USING PHYSLETS AND EASY JAVA SIMULATIONS TO TEACH PHYSICS AND ASTRONOMY

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Wolfgang Christian, Doug Brown, Anne Cox, Francisco Esquembre, Harvey Gould, Todd Timberlake, and Jan Tobochnick

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(DUE-0442581, DUE-0126439, and DUE-9752365)

Our Approach

Open Source Physics (OSP) **Project** provides curriculum resources and tools that engage students in astronomy & physics, computer modeling, and computation with the goal of providing students with new ways to understand, describe, explain, and predict physical phenomena.

- One HTML page ….one Java applet …..one idea/one concept.
- One Java application….one Java simulation…..one idea/one concept.
- One HTML page ….one JavaScript simulation…..one idea/one concept.
- One eBook page ….one JavaScript simulation…..one idea/one concept.

OSP Resource Overview

- Open Source Physics: www.compadre.org/OSP/
- Physlet Physics 2E: www.compadre.org/Physlets
- Physlet Quantum Physics 2E: www.compadre.org/PQP
- Tracker Video Analysis Tool: www.cabrillo.edu/~dbrown/tracker/
- Easy Java/JavaScript Simulations (EJS/EjsS): fem.um.es/Ejs/

Our Group

- OSP Java Code: Wolfgang Christian
- EJS: Paco Esquembre and Felix Garcia
- ComPADRE: Bruce Mason, Matthew Riggsbee, and Lyle Barbado
- JavaScript Simulations: WC, Todd Timberlake, and Michael Gallis
- *Physlet Quantum Physics 2E* : Anne Cox, WC
- Introductory astronomy text: Kristen Thompson

Why might we want to use simulations in teaching physics?

Colliding Galaxies: The Mice

http://www.compadre.org/osp/items/detail.cfm?ID=11246

How can we use simulations in teaching physics?

- **User:** Students access pre-made simulations that (hopefully) they must interact with.
- **Modeler:** Students are given access to a software package with a simple user interface. Students must then simulate the physics of a problem by modeling at a high level of abstraction. For example, adding the physics in the form of differential equations (rates of change) and initial conditions.
- **Programmer:** Students are given tools to program a physics example using traditional computational physics techniques.

What Level of Course?

- **Non-Science Major/Astronomy**
- **Introductory Physics and Astronomy**
- **Major-Level Courses**
- **Introducing Current Research into Courses**

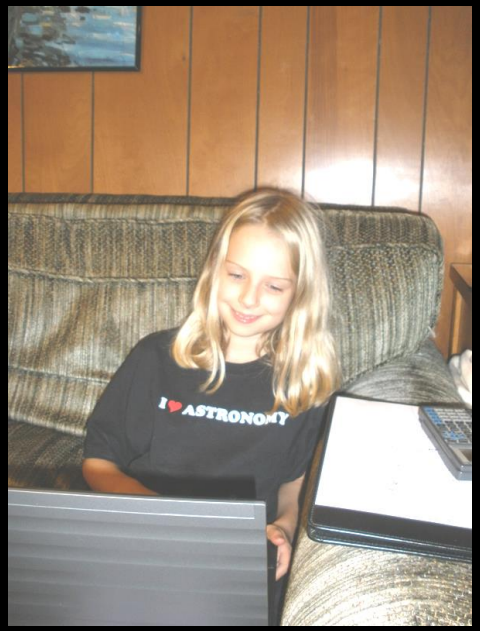
But expectations, outcomes, and scaffolding are different

What version you use will be related to the course you are teaching, your student body, and your expertise.

In general…

…the less sophisticated the student,
the more sophisticated the user interface
...and the more interactive, the better….

...keeping in mind that
technology without pedagogy...
...is just technology.



Coupling Simulation with Pedagogy

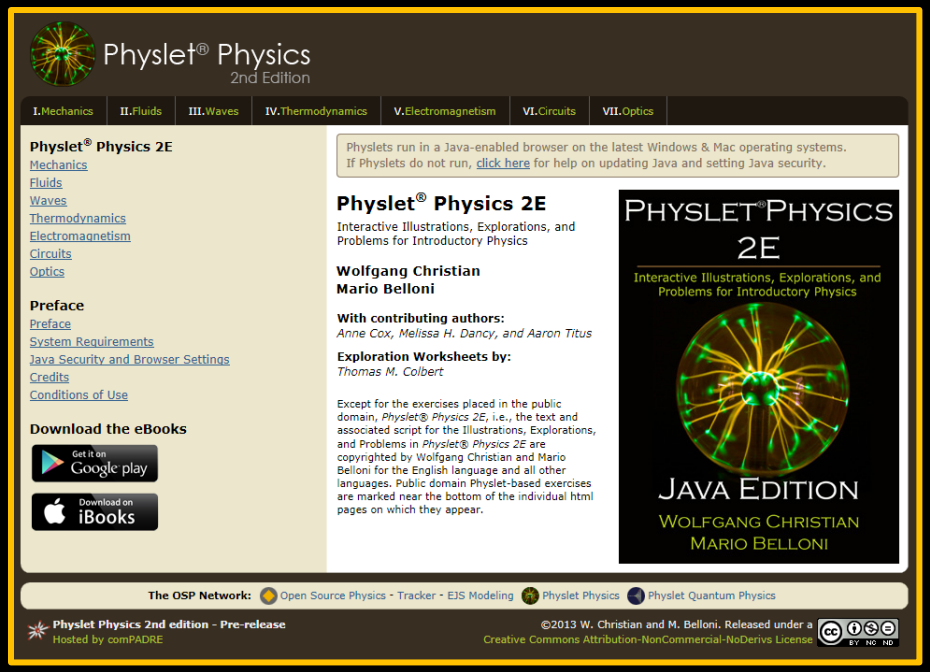
- **User:** Students access pre-made simulations that they must interact with.
- Pedagogies:
  - Peer Instruction / Think-Pair-Share / Clickers
  - Just-in-Time Teaching
  - Guided Inquiry/Tutorial
  - Group Problem Solving
  - Lecture Demonstration
  - TIPERs (Ranking Tasks, etc)
  - In-class Exercise
  - Homework
  - Laboratory Exercises (pre-lab, in-lab, post-lab)
  - Etc.

