Recommended Websites for Animation/Demonstration

Almost all website animations depend on one or more web technologies. Shockwave and Flash are available free from macromedia.com. Java is available from java.com.

1) Flash Animations for Physics – This site contains 89 animations with a description of each animation. At the end of the site is included a page with further links.

2) Best Physics Websites by Rebecca Wenning – Most of the websites were researched through *The Physics Teacher*. A short description follows each site and is accompanied with a rating scale. The best are labeled GEM. There is also a good review of other video material, videotape, DVD, etc.

3) Math, Physics and Engineering Applets (Falstad) – More than forty links, each has a short description of purpose. At the end of the site there is a list of additional websites.

4) PhET (Physics Education Technology) – This site contains sixty links. There is no description of the animation, but there is a ranking for each site based on user feedback.

5) General Physics Java Applets (Surendranath) – This site contains approximately sixty links. There is no description of the individual sites, only titles.

6) Victoria Junior College (Singapore) – Twenty-seven animations, titles only. Nicely done.

Flash Animations for Physics

We have been increasingly using *Flash* animations for illustrating physics content. This page provides access to those animations, which may be of general interest. The animations will appear in a separate window.

The animations are sorted by category, and the file size of each animation is included in the listing. Also included is the minimum version of the Flash player that is required; the player is available free from http://www.macromedia.com/. The categories are:

- Chaos
- Classical Mechanics
- Electricity and Magnetism
- Micrometer Caliper
- Miscellaneous
- Nuclear
- Optics
- Oscilloscope
- Quantum Mechanics
- Relativity
- Sound Waves
- Vectors
- Waves

In addition, I have prepared a small tutorial in using Flash to do physics animations. It contains screen shots and embedded Flash animations, so the file size is a 173K. You may view it in a separate window at:
http://faraday.physics.utoronto.ca/PVB/Harrison/Flash/Tutorial/FlashPhysics.html.

These animations have been translated into Catalan, Spanish and Basque:

En aquest enllaç http://ticat.ua.es/David-Harrison podeu trobar la versió al
català de les animacions Flash de Física
Las animaciones Flash de Física se han traducido al español, y están disponibles en esta dirección: http://ticat.ua.es/David-Harrison

Fisikako Flash animazioak euskeratu dira eta helbide honetan eskura daitezke: http://ticat.ua.es/David-Harrison

There are 89 animations listed below. Some are simple; others are more complex. The most recent animations added to the list are identified.

Category	Title	Description/Comment	
Chaos	NEW Bunimovich Stadium	Illustrating the Chaotic Bunimovich Stadium. Requires Flash 6; file size is 17K.	View
Chaos	Logistic Map	The logistic map, which demonstrates the bifurcations of the population levels preceding the transition to chaos. Requires Flash 6; file size is 15K.	View
Chaos	Lorenz Attractor	Looking at the Lorenz attractor in a chaotic regime, allowing the attractor to be rotated. Requires Flash 6; file size is **550K**.	View
Chaos	Three-Body Gravitational Interaction	Two fixed suns and one planet. Initial conditions are controllable, and up to four different independent planets may be displayed. Requires Flash 6 and a computer with reasonable power; file size is 50K.	View
Classical Mechanics	Displacement and Distance	A simple animation showing the difference between the *distance* and the *displacement*. Requires Flash 5; file size is 5K.	View
Classical Mechanics	Constant Acceleration	One-dimensional kinematics of a body undergoing constant acceleration. Includes visually integrating the acceleration and velocity graphs, and visually differentiating the position and velocity graphs. Requires Flash 6; file size is 30K.	View
Classical Mechanics	Motion Animation	A car with a non-zero initial speed has a constant acceleration whose value can be controlled by the user. Requires Flash 6; file size is 27K.	View
Classical Mechanics	Dropping Two Balls Near the Earth's Surface	Two balls falling near the Earth's surface under the influence of gravity. The initial horizontal speed of one of the balls may be varied. Requires Flash 6; file size is 11K.	View
Classical Mechanics	Galilean Relativity	Illustrating Galilean relativity using his example of dropping a ball from the top of the mast of a sailboat. Requires Flash 6; file size is 22K.	View
Classical Mechanics	Projectile Motion	Firing a projectile when air resistance is negligible. The initial height and angle may be adjusted. Requires Flash 6; file size is 36K.	View
Classical Mechanics	Kinematics of Projectile Motion	A visualization exploration of the kinematics of projectile motion. Requires Flash 6; file size is 9K.	View
Classical Mechanics	The Monkey and the Hunter	An animation of the classic lecture demonstration. The actual demonstration is preferable if possible; then this animation can be given to the students for	View

