



Teaching with Open Source Physics Curricular Material

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Teaching with Technology

Current technologies allow physics educators the ability to integrate instruction with computer-based modeling. This talk describes technologies that encourage interactive-engagement and limit the amount of programming when designing, implementing, distributing, and using computer models. It is based on:

- **Tracker** video analysis and modeling tool analyzes video clips. Students can both analyze the motion of objects and overlay simple dynamical models on the video and see how well the model matches the real-world.
- **Easy Java/JavaScript Simulations** (EjsS) creates interactive simulations in Java or JavaScript simulations without the necessity of prior programming knowledge.
- **OSP ComPADRE Digital Library** archives and distributes curriculum resources, such as **Physlets** and EjsS simulations, that engage students in physics, computation, and computer modeling.

Need for Digital Libraries

A Google search for “*pendulum*” returns 27,100,000 pages; while “*pendulum simulation*” returns 11,900 pages (The search for *pendulum simulation* without the quotes returns 449,000 pages).

- Most of the simulations (or animations that “fake” the physics) are inappropriate for teaching.
- There is usually no instructional material, no support materials for teachers, and no information about how these materials are correlated to state or national science standards.
- Most of these simulations also support a passive (viewing) pedagogy versus an active (interacting) pedagogy.

In order to be effective for instruction, simulations need to be easy to find, simple, adoptable, adaptable, and coupled with support content for students and teachers.

ComPADRE

We are out of the business of web hosting and let the experts do it.

Standard and Custom
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600+ Java Sims
150+ JavaScript Sims
1200+ Physlet Pages

10,000+ visitors/month

5,000+ simulation
downloads/month

OSP
open source physics

Logged in as Bruce, ComPADRE Dir (bmason@ou.edu) - [my profile](#) - [logout](#)
[filing cabinet](#) - [suggest a resource](#) - [administrata](#)

Search the OSP Collection... **Search** **Advanced**

SIMULATIONS
EJS MODELING
CURRICULUM
PROGRAMMING
TOOLS
BROWSE MATERIALS
RELATED SITES
DISCUSSION
ABOUT OSP

Computational Resources for Teaching

The **OSP Collection** 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.

Simulations

OSP Simulations are compiled programs on specific topics. The models can be used for concept building, exploring physical systems that are not accessible otherwise, or as a basis for other student exercises.

[Browse simulations](#)

EJS Modeling

Student modeling, the guided exploration of physical systems and concepts, is a powerful approach to engaged learning. Easy Java Simulations provides the computational tools for students and faculty to explore physics without the need for learning details of java programming.

[Learn more about EJS](#)

Featured Simulation

Polarizer Program
The Polarizer program displays the effect of a plane polarizer on an incident electromagnetic wave. The default electromagnetic wave is plane polarized but this polarization can be changed using

Featured EJS Model

Orbiting Mass on a Cone 3D Model
The EJS Orbiting Mass on a Cone 3D model displays the frictionless dynamics of a mass constrained to orbit on the inside of a

Upcoming OSP Events

[Incorporating Computation and Modeling into Physics Teaching](#)
Workshop for New Physics and Astronomy Faculty
ACP, College Park, MD
November 13-15, 2009

[SC 09: Educational Program](#)
EJS, Pathways, and Digital Libraries Presentations
SC 09: International Conference on High Performance Computing, Networking, Storage, and Analysis
Portland, OR
November 14-17, 2009

[Open Source Physics Content Delivery: Computation, Curriculum, and Libraries](#)
A presentation at the 2009 NSDL annual meeting on use and dissemination of OSP and EJS resources

[Building a National Digital Library of Physics Simulations](#)
Presentations by Wolfgang Christian and Fu-Kwun Hwang at the CCP 2009 conference in Kaohsiung, Taiwan December 2009

The Open Source Physics Project is supported by NSF DUE-0442581.

Personalization

Content ..

- Find
- Collect
- Sort
- Relate
- Annotate
- Share

Lets do a search!

The image is a collage of three screenshots from a web application. The top-left screenshot shows a 'Computer Program Detail Page' for 'Superposition Package' by Mario Belloni and Wolfgang Christian. The top-right screenshot shows a search results page for 'Quantum Spin' with three results listed. The bottom screenshot shows a 'Folder Management' interface for a 'Quantum Relations' folder, displaying a tree view of sub-folders and a list of documents within that folder.

Quantum Relations

Save

Save into folder:

- Quantum Relations
- de Raedt
- Dephasing
- Entanglement
- Falstad
- Joffre
- Spin

Open Source Physics Results Partner Results

Search Terms: Quantum Spin

Results #1-#3 of 3

sort by: [relevance](#) | [subject](#) | [date](#) | [title](#) | [author](#)

- [1. Spins Package](#) [Computer Program] [A]

[Details](#) | [Post a comment](#) | [Save this resource](#) | [Relations](#) | [Control Menu](#)

The Spins package is a self-contained file for the teaching of measurement and time mechanics. The file contains ready-to-run OSP programs and a set of curricular ...

