USING PHYSLETS AND EASY JAVA SIMULATIONS TO TEACH PHYSICS AND ASTRONOMY

OSP COMPADRE: WWW.COMPADRE.ORG/OSP/

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Today

- Brief description/demo of tools.
- Explore OSP site/materials
- Discussion of how to use.

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
- Physlet Physics 3E: http://www.compadre.org/books/Physlets-3E
- 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
- Java and JavaScript Simulations: MB, WC, Todd Timberlake, and Michael Gallis
- *Physlet Physics 3E* : Anne Cox, MB, WC
- Intro Astronomy eBook: Kristen Thompson, MB

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.

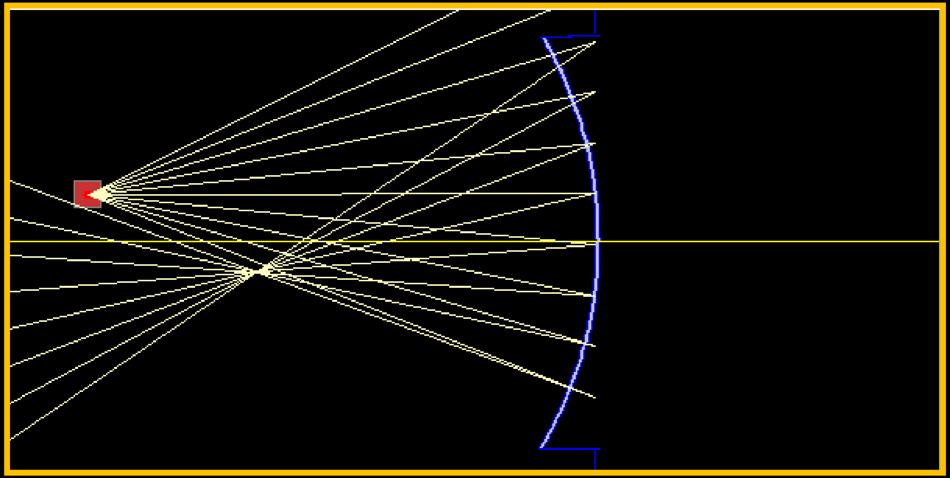
Simulation Terminology 101

- **Java:** Programming language for simulations. Simulations can be run as stand-alone archives (jars) or as applets. All Java applets ceased to work in March 2017. All desktop Java applications will continue to function.

- **JavaScript:** Scripting language created in 1995 and is part of the HTML5 standard.

- **HTML5:** Markup language standard for the Web going forward. Supports JavaScript, CSS, etc. Does not support Java.

JiTT Example: JS Physlet



A point source is located to the left of a mirror. You can click-drag the point source to any position **(position is given in centimeters)**.

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

OSP ComPADRE search: Focal Length JS

Mass and Spring Simple Harmonic Oscillator JS Model

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 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.

How can we use simulations in teaching physics? Pedagogies?

- **User:** Students access pre-made simulations that (hopefully) they must interact with.
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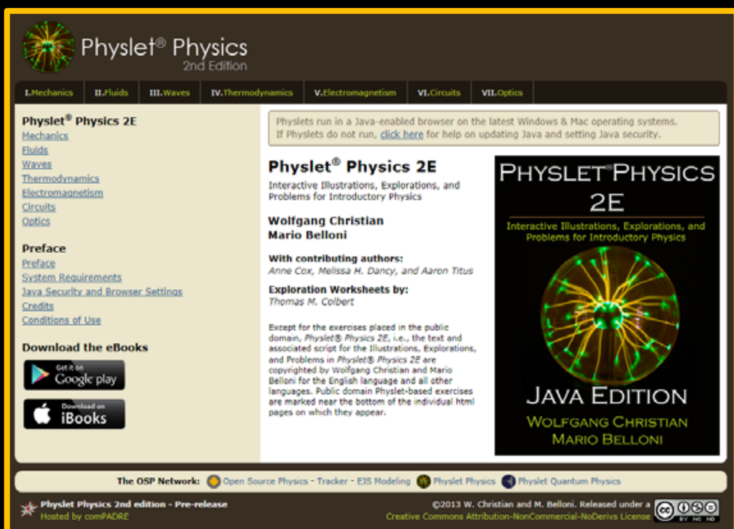
Coupling Simulation with Pedagogy