1,000 PHYSLET-BASED EXERCISES ON COMPADRE

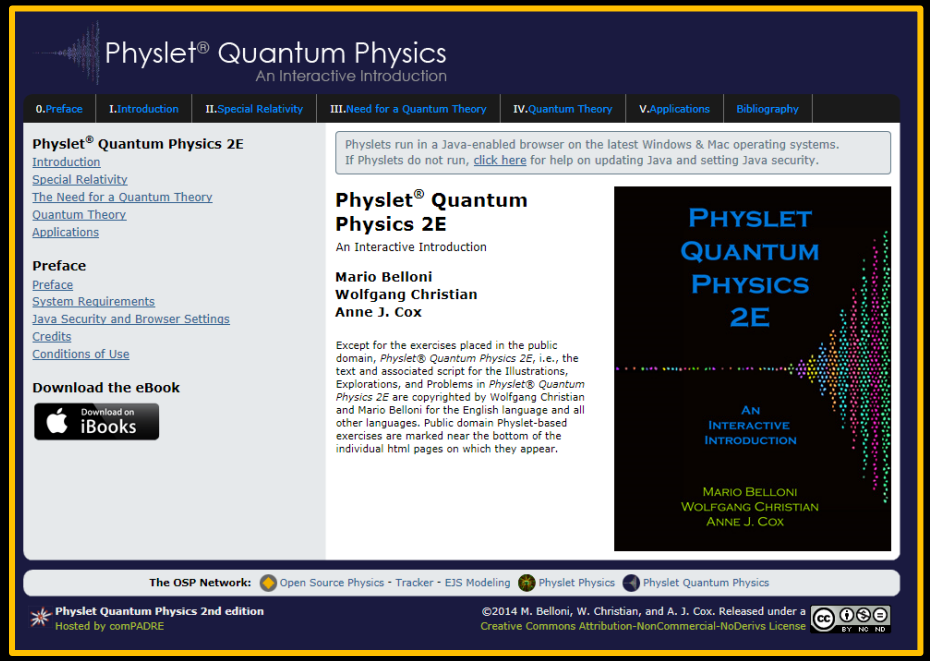
Physlets — "Physics applets" — are small, flexible Java applets that are ...

- Visual and interactive
- Flexible (modular and scriptable)
- Uniform User Interface
- Pedagogically adaptable
- Web based with Java-enabled browser (e.g., IE, Safari, Firefox, Opera).
- Free for noncommercial use.

www.compadre.org/PQP

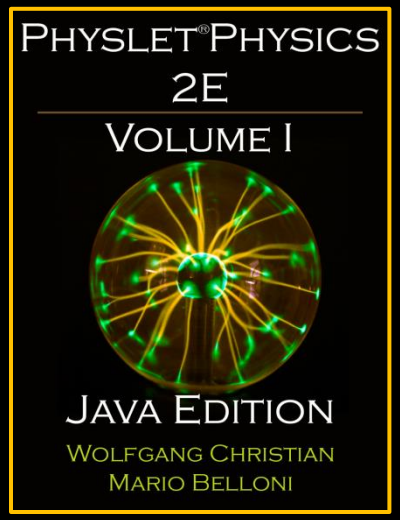


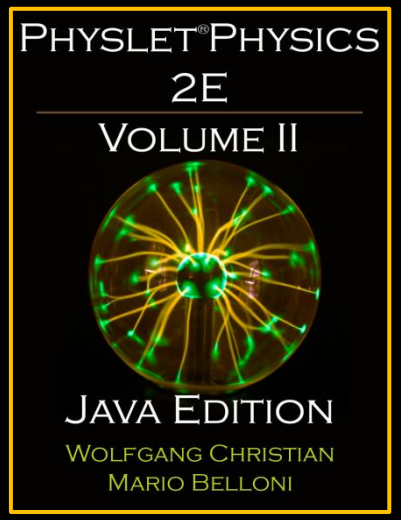
www.compadre.org/Physlets

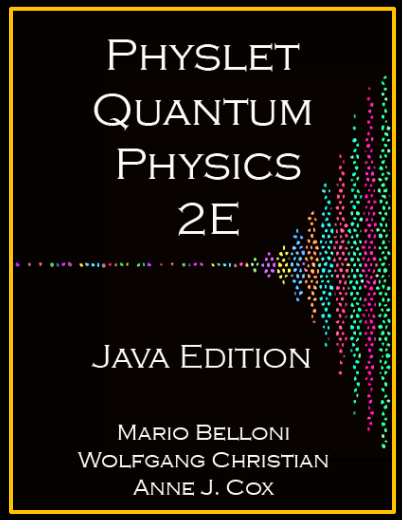


PHYSLETS ON ITUNES AND GOOGLE PLAY

eBooks: Physlet Physics 2E Volumes I & II and PQP 2E are in epub3 format. On Macintosh and Windows computers, books link and run interactive content on ComPADRE; runs with narrative only on all tablets.

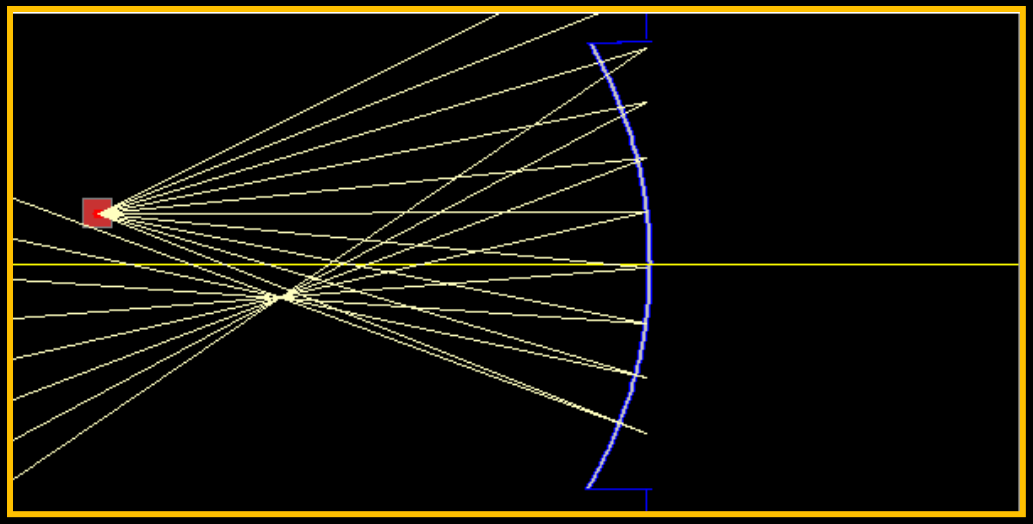






These electronic books are available for free on iTunes and the Google Play store.