<http://www.compadre.org/OSP/document/ServeFile.cfm?ID=7329&DocID=491>

- [2. QM Spins Program](#) [Computer Program] [A]

[Details](#) | [Post a comment](#) | [Save this resource](#) | [Relations](#) | [Control Menu](#)

The QM Spins program simulates the Stern-Gerlach experiment. The simulation shows the result of measuring the spin of a particle.

<http://www.compadre.org/OSP/document/ServeFile.cfm?ID=7329&DocID=491>

- [3. Open Source Physics Curricula](#) [Computer Program] [A]

[Details](#) | [Post a comment](#) | [Save this resource](#) | [Relations](#) | [Control Menu](#)

M. Belloni, W. Christian, and D. Brannaman

The Open Source Physics Curricula project is part of the Open Source Physics project for the National University of Singapore.

<http://www.compadre.org/OSP/document/ServeFile.cfm?ID=7329&DocID=491>

Quantum Relations folder

- Filing Cabinet Root
 - Quantum Relations
 - de Raedt
 - Dephasing
 - Entanglement
 - Falstad
 - Joffre
 - Spin
 - Vis Quantum Mechanics

Bookmarks Sharing Folder Management Citation Guide

Quantum Relations

- Superposition Package: Eigenstates and Sums
 - Quantum 1: 1D Quantum States

This package of exercises and tutorial materials introduces students to 1D quantum eigenstates and sums of eigenstates. Relations to potential functions and time dependence are stressed.

[details](#) - [download page](#) - [edit personal note](#) - [cite](#)

- Spins Package: 2-state Physics

This simulation of Stern-Gerlach experiments provides a powerful tool to teach quantum physics as linear algebra. Examples of measurements and time dependence are given.

[details](#) - [download page](#) - [edit personal note](#) - [cite](#)

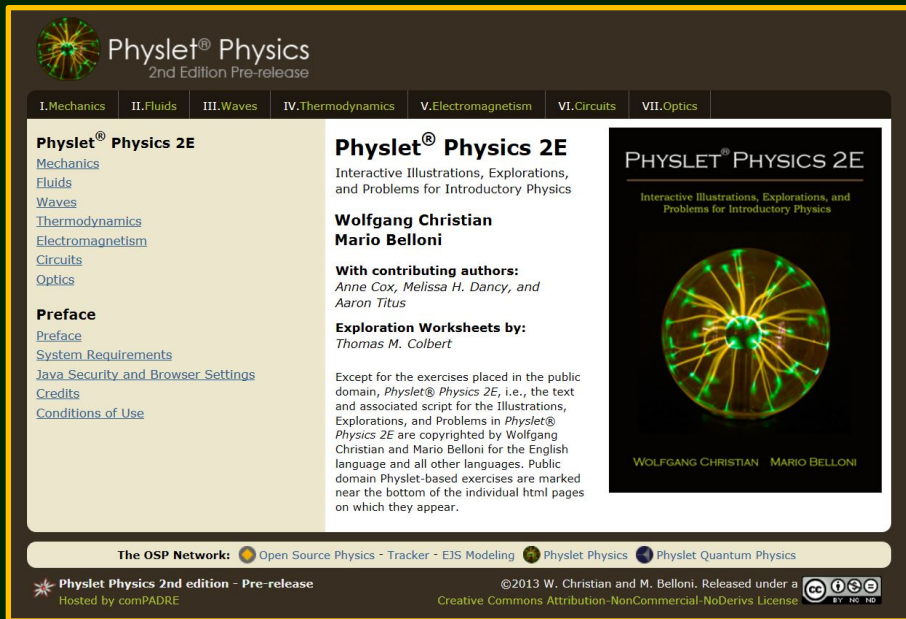
Quantum Relations Options

Copy or Move bookmarks selected above to the folder >>

Visit the [Folder Management](#) tab to create sub-folders, rename, move, or delete this folder. You may also provide an [annotation](#) for this folder. Visit the [Sharing](#) tab for information on sharing this folder.