- **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

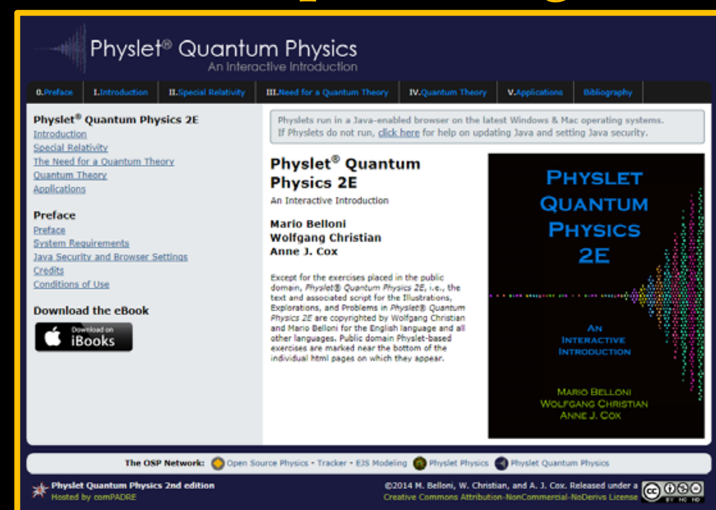
Physlets—"Physics applets"—are small, flexible Java applets that are ...

- 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/Physlets

www.compadre.org/PQP

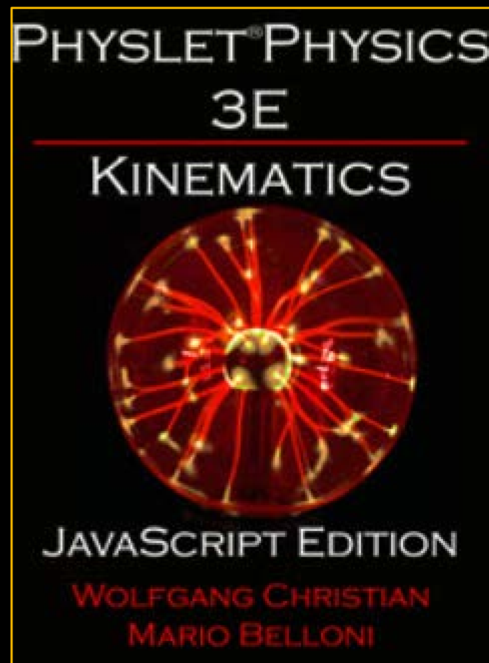


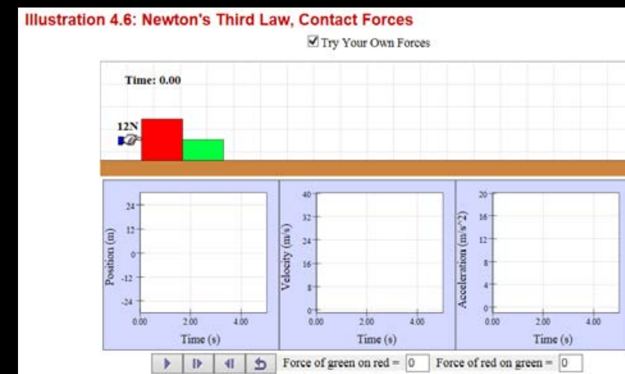
Converting the 1,000 pieces of curricular material to HTML5

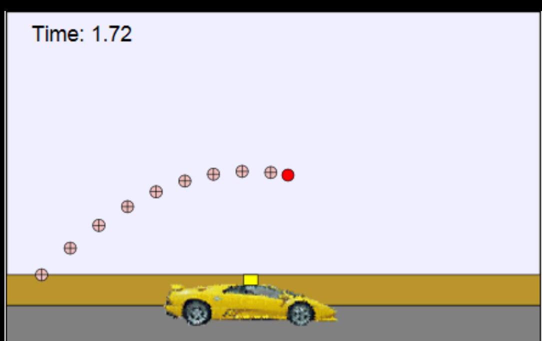
PP 3E on ComPADRE

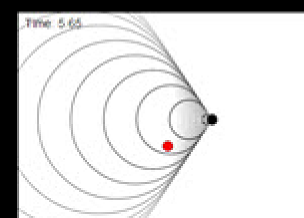
http://www.compadre.org/books/Physlets-3E