JiTT Example: Physlets

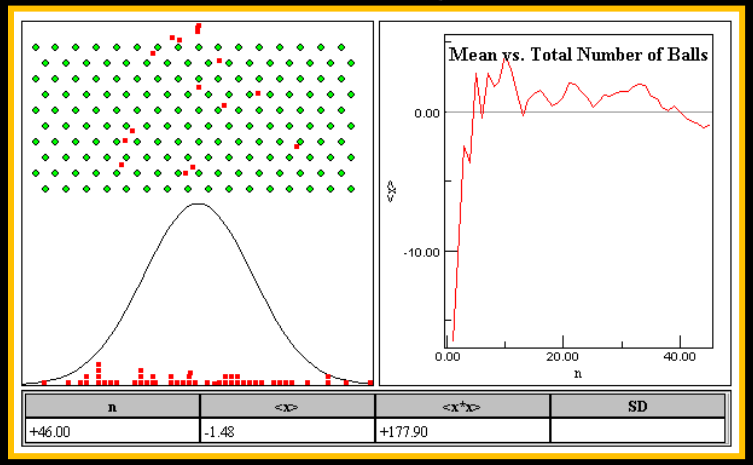


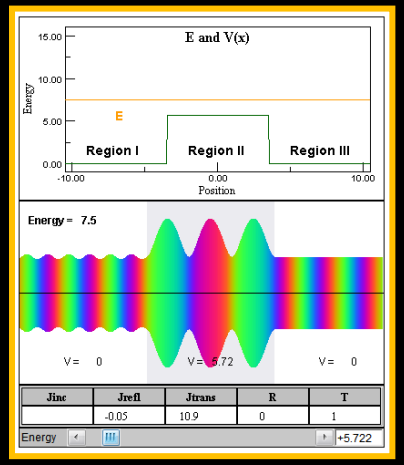
A point source is located to the left of a mirror. You can drag this point source to any position **(position is given in meters and angle is given in degrees)**.

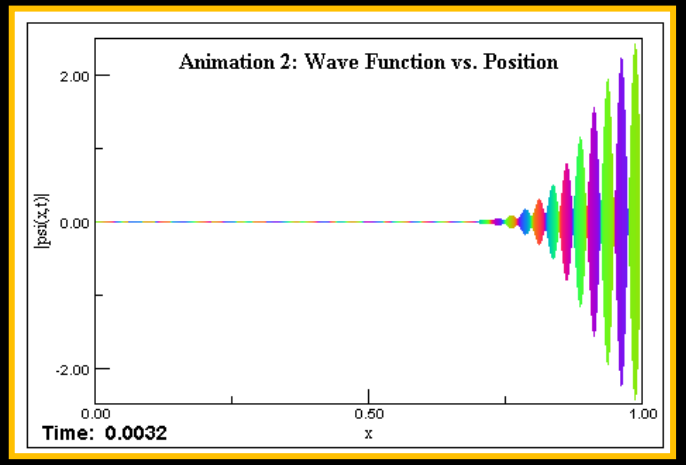
1. Find the focal length of the mirror.
2. Describe the technique you used to determine the focal length.

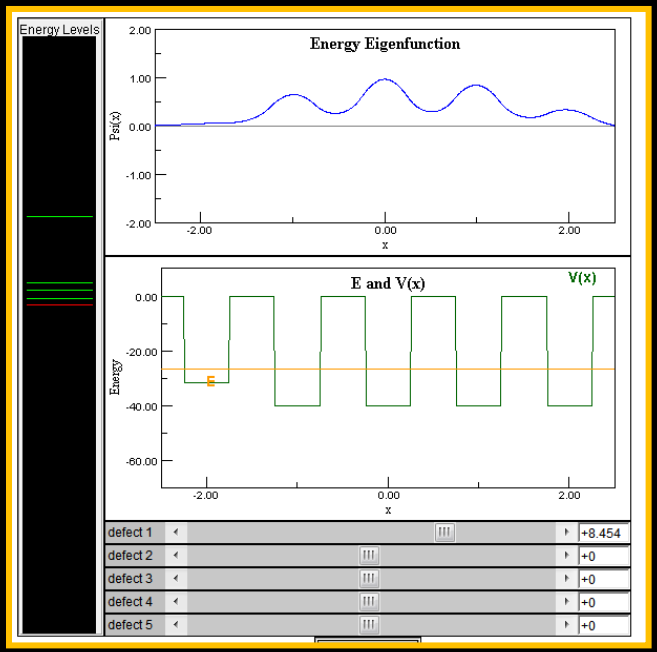
http://www.compadre.org/Physlets/optics/prob33_1.cfm

PQP 2E on ComPADRE

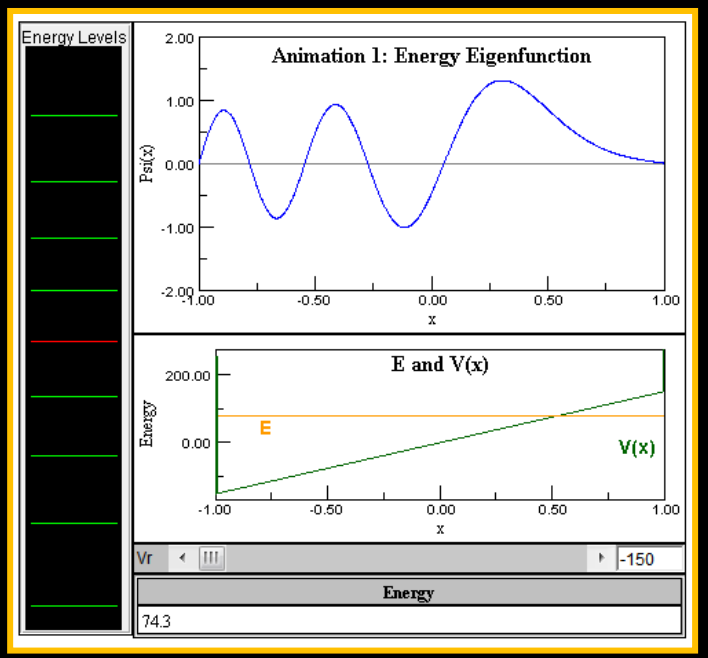








- sp. relativity
- modern physics
- classical/qm
- eigenfunction shape
- time evolution
- scattering
- non-standard qm wells
- atomic physics
- stat mech