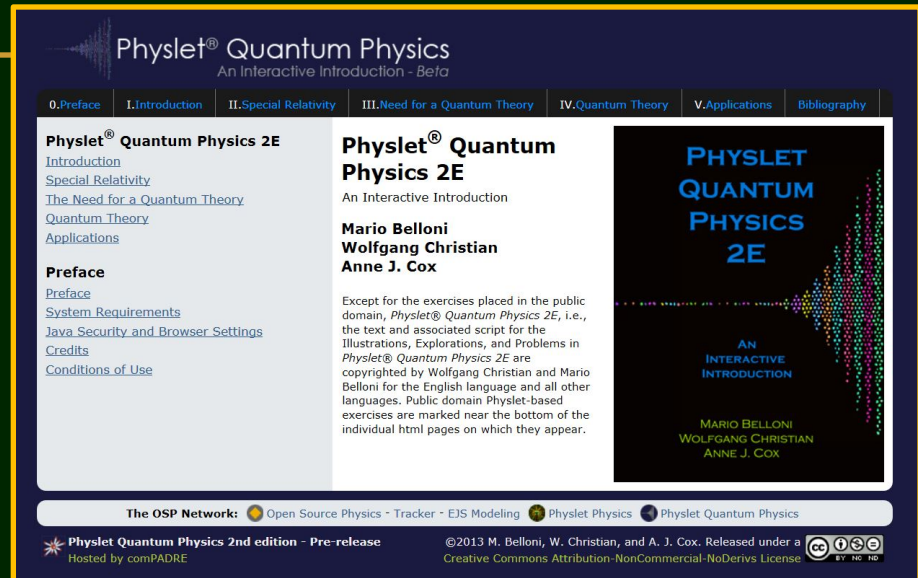
PP2E and PQP2E on ComPADRE

Materials are currently available (*Physlet Physics 2E* and *Physlet Quantum Physics 2E*) on ComPADRE. 1ed in 2003



The screenshot shows the homepage for Physlet Physics 2E. At the top left is the Physlet Physics logo with the text "2nd Edition Pre-release". Below the logo is a navigation bar with tabs for I. Mechanics, II. Fluids, III. Waves, IV. Thermodynamics, V. Electromagnetism, VI. Circuits, and VII. Optics. The main content area is divided into two columns. The left column contains a table of contents with links for Mechanics, Fluids, Waves, Thermodynamics, Electromagnetism, Circuits, and Optics. Below this is a "Preface" section with links for Preface, System Requirements, Java Security and Browser Settings, Credits, and Conditions of Use. The right column features the title "Physlet® Physics 2E" followed by a description: "Interactive Illustrations, Explorations, and Problems for Introductory Physics". Below this is the authors' names, Wolfgang Christian and Mario Belloni, and a list of contributing authors: Anne Cox, Melissa H. Dancy, and Aaron Titus. There is also a section for "Exploration Worksheets by: Thomas M. Colbert". A large image of a colorful, starburst-like pattern is shown. At the bottom, there is a footer with the text "The OSP Network:" followed by icons for Open Source Physics - Tracker - EJS Modeling, Physlet Physics, and Physlet Quantum Physics. Below that is the copyright information: "©2013 W. Christian and M. Belloni. Released under a Creative Commons Attribution-NonCommercial-NoDerivs License" and the CC BY-NC-ND logo.

Java Code: New signed jar. Updated and tested 1,300 pages.
New Narrative: Follows original format but many exercises and sections rewritten (especially PQP 2E). 1ed in 2013



The screenshot shows the homepage for Physlet Quantum Physics 2E. At the top left is the Physlet Quantum Physics logo with the text "An Interactive Introduction - Beta". Below the logo is a navigation bar with tabs for 0. Preface, I. Introduction, II. Special Relativity, III. Need for a Quantum Theory, IV. Quantum Theory, V. Applications, and Bibliography. The main content area is divided into two columns. The left column contains a table of contents with links for Introduction, Special Relativity, The Need for a Quantum Theory, Quantum Theory, and Applications. Below this is a "Preface" section with links for Preface, System Requirements, Java Security and Browser Settings, Credits, and Conditions of Use. The right column features the title "Physlet® Quantum Physics 2E" followed by a description: "An Interactive Introduction". Below this is the authors' names, Mario Belloni, Wolfgang Christian, and Anne J. Cox. A large image of a colorful, starburst-like pattern is shown. At the bottom, there is a footer with the text "The OSP Network:" followed by icons for Open Source Physics - Tracker - EJS Modeling, Physlet Physics, and Physlet Quantum Physics. Below that is the copyright information: "©2013 M. Belloni, W. Christian, and A. J. Cox. Released under a Creative Commons Attribution-NonCommercial-NoDerivs License" and the CC BY-NC-ND logo.