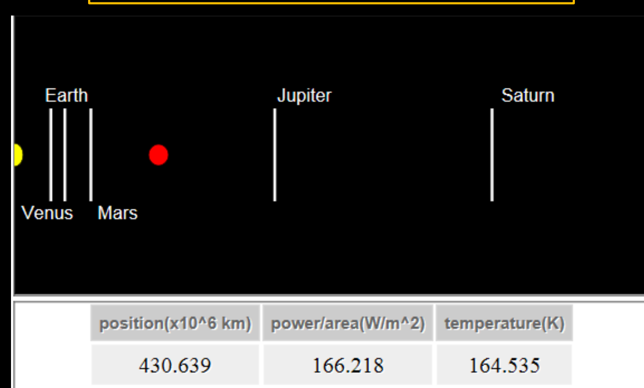
- Kinematics
- Newton's Laws
- Gravitation
- Oscillations and Waves
- Heat and Temperature

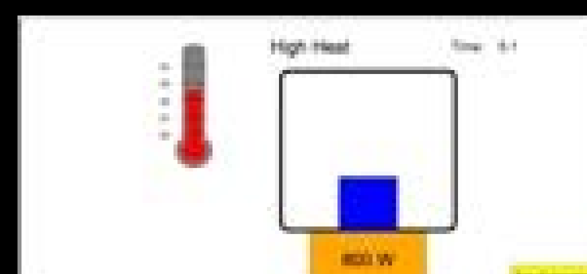




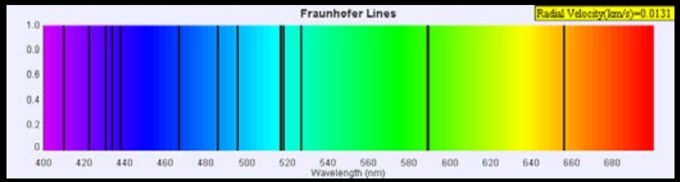


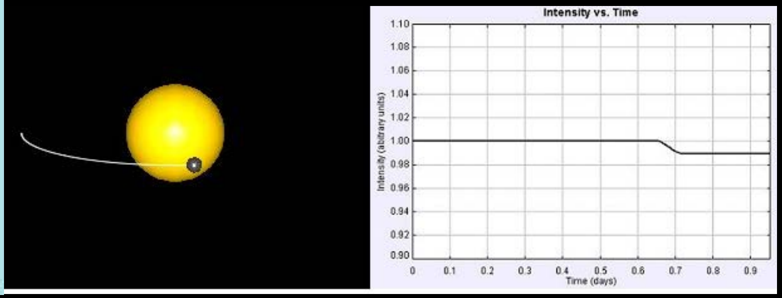


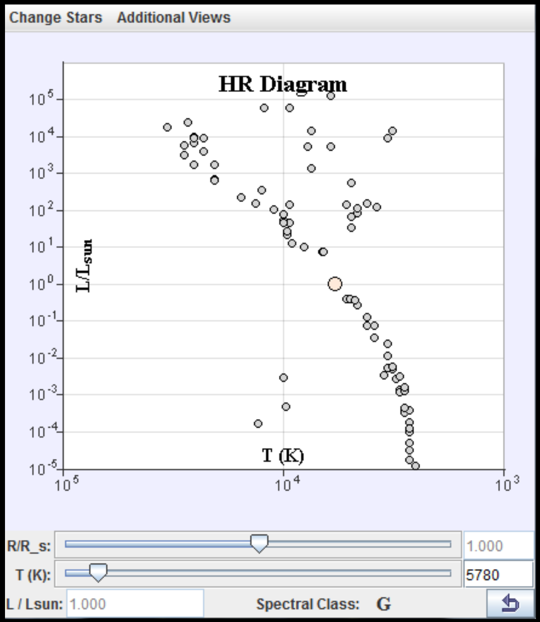




OSP/EJS Astronomy Simulations







Over 50 stand-alone Java programs for 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.

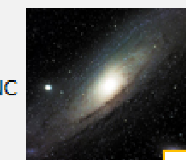
A survey of the current scientific view of the Universe. Emphasis on the physical and mathematical principles necessary to understand how astronomers observe and interpret phenomena. Topics include the historical development of major astronomical theories, the interaction of light and matter, the life 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.

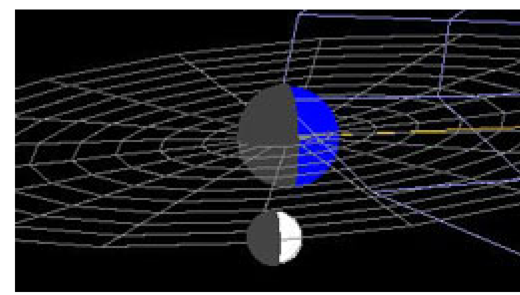
website

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.