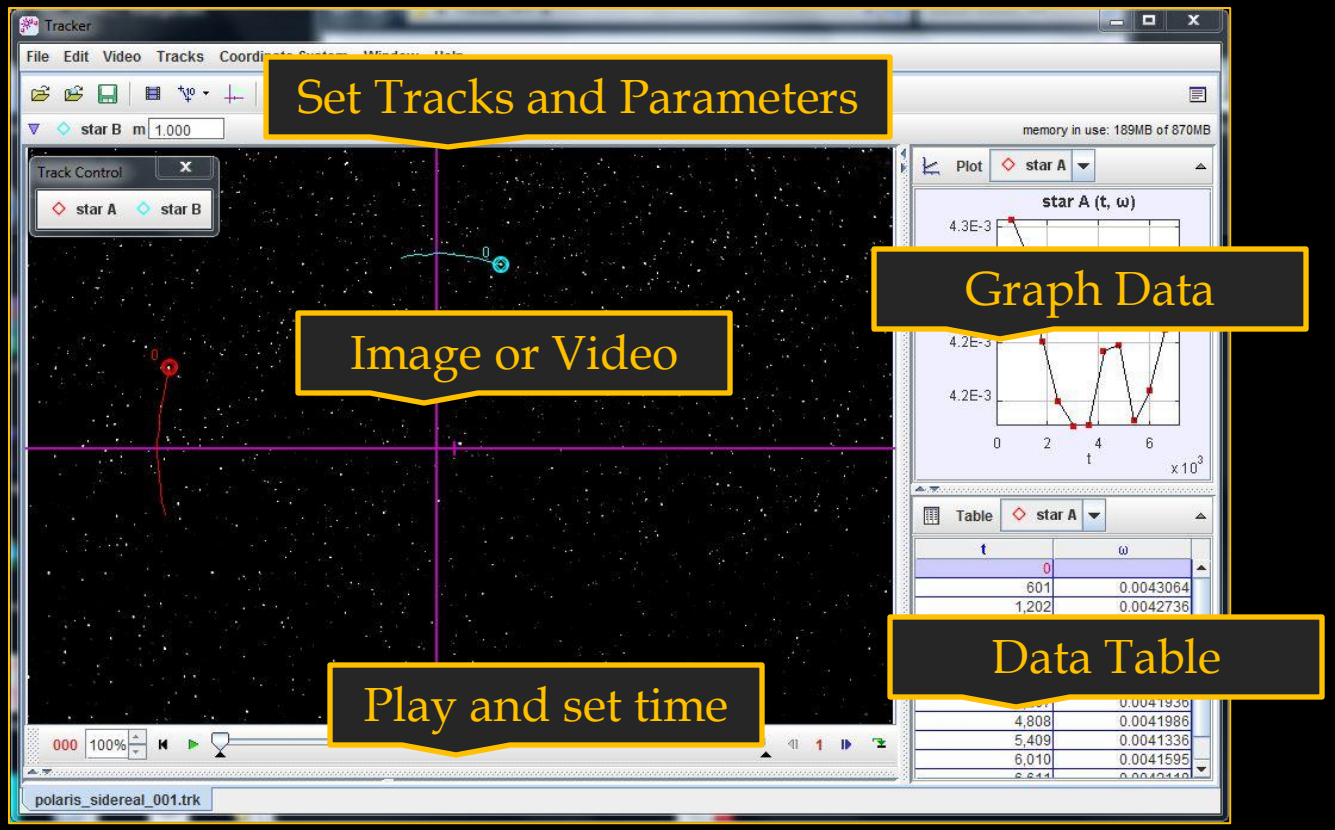
OSP: Coupling Simulation with Pedagogy

Modeler: Students (intro, classical mechanics, computational physics) are given access to a software package with a simple user interface. Students simulate the physics of a problem by modeling at a high level of abstraction. For example, adding the physics in the form of differential equations (rates of change) and initial conditions.

- **Tracker:** is a free and open source video analysis software program.