www.compadre.org/Physlets

www.compadre.org/PQP

Role of Simulations in Teaching

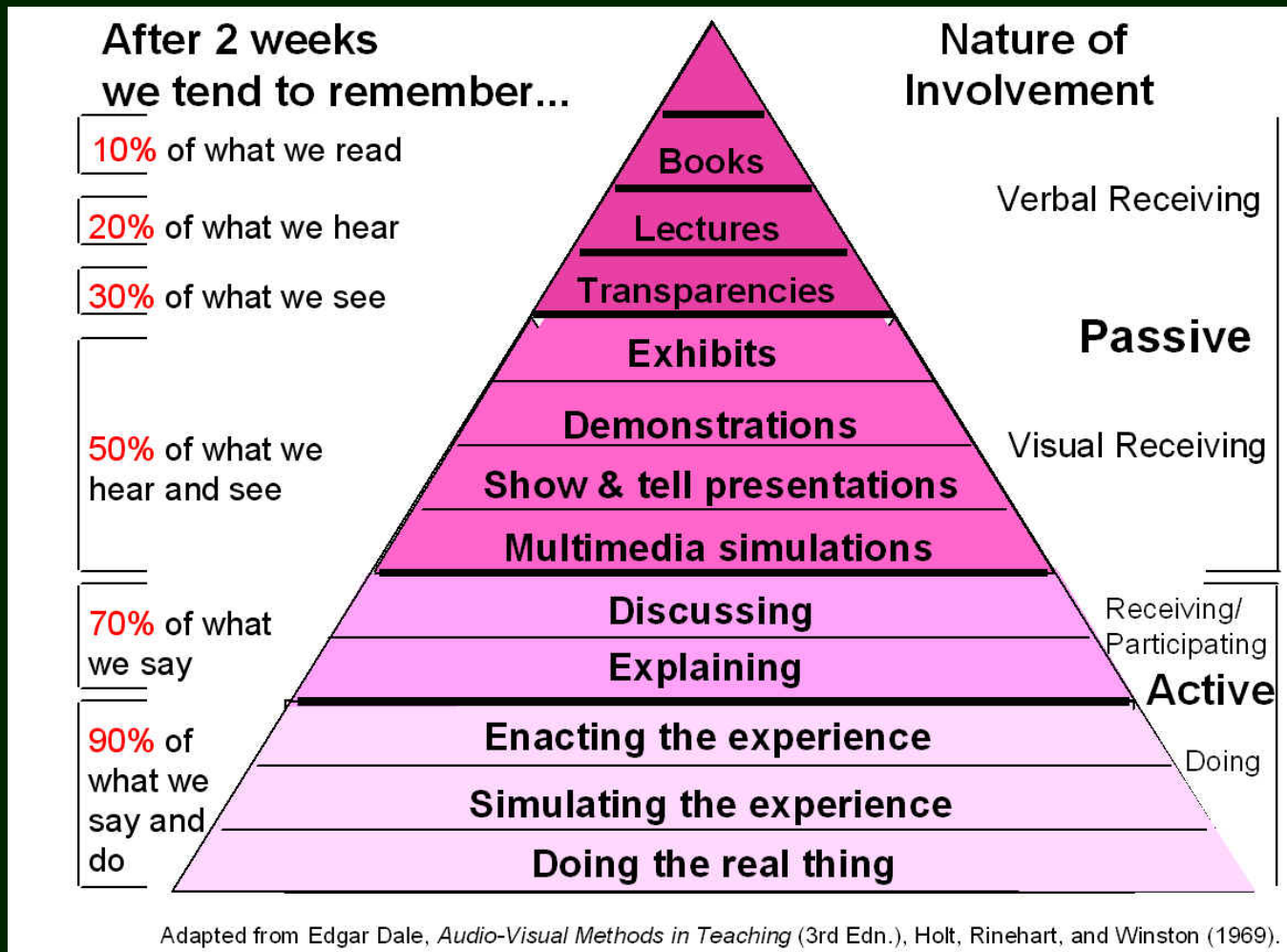
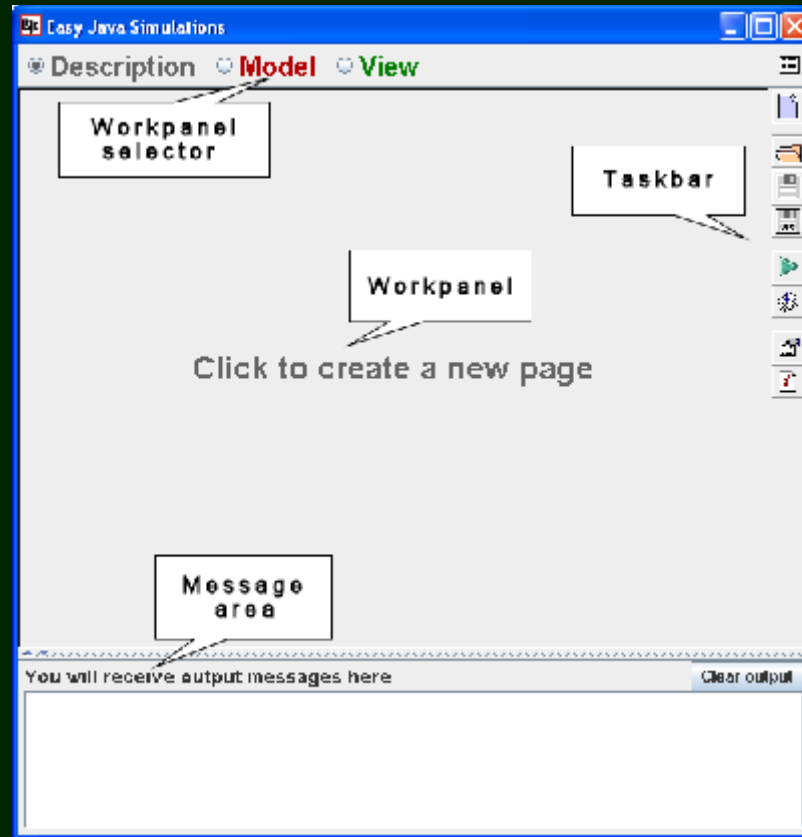


image from Bob Beichner

Easy Java/JavaScript Simulations



Load, modify, and save a model. [[Colliding Galaxies](#)]