		later review. Requires Flash 6; file size is 21K.	
Classical Mechanics	Racing Balls	Two balls roll down two different low-friction tracks near the Earth's surface. The user is invited to predict which ball will reach the end of the track first. This problem is difficult for many beginning physics students. Requires Flash 6 (Release 79); file size is 140K.	View
Classical Mechanics	Racing Skiers	The "Racing Balls" animation, which is accessed via the above line, sometimes triggers cognitive dissonance and rejection in beginning students. For some of these, changing the balls to skiers helps to clarify the situation, and that is what this animation does. The "Racing Balls" one should be used with students first. Requires Flash 6 (Release 79); file size is 145K.	View
Classical Mechanics	Air Track Collisions	Elastic and inelastic collisions on an air track, with different masses for the target cart. Requires Flash 6; file size is 70K.	View
Classical Mechanics	Newton's Cradle	A small animation of Newton's Cradle, sometimes known as Newton's Balls. Requires Flash 6; file size is 1K.	View
Classical Mechanics	Hooke's Law	A simple animation illustrating Hooke's Law. Requires Flash 6; file size is 13K.	View
Classical Mechanics	Coordinate System for Circular Motion	An unusual coordinate system for describing circular motion. Requires Flash 6; file size is 94K.	View
Classical Mechanics	Vertical Circular Motion	A mass is in circular motion in the vertical plane. We show the weight and force exerted by the tension in the string. Requires Flash 6; file size is 7K.	View
Classical Mechanics	Forces on a Pendulum	The weight, force due to tension, and total force exerted on the bob of a pendulum are shown. Requires Flash 6; file size is 8K.	View
Classical Mechanics	Rolling Disc	A simple animation that traces the motion of a point on a rolling disc. Requires Flash 6; file size is 31K.	View
Classical Mechanics	Right-Hand Screw Rule	The direction of the angular velocity vector given by a right-hand screw rule. Requires Flash 6; file size is 196K. Also linked to from the *Vectors* section.	View
Classical Mechanics	Direction of the Angular Velocity	A simple animation of the direction of the angular velocity vector. Requires Flash 6; file size is 125K.	View

	Vector		
Classical Mechanics	Curling	Curling rocks and tori sliding across surfaces. Requires Flash 6; file size is **601K**.	View
Classical Mechanics	NEW How Does a Cat Land on its Feet?	The saying is that cats always land on their feet. This animation explains how they do this. Requires Flash 6; file size is 81K.	View
Classical Mechanics	Precession of a Spinning Top	A simple animation of a spinning top, which precesses. Requires Flash 5; file size is **739K.**	View
Classical Mechanics	Simple Harmonic Motion I	Demonstrating that one component of uniform circular motion is simple harmonic motion. Requires Flash 6; file size is 10K.	View
Classical Mechanics	Simple Harmonic Motion II	Illustrating and comparing simple harmonic motion for a spring-mass system and for an oscillating hollow cylinder. Requires Flash 5; file size is 20K.	View
Classical Mechanics	Damped Simple Harmonic Motion	The damping factor may be controlled with a slider. The maximum available damping factor of *100* corresponds to critical damping. Requires Flash 6; file size is 12K.	View
Classical Mechanics	Driven Simple Harmonic Motion	A harmonic oscillator driven by a harmonic force. The frequency and damping factor of the oscillator may be varied. Requires Flash 6; file size is 199K.	View
Classical Mechanics	Coupled Harmonic Oscillators	Two simple pendulums connected by a spring. The mass of one of the pendulums may be varied. Within mathematical rounding errors, the resolution on the screen of one pixel and a frame rate of 12 frames per second the animation is correct, not an approximation. Requires Flash 6; file size is 47K.	View
Electricity and Magnetism	Comparing a DC Circuit to the Flow of Water	A simple DC circuit has a DC voltage source lighting a light bulb. Also shown is a hydraulic system in which water drives a turbine. The two systems are shown to be similar. Requires Flash 6; file size is 51K.	View
Electricity and Magnetism	Field Lines	Illustrating representing an electric field with field lines. Requires Flash 5; file size is 22K.	View
Electricity and Magnetism	A Simple Buzzer	A simple buzzer consisting of a battery, a flexible metal strip, a piece of iron, and some wire. Requires Flash 6; file size is 20K.	View
Electricity and Magnetism	Electric Field of an Oscillating Charge	An electric charge is executing simple harmonic motion, and the animation shows the electric field	View