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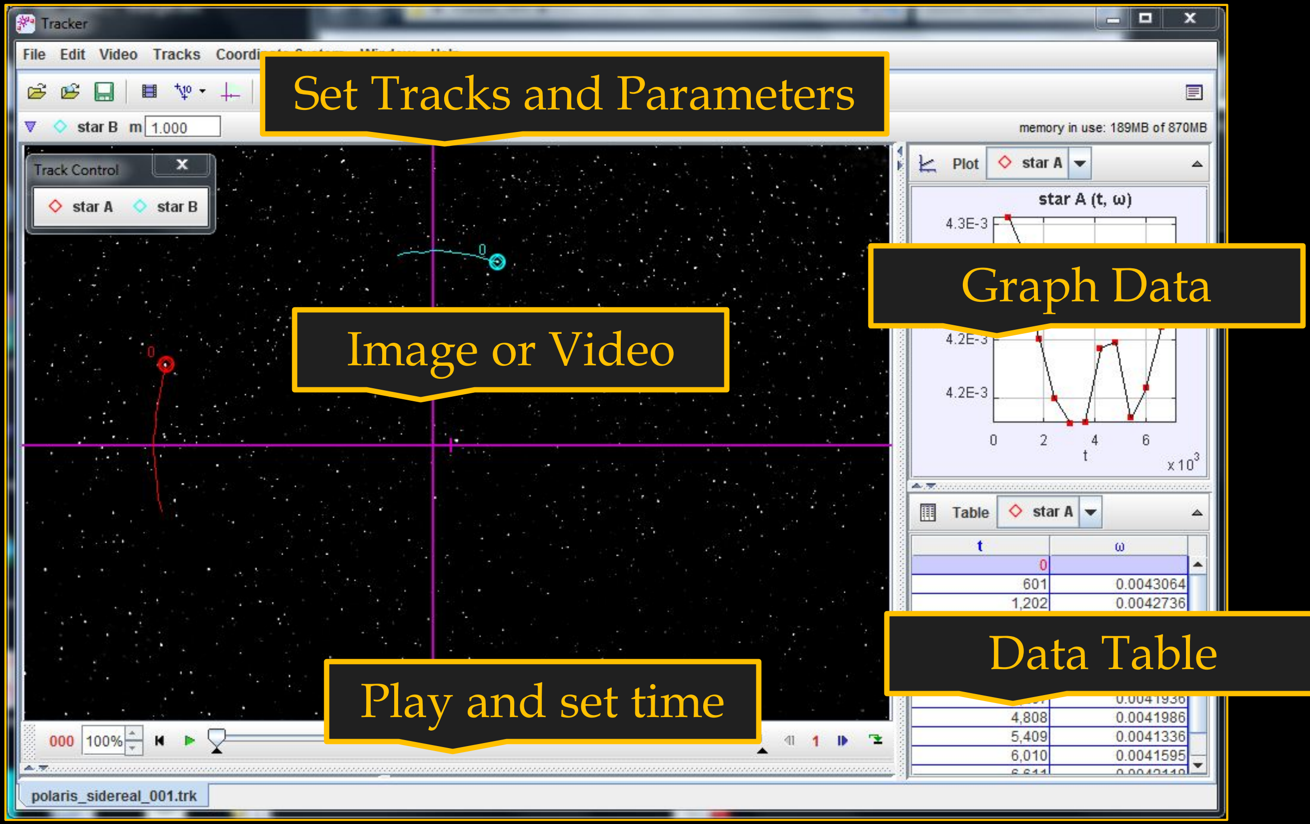
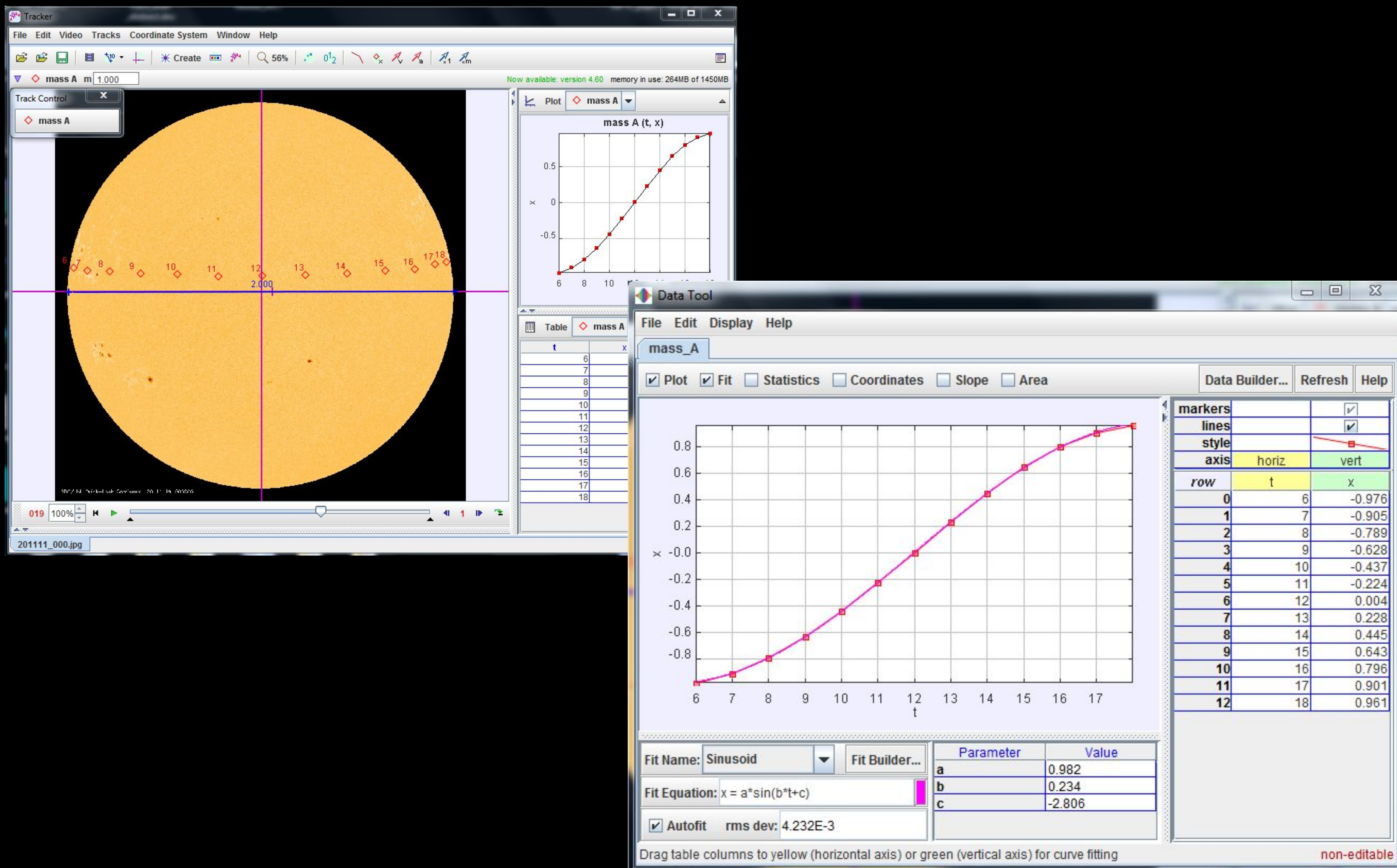
Tracker