Computer Models

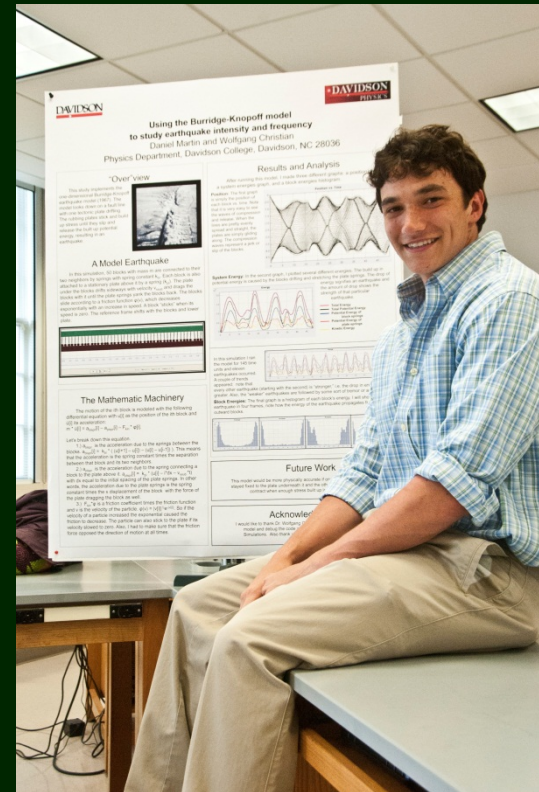
- Models allows students to think about things in terms of simpler artificial things.
- Curriculum
 - Exploratory models engage the student in ideas presented by an expert (teacher). Students are led to confront another's view of a problem.
 - Model-based and programming activities are expressive exercises that require students to externalize their own ideas and assumptions and to create concrete representations that they can reflect on.



Undergraduate Computational Physics

Teaching should reflect current research and professional practice. 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: oscillators, Newtonian orbits, and few-body problems.
- PDEs and boundary value problems: Laplace and Poisson equations.
- Stochastic models and Monte Carlo algorithms: Random walks and the Ising model.
- Chaos theory: Logistic map and driven pendulum.
- **Final project of the student's choice.**



AAPT/ComPDRE Filing Cabinets

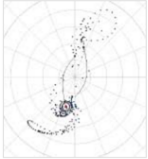
Authoring by Building Mash-ups in the Digital Library

Computer Program Detail Page

Colliding Galaxies

written by Wolfgang Christian and Kyung Taek Lim

The Colliding Galaxies Model is an implementation of Alar and Juri Toomres' 1972 super computer model showing the formation of galactic bridges and tails under the assumption that galactic cores are point masses and that one galactic core is surrounded by 2D concentric rings of orbiting stars. The model assumes that the stars (test particles) orbiting the galactic cores are non-interacting. When the two galaxies pass one another, tidal forces deform the star distribution into classic tidal features. Our EJS model reproduces this result showing that there is a long curving tail and that only the outermost ring of stars is affected by its companion galaxy. A thin bridge is also formed and some of the stars are captured by the companion galactic core.



The Colliding Galaxies Model Model was developed as a final project in a sophomore-level Computational Physics course (Phy 200) using the Easy Java Simulations (EJS) modeling tool. It is distributed as a ready-to-run (compiled) Java archive. Double clicking the ejs_mech_orbits_CollidingGalaxies.jar file will run the program if Java is installed.

Please note that this resource requires at least version 1.5 of Java.

[download 1767kb .jar](#)
Published: May 16, 2009
[previous versions](#)

[View the supplemental document attached to this resource](#)
[View the source code document attached to this resource](#)

Subjects	Levels	Resource Types
Astronomy - Galaxies = Galactic Structure	- Upper Undergraduate - Lower Undergraduate	- Instructional Material = Interactive Simulation
Classical Mechanics - Gravity = Orbits - Motion in Two Dimensions = Center of Mass = Central Forces		
General Physics - Computational Physics		

Intended Users	Formats	Ratings
- Learners - Educators	- application/java	★★★★★ Rated 5.0 stars by 2 people Want to rate this material? Login here!