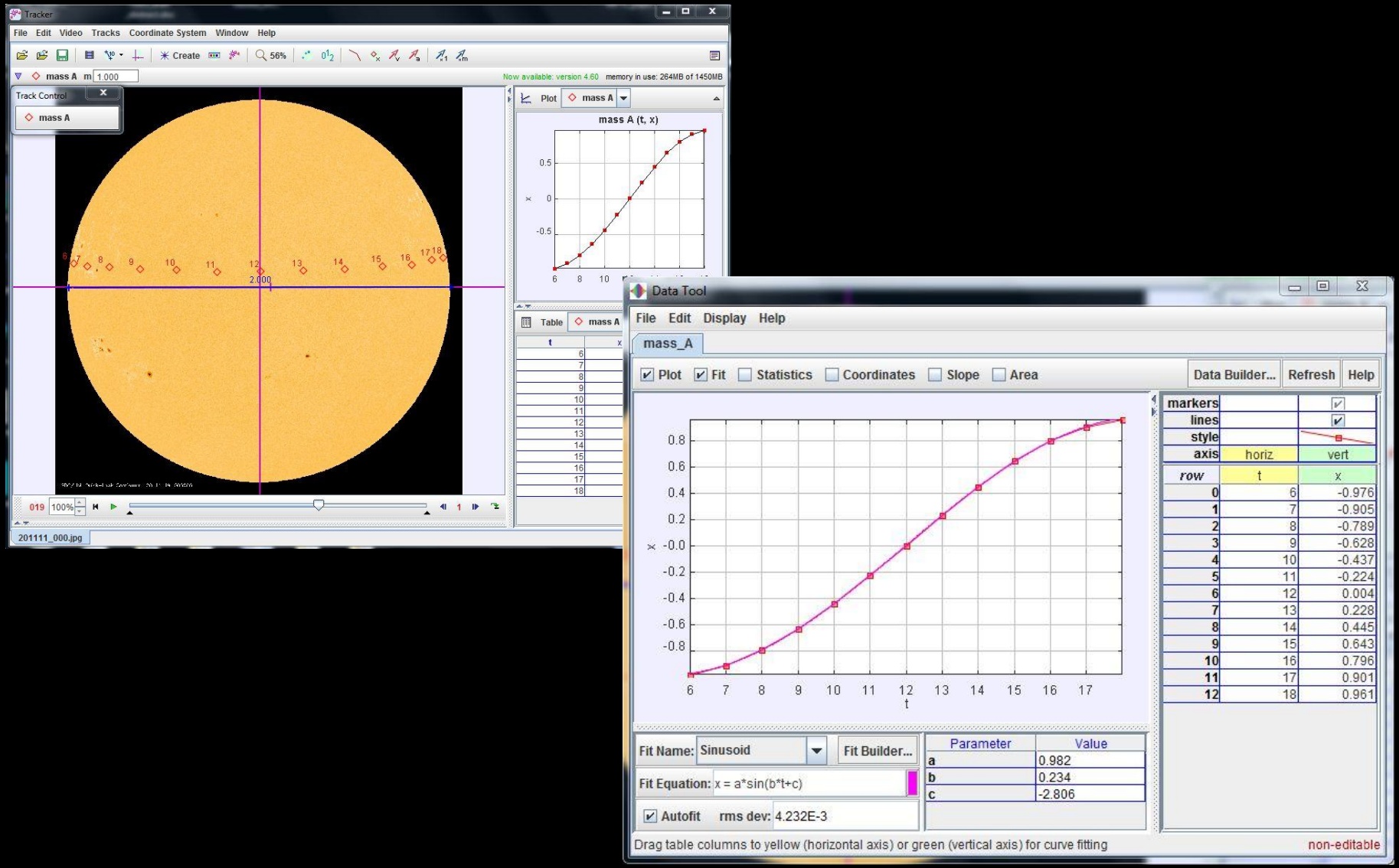
- **Easy Java Simulations:** (EJS) is free open source software that is designed to create interactive simulations in Java (applications and applets) without the necessity of prior programming knowledge to quickly and easily prototype, test, and distribute packages of Java simulations. EJS allows students, teachers, and curriculum authors to easily write and/or change simulations. Can also be used to teach computational physics.

Tracker

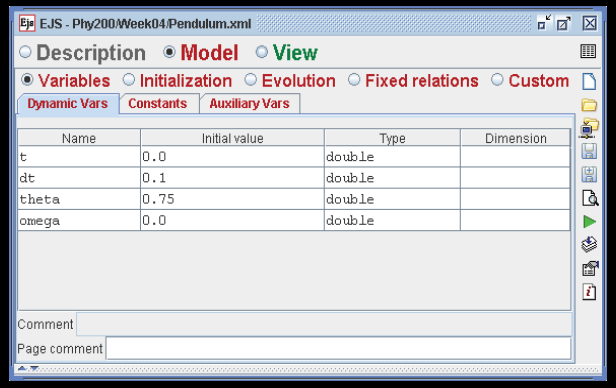


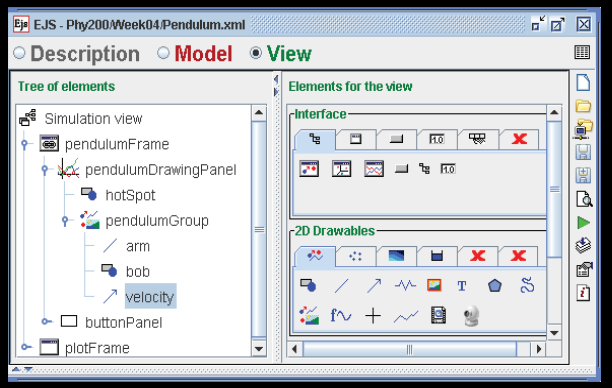
OSP-based free and open source (hmm..) video analysis program. On the OSP Collection there are numerous examples from Angry Birds to solar rotation rates.

Tracker: Solar Rotation

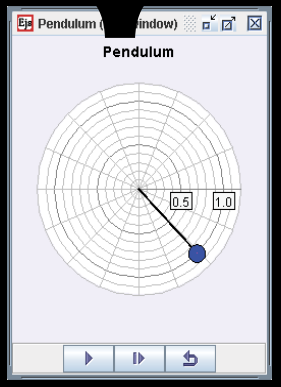


Creating an EJS Simulation



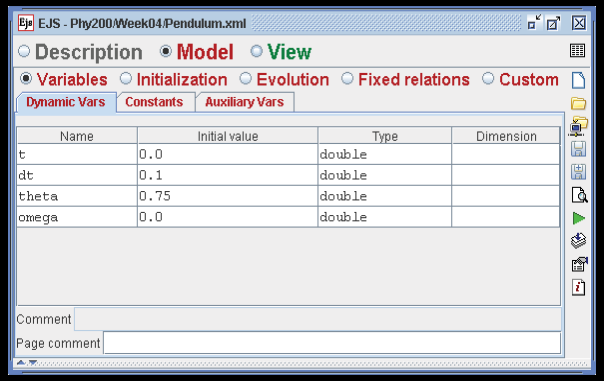


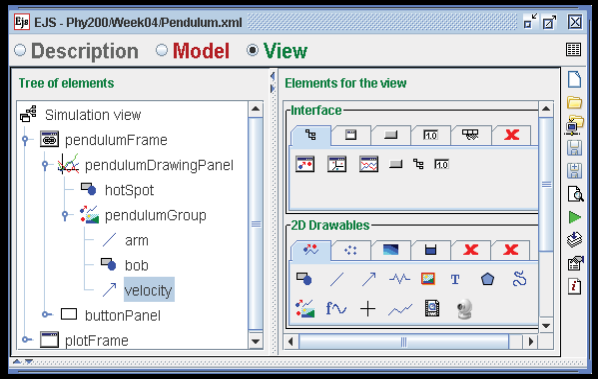
Easy Java Simulations: **(EJS) is free open source software that is designed to create interactive simulations in Java (applications and applets) without the necessity of prior programming knowledge.**

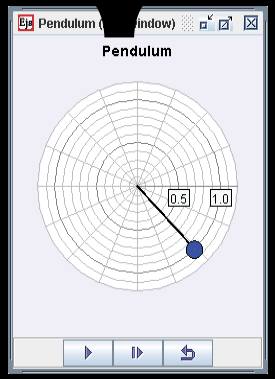


The advantage of EJS for physics teaching is it separates the model into logical parts (variables and evolution) and it separates the model from the view (the visualization of the simulated model).