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, plus students can take their own videos.

Tracker: Solar Rotation



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EJS/EjsS
Creating Java and JavaScript Simulations

To create Java and JavaScript (HTML5 compliant) simulations we use the EJS/EjsS Tool

- New EjsS creates both Java and JS simulations
- Currently converting PP2E to JavaScript (PP3E)
- To see examples (>200) of JS simulations: www.compadre.org/osp search "JS" for JavaScript

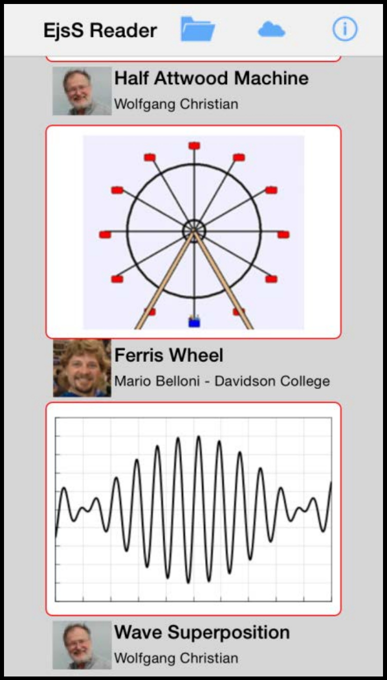
JavaScript Simulations

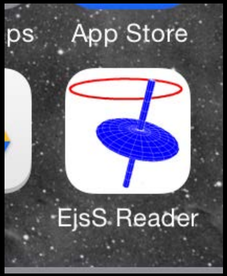
While our JS simulations run on any JS-enabled browser, the easiest way to browse material is with the EjsS Reader App on iPad & Android.