Item Details | **Related (2)** | **Cite** | **Shared Folders (7)**

Access Rights: **Free access**
License: This material is released under a GNU General Public License Version 3 license. Additional information is available.
Rights Holder: Wolfgang Christian

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Related Materials
Is Based On
[Easy Java Simulations Modeling and Authoring Tool](#)
Covers the Same Topic As
[Orbiting and Colliding Galaxies 3D Model](#)
[See details...](#)

Similar Materials
[Orbits Within Spherical Galaxies Model](#)
[Two Body Orbits Model](#)
[Classical Helium Model](#)
[More...](#)



Davidson Student Projects folder

My Folders

My Filing Cabinet

Davidson Student Projects

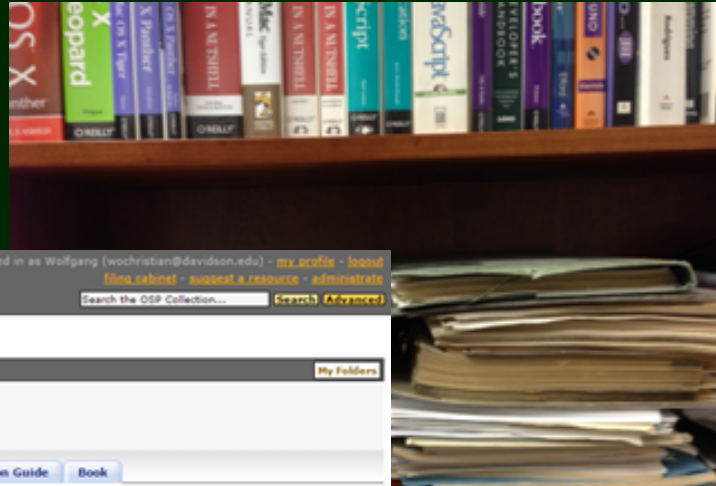
Bookmarks | **Sharing** | Folder Management | Citation Guide

Davidson Student Projects (16 resources, 2 subfolders)
Computational Physics (Phy 200) end of term projects.

- Colliding Galaxies**
The Colliding Galaxies Model is an implementation of Alar and Juri Toomres' 1972 super computer model showing the formation of galactic bridges and tails under the assumption that galactic cores are point masses and that one galactic core is surrounded by 2D concentric rings of orbiting stars. The model assumes that the stars (test particles) orbiting the galactic cores are non-interacting. When the two galaxies pass one another, tidal forces deform the star distribution into classic tidal features. Our EJS model reproduces this result showing that there is a long curving tail and that only the outermost ring of stars is affected by its companion galaxy. A thin bridge is also formed and some of the stars are captured by the companion galactic core.
[details](#) - [download](#) - [edit bookmark](#) - [cite](#)
- Dielectric Breakdown Lightning Model**
The Dielectric Breakdown Lightning Model implements a common method for modeling lightning using a grid with regions of varying electric potential to simulate the electrical charge buildup during a lightning storm. To simulate the source of the lightning in the cloud, we set the potential to zero and place a small region of negative charge near the top of the grid. Along the bottom of the grid, we set the boundary potential to one to simulate the positive charge on the ground. All other grid points are given an initial electric potential equal to 0.5. After solving Laplace's equation, we examine all the grid points that are adjacent to a negative charge. We choose one adjacent point as the new growth site for the lightning, representing a point where the air is ionized and lightning will develop.
[details](#) - [download](#) - [edit bookmark](#) - [cite](#)
- Baton Orbit Model**
Baton Orbit Model shows the trajectory of a baton-like object orbiting under the influence of a $1/r^2$ force. This model was motivated by the tumbling motion of one of Saturn's moons, Hyperion. Hyperion is the only celestial body in our solar system which exhibits chaotic tumbling. The chaotic motion is attributed to the uneven mass distribution and highly elliptical orbit of the moon. In order to model the behavior of Hyperion, we approximate its shape using a baton-like object composed of two point masses connected by a mass-less rod. This uneven mass distribution causes a net force and a net torque on its center of mass.
[details](#) - [download](#) - [edit bookmark](#) - [cite](#)
- Double Pendulum With Poincare Map Model**
The Double Pendulum model displays the motion of a two-part pendulum and its Poincare map. A double pendulum is a simple pendulum with another pendulum attached to its end and the state of this dynamical system is specified by two angles and two angular velocities. Because there is no friction, the double pendulum is an example of a Hamiltonian system and energy is conserved. This EJS model simplifies the system by using equal length arms and masses. Clicking in the Poincare section sets the initial conditions of the rotor. The user can examine and modify this simulation if EJS is installed by right-clicking within the plot and selecting "Open EJS Model" from the pop-up menu item.
[details](#) - [download](#) - [edit bookmark](#) - [cite](#)

AAPT/ComPADRE Books

Going from this



To this



To this

Waves: An Interactive Tutorial by Kyle Farinash and Wolfgang Christian

1. Basic Properties 2. Combining Waves 3. External Interactions 4. Applications

Waves: An Interactive Tutorial

This online book uses a series of tutorials based on interactive simulations and animations to explore the physics of waves. Students develop their understanding of waves through guided questions and exercises based on these simulations.