EJS Simulation in 5 Minutes





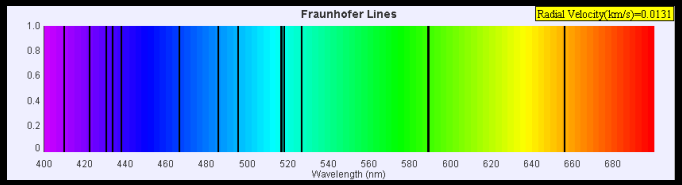


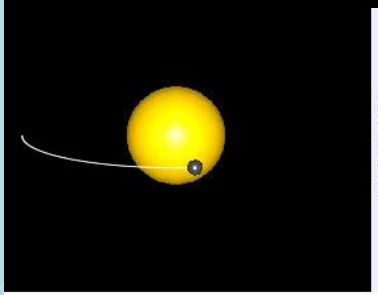
Ready, Set, Go….

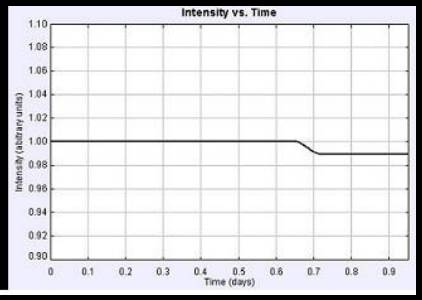
Characteristics of EJS Models

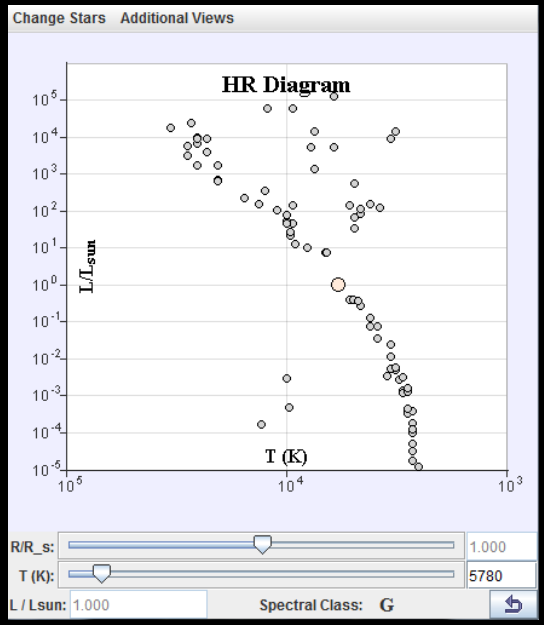
- Can be run:
  - As stand alone programs
  - As applets in HTML pages
  - In an single executable package that bundles many simulations together with curricular materials.
- Are written in Java and are distributed under the GNU GPL license.
- Can be modified with EJS; source code distributed
- Can be distributed from a digital library to a teacher or student desktop authoring tool via the internet.
- Over 500 simulations on the OSP Collection on ComPADRE

JiTT Example: OSP/EJS Astronomy









Over 50 simulations for JiTT in intro astronomy on

OSP Collection on ComPADRE

Also organized in

M.B. Astro Filing Cabinet

Shared Folders

Astronomy 105 (2 resources, 14 subfolders)
Materials in Support of a College-Level Introductory Astronomy Course at Davidson College.

A survey of the current scientific view of the Universe. Emphasis on the physical and mathematical principles necessary to understand how astronomers observe and interpret phenomena. Topics include the historical development of major astronomical theories, the interaction of light and matter, the life cycle of stars, and the structure and evolution of the Universe. No laboratory.

Astronomy 105 Course Home Page

This website is the course homepage for the Davidson College Astronomy (PHY 105) course from the Spring of 2012 taught by Mario Belloni. Many of the following materials were used in the teaching of this course during the spring of 2012.

website

Davidson College Astrophotography Project

For the past year, as part of teaching the astronomy class (PHY 105), we have been taking astrophotographs. Follow the link to see both our personal and student photos taken in Davidson, NC either on campus or at the Pine Road Observatory.

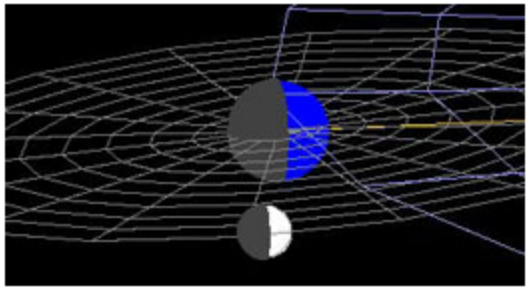
website

Copy selected into:

Astronomy 105 Subfolders

- Naked Eye Astronomy (12)
- Optical (Classical) Astronomy (0)
  - Solar System Models (10)
  - Orbits (7)
  - Optics (11)
- Modern Astronomy (0)
  - Stars and Stellar Properties (6)
  - Stellar Aberration and Parallax (5)
  - Exoplanets (2)
  - Galaxies (9)
  - General Relativity (5)
    - Classical Simulations (3)
    - Schwarzschild Metric Simulations (9)
    - Kerr Metric Simulations (4)