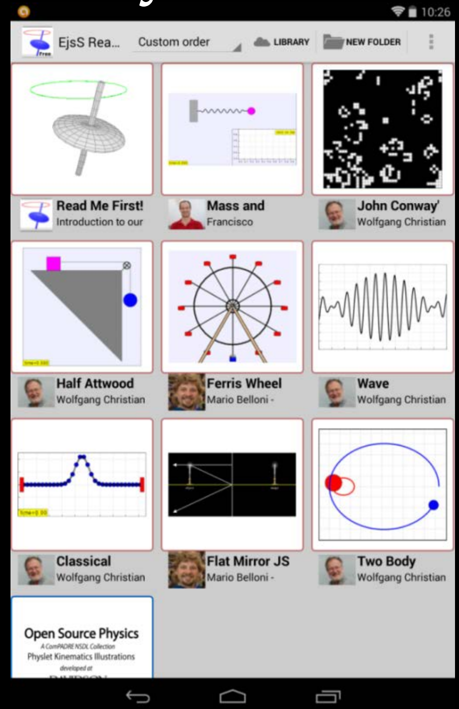
In the Apple AppStore and Google Play Store

search for

“ejss”



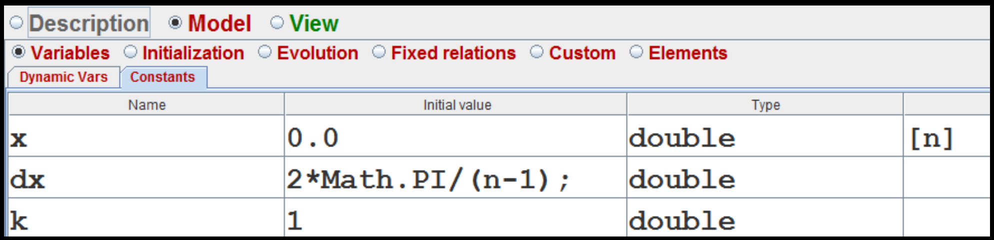


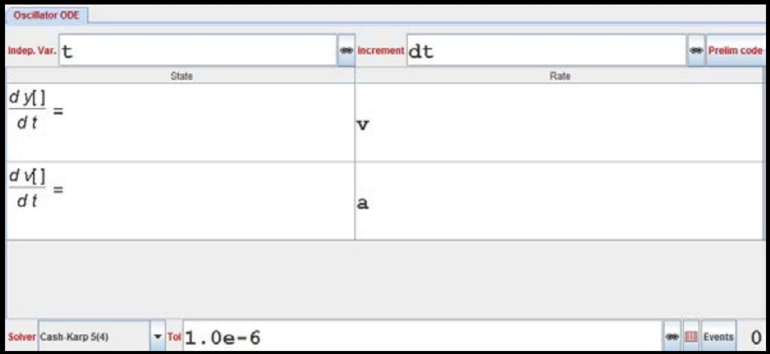


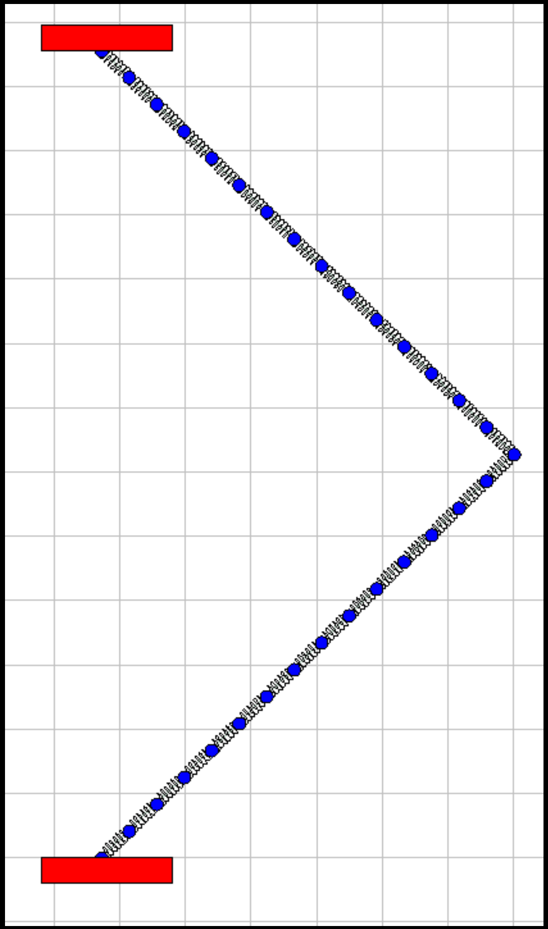
Reader App (Apple)

Reader App (Android)

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).