- 1. Basic Properties
- 2. Combining Waves
- 3. External Interactions
- 4. Applications

About this book

This is a set of interactive tutorials designed to teach the fundamentals of wave dynamics. It starts with very simple wave properties and ends with an examination of nonlinear wave behavior. The emphasis here is on the properties of waves which are difficult to illustrate in a static textbook figure. The tutorial may be used in conjunction with a text or as a stand alone introduction to waves. Exposure to calculus and basic physics is assumed in the latter sections.

NOTE: The simulations are now all in JavaScript and have been tested to run in Chrome and Firefox browsers with JavaScript enabled. They should also run in those browsers on tablets and smart phones.

Introduction to Waves Tutorial

More about the design and goal of this tutorial, with a simple example.

[ready-to-run](#) - [details](#)

Available on ComPADRE Now!

Modeling Wealth Inequality

1. Simulations Without Taxes

This online book uses a series of explore an agent-based model to wealth inequality.

- 1. Simulations Without Taxes
- 2. Simulations With Taxes
- 3. Resources
- 4. Exercises

About this book

Time Evolution of a Wave Function

1. Part A 2. Part B 3. Part C

This AAPT/ComPADRE file folder provides a computer-based tutorial on the "Time Evolution of the Wave Function." This tutorial is the result of a recently developed computer-based tutorial that have resulted from the collaboration of the Quantum Interactive Learning Tutorial project and the Open Source Physics project.

- 1. Part A
- 2. Part B
- 3. Part C
- 4. Worksheets

About this book

Waves: An Interactive Tutorial

by Kyle Forinash and Wolfgang Christian

Hosted by AAPT ComPADRE


1. Basic Properties 2. Combining Waves 3. External Interactions 4. Applications

Waves: An Interactive Tutorial

This online book uses a series of tutorials based on interactive simulations and animations to explore the physics of waves. Students develop their understanding of waves through guided questions and exercises based on these simulations.

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despite recent work assessing and improving the conceptual understanding of students and despite availability of computer simulations. Students, therefore, often see quantum mechanics in terms of misleading or incomplete visualizations, as one dimensional and time independent, and devoid of almost any connection with classical physics. To address this situation, the AAPT/ComPADRE book presents class-tested interactive Open Source Physics based curricular material in support of the teaching of quantum mechanics. These exercises address both quantitative and conceptual difficulties encountered by many students, such as the time development of superposition states.

©2015 Wolfgang Christian, Mario Belloni, and Chandrabhika Singh.

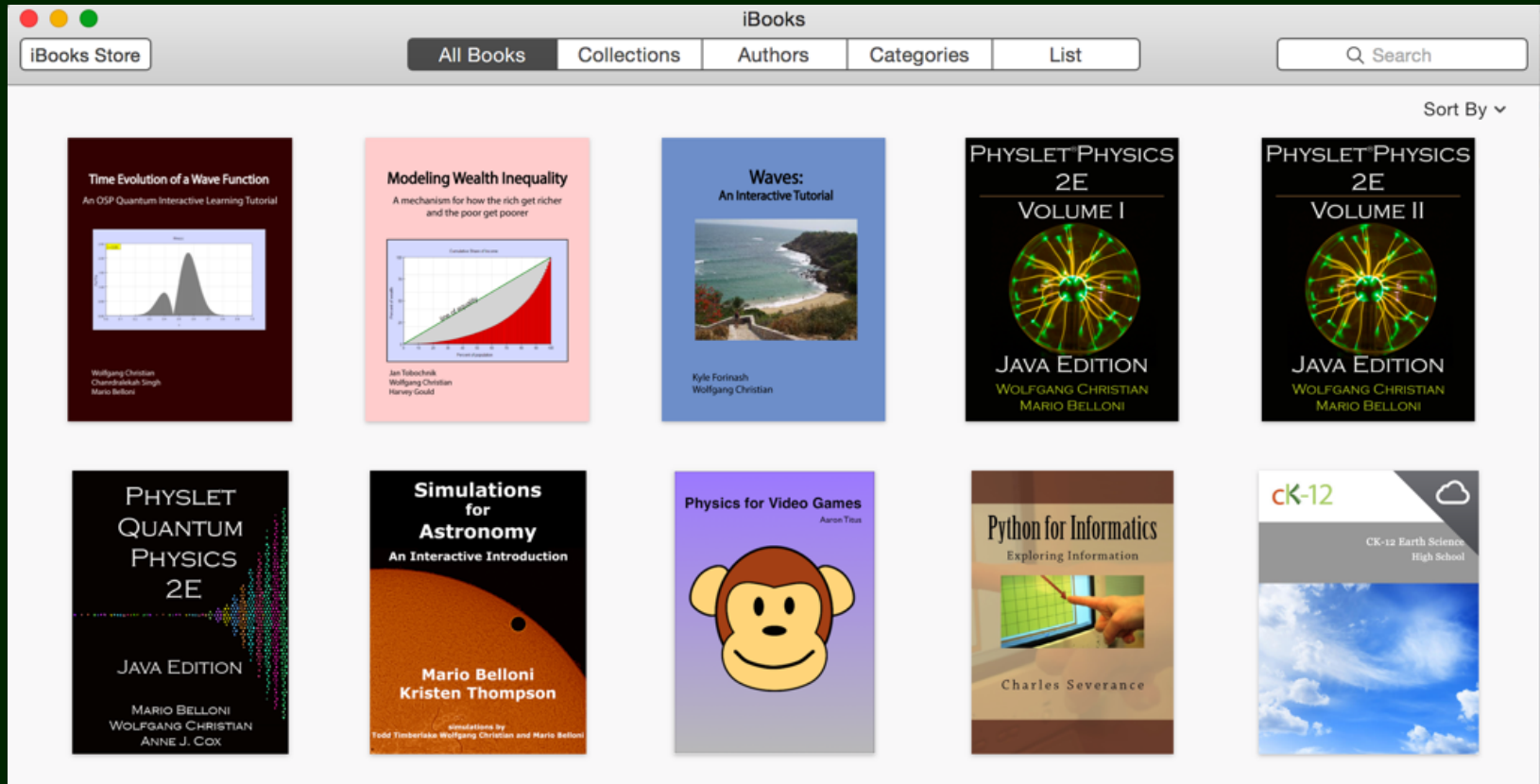
Hosted by AAPT ComPADRE as a member service