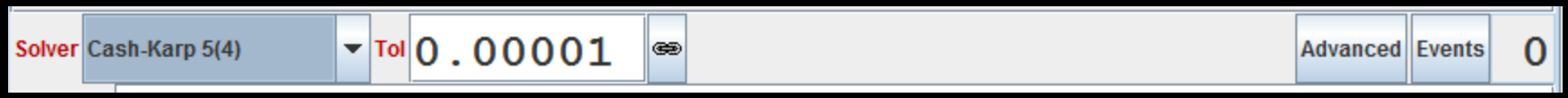
Featured Curriculum Package

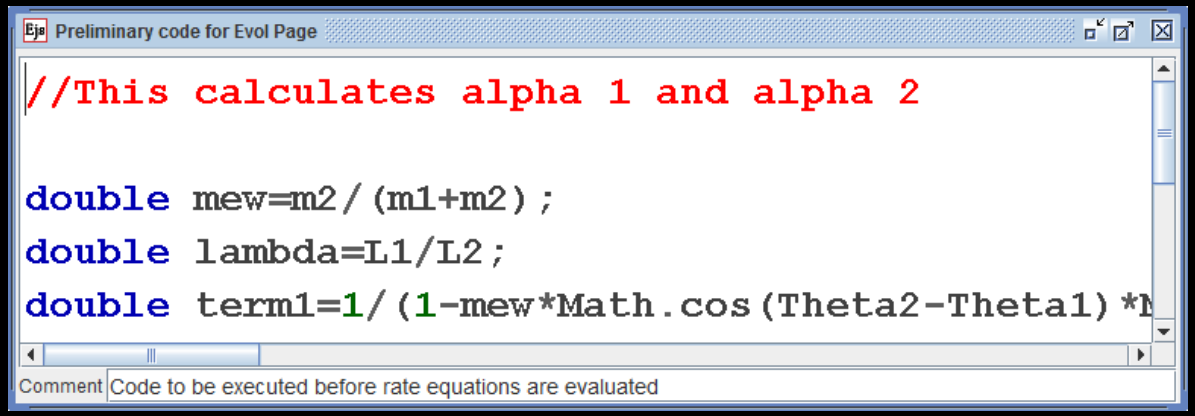


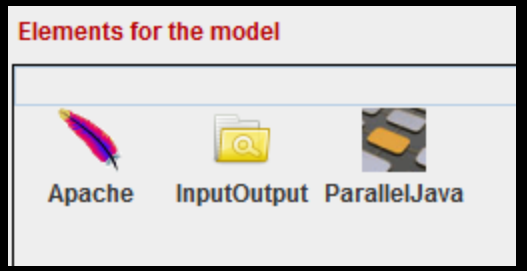
Introductory Astronomy Models
A shared file folder of Astronomy models designed for a college-level introductory astronomy course. This shared folder contains over 50 EJS models and is broken up into three parts: naked-eye astronomy, classical astronomy (optics and orbits), and modern astronomy.

OSP: Coupling Simulation with Pedagogy

Programmer: **Students are given tools to program a physics example using traditional computational physics techniques.** We use **Easy Java Simulations** **since it has as many advanced tools**

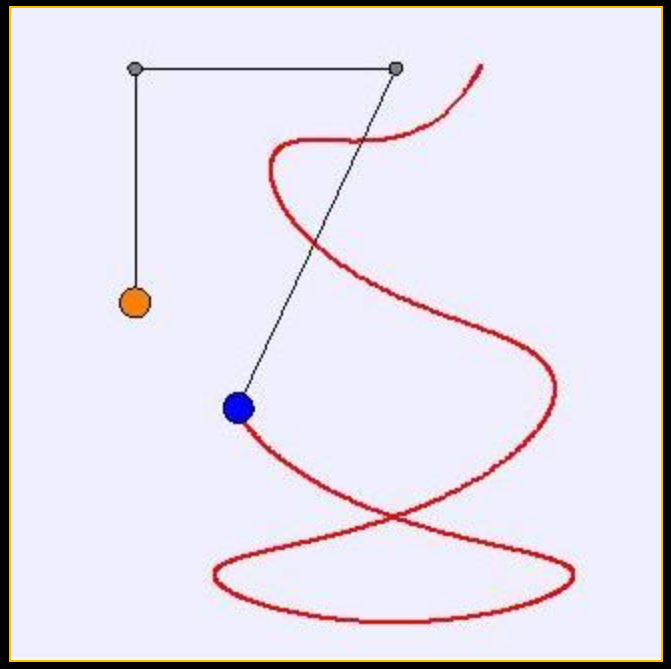


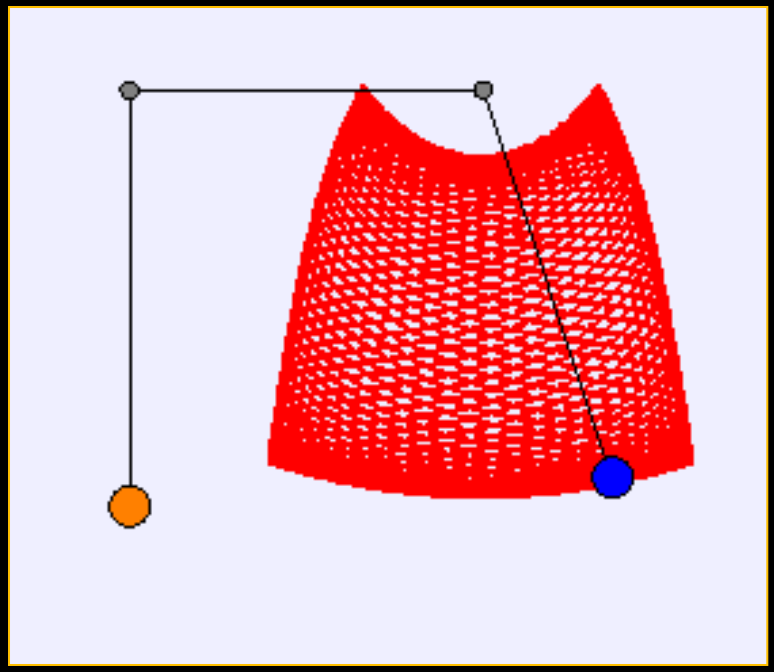





```
public void poincarePanelAction() {
  double x =_view.poincarePlottingPanel.getMouseX();
  double y =_view.poincarePlottingPanel.getMouseY();
  if(!checkValues(x,y,E0)) return;
  if(t!=0){
```

Example of Computational Physics and Experimental Physics: The Swinging Atwood's Machine





[SAM Simulation] [SAM Video] [fSAM Simulation]

On OSP ComPADRE

More Examples of Comp Physics

Wolfgang's Shared Folder My Folders

Wolfgang's Shared Folders

└ **An Introduction to Computer Simulation Methods -- EJS Edition**

An Introduction to Computer Simulation Methods -- EJS Edition (9 resources, 2 subfolders)

The *Easy Java Simulations* (EJS) adaptation of an *An Introduction to Computer Simulation Methods* by Harvey Gould, Jan Tobochnik, and Wolfgang Christian emphasizes physics modeling by example. We have chosen EJS for this edition because its dynamic and highly interactive user interface greatly reduces the amount of programming required to implement an idea. EJS is a Java program that enables both programmers and novices to quickly and easily prototype, test, and distribute packages of Java simulations. EJS gently introduces students to Java syntax but even experienced programmers find it useful because it is faster and easier program in EJS than in other environments.