Computational Physics

Solver Cash-Karp 5(4) Tol 0.00001 Advanced Events 0

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

Elements for the model

Apache InputOutput ParallelJava

Hardware InputOutput Numerics SoftwareLinks

Wolfgang's Shared Folder My Folders

Wolfgang's Shared Folders
└ An Introduction to Computer Simulation Methods -- EJS Edition

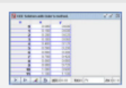
An Introduction to Computer Simulation Methods -- EJS Edition (9 resources, 2 subfolders)
The *Easy Java Simulations* (EJS) adaptation of an *An Introduction to Computer Simulation Methods* by Harvey Gould, Jan Tobochnik, and Wolfgang Christian emphasizes physics modeling by example. We have chosen EJS 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) edition of the *An Introduction to Computer Simulation Methods* and discusses the importance of computers in physics and the nature of computer simulation.

detail page - download

EJS CSM Textbook Chapter 2: Creating simulations



Chapter 2 introduces Java syntax and EJS elements in the context of simulating the motion of falling particles near the Earth's surface.

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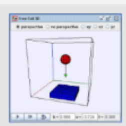
EJS CSM Textbook Chapter 3: Simulating Particle Motion



Chapter 3 presents several numerical methods needed to simulate the motion of particles using Newton's laws and introduces the Ordinary Differential Equation (ODE) editor that makes it possible to select different numerical algorithms for ODE-based models. EJS 3D elements are also introduced to model motion in three dimensions.

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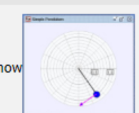
EJS CSM Textbook Chapter 4: Oscillations



Chapter 4 explores the behavior of oscillatory systems, including the simple harmonic oscillator, a simple pendulum, and electrical circuits. We introduce the concept of phase space and also show how the EJS ODE editor is used to solve arrays of differential equations.

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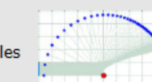
EJS CSM Textbook Chapter 5: Few-Body Problems



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.

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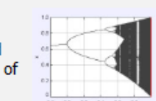
EJS CSM Textbook Chapter 6: The Chaotic Motion of Dynamical Systems



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.

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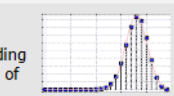
EJS CSM Textbook Chapter 7: Random Processes



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.

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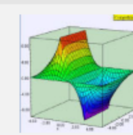
EJS CSM Textbook Chapter 10: Electrodynamics



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.

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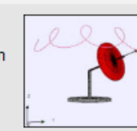
EJS CSM Textbook Chapter 17: Visualization and Rigid Body Dynamics



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.

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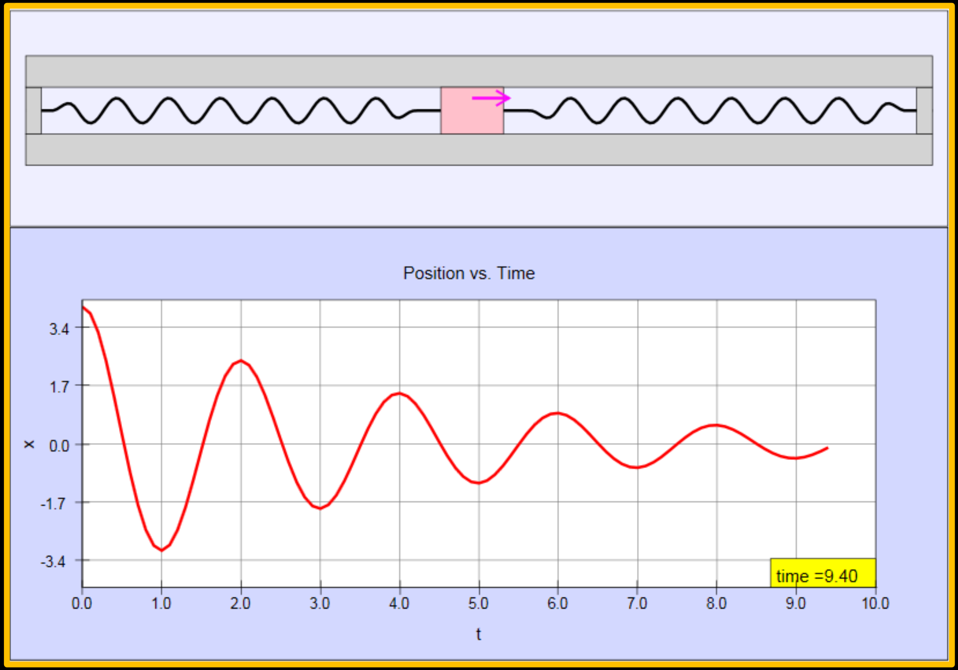
JiTT Example: JS Physlet



The Horizontal Mass and Spring Harmonic Oscillator model illustrates the forces and dynamics of a simple oscillator.