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Authoring Epub 3 with EjsS

And this



Distributing Content with the EjsS Reader



The screenshot displays the EjsS Reader interface, titled "EjsS Reader - Viewer for Easy Java/Javascript Simulations". The interface includes a toolbar with icons for search, home, refresh, and print, along with a "foldername" field and a "Create" button. Below the toolbar, a file browser shows a "[root] /" directory. A tip at the top right reads: "Tip: Drag & Drop files from your desktop to your browser." The main area contains nine simulation thumbnails, each with a small author portrait and a title:

- QM Barrier Scattering** by Wolfgang Christian: A plot of wave function $\Psi(x)$ vs x showing multiple peaks and troughs.
- Bound Eigenstate Superpos...** by Wolfgang Christian: A plot of wave function $\Psi(x)$ vs x showing two overlapping wave packets.
- Free Particle Eigenstate Sup...** by Wolfgang Christian: A plot of wave function $\Psi(x)$ vs x showing several distinct wave packets.
- Simulation: Ten agent econ...** by W. Christian: A bar chart showing wealth vs agent number.
- Simulation: Pareto's Principle** by W. Christian: A graph of cumulative share of income vs percent of population, showing a red area under a green line of equality.
- Antenna** by Author name: A diagram showing the y-component of change in electric field between a sending and receiving antenna.

Available Android, iOS, and [Online](#) with Google Chrome,

What we have learned about:

Getting Simulations Right

- Work on curriculum development from the start as you work on programming. It will carry the message in the end.
- Focus on an important concept or application. Too many options distract.
- The devil is in the detail. A small practical problem can ruin a grand plan.
- It is HARD to do new things in front of students. (e.g. JiTT, Peer Instruction, ILD, Flipped Classroom, Etc.)
- Real curriculum change, which means changing people, takes time. My first book, *CUPS: Waves and Optics*, was published in 1994.

The **OSP-EjsS-ComPADRE** platform removes many of the complicated tasks involved in integrating simulation and modeling into the classroom allowing teachers and students to focus on the science.



Open Source and CC – Facilitating Collaboration

Open Source Physics @Singapore A Singapore physics teacher's blog that us... search

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Recent Date Label Author

Using Tracker as a Model-Building Pedagogical Tool
Level: Upper Secondary and JC
Subject: Science
Time: 10 min
This hands-on workshop aims to role model analysis and modeling tool https://www.c... Professor Douglas Brown, USA, to allow stud... the model building process in the kinemat... rolling horizontally with friction. The model bu... velocity model, evidence-based constant of... push and frictional motion model.

Sharing of teacher growth story by leongster

Primary Level Template About

A Level Template About

O Level Template About

Creating Electronic Interac...
Books for Computers
Tablets/Cell Phones Using
Java/JavaScript Simulations,
Modeling

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Feedyly Tools

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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 (Henderson & Dancy).

OSP Collection Team & Collaborators

- **OSP Managing Editor:**
 - Wolfgang Christian - Davidson College
- **OSP and EJS Curriculum Authors:**
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 - Todd Timberlake – Berry College
 - Harvey Gould - Clark University
 - Jan Tobochnik - Kalamazoo College
 - Loo Kang Wee – MOE Singapore
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 - Doug Brown - Cabrillo College
- **Easy Java Simulations Developers:**
 - Francisco Esquembre - Universidad de Murcia
 - Felix García Clemente - Universidad de Murcia
 - Luis de la Torre - Universidad Nacional de Educación a Distancia
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 - Bruce Mason – University of Oklahoma
 - Lyle Barbato- AAPT
 - Matt Riggsbee- AAPT
 - Caroline Hall- AAPT



