials: MWF 9:30-10:20 in the Learning Resource Center in Chambers

Computational Physics Q&A

We continue our study of the EJS modeling environment by building simple time dependent models. Readings and in-class examples will cover the following:

- Time-dependent functions
- Parsers
- Object and their methods

Time Dependent Models
Engelhardt EJS Introduction
Class Notes
Project 1: Gravitational Potential Plot
Videos

Introduction To Modeling  Time Dependent Models  Introduction to Differential Equations
Modeling Cycle

- The goal of modeling is to teach in a student-centered environment where students do not solve problems in a formula-centered way.
- Modeling Instruction attempts to enhance student achievement through a process called the **Modeling Cycle**, (following Robert Karplus’ Learning Cycle).
- Throughout the Modeling Cycle we rely on student engagement and explanation as the dynamic of learning.
- The start of the modeling cycle is the development phase:
  - Qualitative description
  - Identification of variables
  - Planning an experiment
  - Performing the experiment
  - Analysis of experiment
  - Presentation of results
  - Generalization

Although the Modeling Cycle can be used without computers, it is well suited for computer modeling if we replace the word “experiment” with “simulation” in the development phase.

After the development phase, the model is deployed in a variety of new physical situations in a variety of different ways.
Computational Modeling

- Modeling is thinking about things in terms of simpler artificial things. Computer modeling is about implementing these artificial things using code and having these code Object evolve and interact via algorithms.

- Course Activities
  - Bi-weekly exploratory models engage the student in ideas presented by an expert (teacher). Students are led to confront another's view of a problem.
  - Mid-term and final projects are expressive activities that require students to externalize their own ideas and assumptions and to create concrete representations that they can experiment with and reflect on.

One problem with our system of education is that we reward students for knowing the answers to questions they have never asked.
“But in my view, the most important implication of choosing a web-based technology is the way it facilitates sharing.” Joe Redish 2001
Personalization

Content ...
• Find
• Collect
• Sort
• Relate
• Annotate
• Share

Distance Education & Online Learning
The **OSP-ComPADRE platform** removes many of the complicated tasks involved in integrating computation into the classroom allowing teachers to focus on the science. OSP provides the computational structure, including a computational physics textbook, for our project. The ease with which models can be modified in the EJS environment allows learners to explore new physics and test the limitations of the models being used. This also encourages the sharing of curricular materials by allowing instructors to adapt existing EJS models to their particular needs. The third piece of the platform, the ComPADRE digital library, supports distribution and collaboration by providing an internet portal and a web service of models that are directly downloadable into the EJS modeling tool.

The OSP Collection in ComPADRE is a repository where programs, models, and curricular materials can be organized and shared by developers and instructors around the world. Any user can connect directly to this, and other, collections and download materials. Easy library access also encourages contributions to the library.
OSP Collection Team

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- **ComPADRE:**
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  - Lyle Barbato- AAPT
  - Matt Riggsbee- AAPT
  - Caroline Hall- AAPT
Open Source Physics

In 2012, the OSP Collection had 500,000 page views and 22,000 visits from visitors returning six or more times. More importantly, there were 50,000 simulations downloaded from the Collection and many additional source code downloads from within EJS into users’ workspaces. Physlets and the OSP Collection are recognized by over 50% and 22%, respectively, of United States physics faculty as a research-based instructional strategy they are familiar with or have used.

www.compadre.org/osp