EJS CSM Textbook Chapter 1: Introduction to modeling

Chapter 1 introduces the *Easy Java Simulations* (EJS) ec
Simulation Methods and discusses the importance of cor
computer simulation.

detail page - download

EJS CSM Textbook Chapter 2: Creating simulations

Chapter 2 introduces Java syntax and EJS elements in th
particles near the Earth's surface.

detail page - download

EJS CSM Textbook Chapter 3: Simulating Particle M

Chapter 3 presents several numerical methods needed t
Newton's laws and introduces the Ordinary Differential E
to select different numerical algorithms for ODE-based n
to model motion in three dimensions.

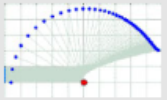
detail page - download

EJS CSM Textbook Chapter 4: Oscillations

Chapter 4 explores the behavior of oscillatory systems, i
simple pendulum, and electrical circuits. We introduce t
the EJS ODE editor is used to solve arrays of differential

detail page - download

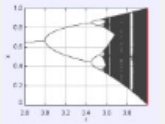
EJS CSM Textbook Chapter 5: Few-Body Problems



Chapter 5 applies Newton's laws of motion to planetary motion and other systems of a few particles and explores some of the counter-intuitive consequences.

detail page - download

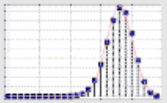
EJS CSM Textbook Chapter 6: The Chaotic Motion of Dynamical Systems



Chapter 6 studies simple nonlinear deterministic models that exhibit chaotic behavior. We will find that the use of the computer to do numerical experiments will help us gain insight into the nature of chaos.

detail page - download

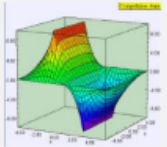
EJS CSM Textbook Chapter 7: Random Processes



Chapter 7 introduces Random processes in the context of several simple physical systems, including random walks on a lattice, polymers, and diffusion controlled chemical reactions. The generation of random number sequences also is discussed.

detail page - download

EJS CSM Textbook Chapter 10: Electrodynamics



Chapter 10 computes the electric fields due to static and moving charges, describes methods for computing the electric potential in boundary value problems, and solves Maxwell's equations numerically.

detail page - download

EJS CSM Textbook Chapter 17: Visualization and Rigid Body Dynamics

Chapter 17 studies affine transformations in order to visualize objects in three dimensions. We then solve Euler's equation of motion for rigid body dynamics using the quaternion representation of rotations.

detail page - download

JavaScript Simulations

To create JavaScript simulations, which are HTML5, compliant we use the new EjsS Tool

- New EjsS creates both Java and JS simulations
- To see examples (>100) of JS simulations:

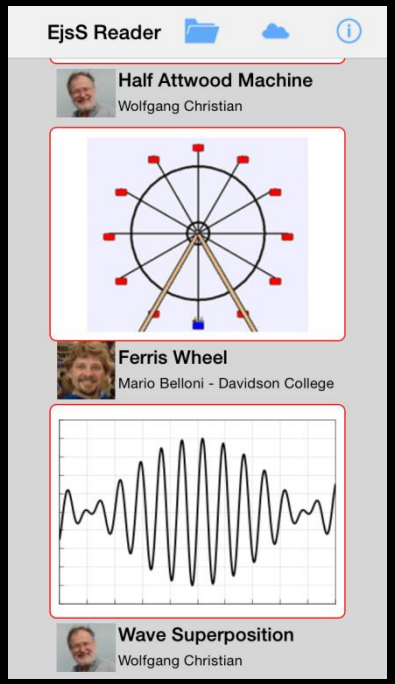
www.compadre.org/osp search "JS"

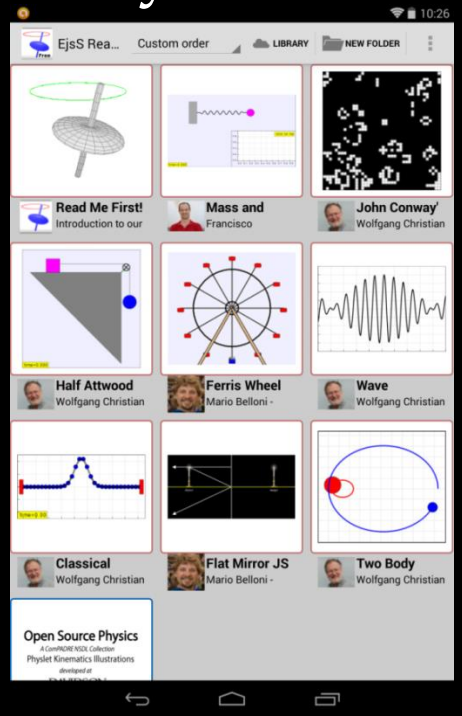
JavaScript Simulations

While our JS simulations run on any JS-enabled browser, the easiest way to browse material is with the EjsS Reader App on iPad & Android.

In the Apple AppStore and Google Play Store search for

"ejss"





Reader App (Apple)

Reader App (Android)

Summary: OSP Resources and Tools

Open Source Physics (OSP) **Project** provides curriculum resources and tools that engage students in astronomy & physics, computer modeling, and computation with the goal of providing students with new ways to understand, describe, explain, and predict physical phenomena.

- The **OSP Collection** is a ComPADRE repository where >500 EJS (Java & JavaScript) models and curricular materials are organized & shared.
- **Physlets** are small interactive Java applets that are designed for the teaching physics in a web environment. **Physlet Physics 2E** is an integrated curriculum of over 800 items spanning the introductory physics sequence. **Physlet Quantum Physics 2E** contains over 200 items covering modern physics through advanced quantum theory. All 1,000 exercises in these two collections are available on ComPADRE and there are ebook companions available on iTunes and the Google Play store.
- **Easy Java Simulations** **(EJS)** encourages modeling and authoring with basic programming in Java and JavaScript. EJS removes many of the complicated tasks involved in integrating computation into the classroom allowing students and teachers to focus on the science.
- **Tracker** video analysis and modeling tool analyzes video clips. Students can both analyze the motion of objects and overlay simple models on the video & see how the model matches the real-world.

The Open Source Physics Project

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