This simulation uses **the accelerometer on your mobile device** to read the direction of the gravitation field *g*.

You may need to lock the orientation of your screen to maintain a fixed view as you tilt your device. For use on computers without an accelerometer or for classroom use, the "No sensor" mode simulates a tilted device in the view.

Mass and Spring Simple Harmonic Oscillator JS Model

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- 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/

The OSP Network: Open Source Physics - Tracker - EJS Modeling Physlet Physics Physlet Quantum Physics

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….

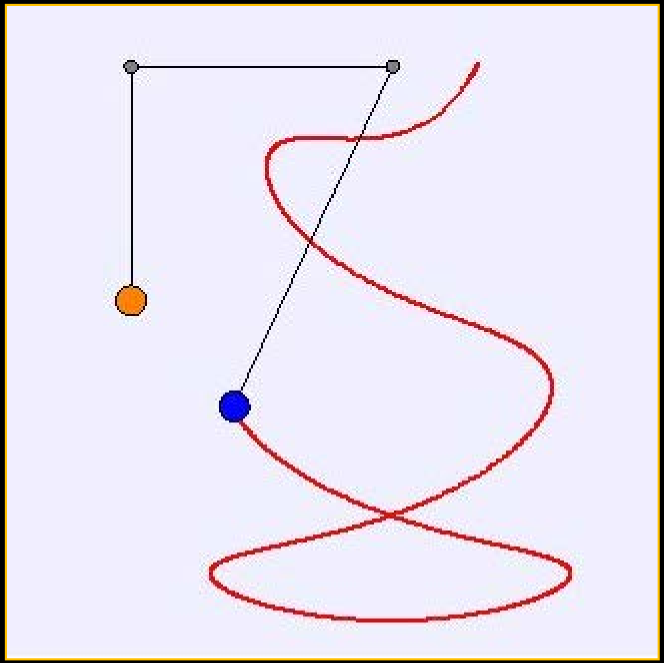
...keeping in mind that
technology without pedagogy...
...is just technology.

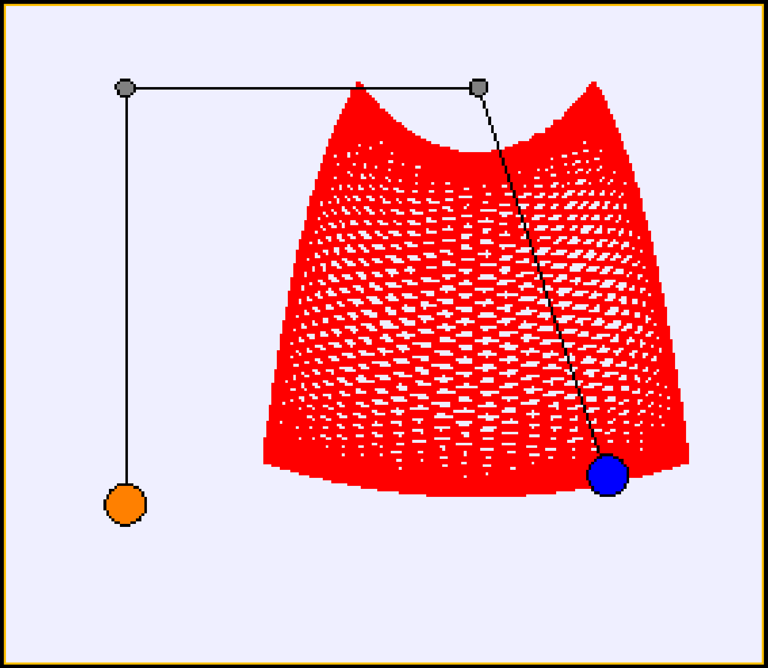
OSP: Coupling Simulation with Pedagogy

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.

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





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

On OSP ComPADRE

Open Source Physics Resources and Tools

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- 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 being converted to JavaScript.
- **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.