		lines around it. Requires Flash 6 and a computer with reasonable power; file size is 40K.	
Electricity and Magnetism	Electric and Magnetic Fields of an Oscillating Charge	A three-dimensional animation of the "far" fields of an oscillating charge. Requires Flash 6; file size is 120K.	View
Electricity and Magnetism	Circular Polarization	Circular polarization generated from a linearly polarized electromagnetic wave by a quarter-wave plate. Requires Flash 6; file size is **785K.**	View
Electricity and Magnetism	Spinning Charges and an Inhomogeneous Magnetic Field 1	A spinning charged object passes through an inhomogeneous magnetic field. This animation is also used in a discussion of the Stern-Gerlach experiment. Requires Flash 6; file size is 74K.	View
Electricity and Magnetism	Spinning Charges and an Inhomogeneous Magnetic Field 2	A spinning charged object passes through an array of three magnets, each producing an inhomogeneous magnetic field. This animation is also used in a discussion of the Stern-Gerlach experiment. Requires Flash 6; file size is 79K.	View
Micrometer Caliper	Measuring with a Micrometer	A simple animation of using a micrometer to measure the width of a pencil. Requires Flash 5; file size is 13K.	View
Micrometer Caliper	An Exercise in Reading a Micrometer	Provides controls to position the micrometer, and when a button is clicked displays the reading. Requires Flash 5; file size is 30K.	View
Miscellaneous	A Simple Piston and Boyle's Law	A small animation showing a piston compressing a sample of gas. As the volume of the gas goes down, the density and, therefore, the pressure, goes up. Requires Flash 5; file size is 3.9K.	View
Miscellaneous	Derivative of the Sine Function	An animation illustrating that the derivative of a sine function is a cosine. Requires Flash 6, file size is 20K.	View
Miscellaneous	Area of a Circle as a Limit	Illustrating that the area of a circle is a limit of the sum of the areas of interior triangles as the number of triangles goes to infinity. Requires Flash 5; file size is 12K.	View
Miscellaneous	Integration	Illustrating the meaning of the integral sign, including an example. Requires Flash 5; file size is 124K.	View
Nuclear	Scattering	Simulating nuclear scattering experiments by scattering ball bearings off targets. This is based on an experiment in the First Year Physics	View

		Laboratory at the University of Toronto. Requires Flash 6 (Release 79); file size is 182K.	
Nuclear	Nuclear Decays	The decay of 500 atoms of the fictional element Balonium. Uses a proper Monte Carlo engine to simulate real decays. Requires Flash 6; file size is 27K.	View
Nuclear	Pair Production	A simple illustration of electron-positron production and annihilation. Requires Flash 5; file size is 21K.	View
Nuclear	The Interaction of X-Rays with Matter	Illustrating the three principle modes by which X-rays interact with matter. Requires Flash 6; file size is 47K.	View
Optics	Rotating a Mirror and the Reflected Ray	Illustrating that when a mirror is rotated by an angle, the reflected ray is rotated by twice that angle. Requires Flash 6; file size is 20K.	View
Optics	Reflection and Refraction	Illustrating reflection and refraction, including total internal reflection. Requires Flash 6; file size is 33K.	View
Optics	Object-Image Relationships	Ray tracing for a thin lens showing the formation of a real image of an object. Requires Flash 5; file size is 17K.	View
Optics	Using an Optical Bench	A simulation of an optical bench with a light source, object, thin lens and an image. The screen that displays the image is moved. Requires Flash 5; file size is 14K.	View
Oscilloscope	The Time Base Control 1	Shows the effect of changing the time base control on the display of an oscilloscope. There is no input voltage. Requires Flash 5; file size is 10K.	View
Oscilloscope	The Time Base Control 2	Shows the effect of changing the time base control on the display when there is an input voltage varying in time. Requires Flash 5; file size is 12K.	View
Oscilloscope	The Time Base Control 3	Shows the effect of changing the time base control on the display when there is an input voltage varying in time when the frequency of the voltage is high. Requires Flash 5; file size is 17K.	View
Oscilloscope	The Voltage Control	Shows the effect of changing the voltage control on the display. Requires Flash 5; file size is 10K.	View
Oscilloscope	The Trigger	Shows the effect of changing the trigger level on the display. Requires Flash 5; file size is 5.9K.	View
Quantum	The Bohr Model	The photon excitation and photon emission of the	View

Mechanics		electron in a hydrogen atom as described by the Bohr model. Requires Flash 6: file size is 77K.	
Quantum Mechanics	Complementarity	Here we visualize a hydrogen atom, which consists of an electron in orbit around a proton. In one view the electron is a *particle* and in the other view it is a *probability distribution*. The reality is neither view by itself, but a composite of the two. Requires Flash 5; file size is 15K.	View
Quantum Mechanics	The Double-Slit Experiment 1	The famous "Feynman Double-Slit Experiment" for electrons. Here we fire one electron at a time from the electron gun, and observe the build-up of electron positions on the screen. Requires Flash 5; file size is 15K.	View
Quantum Mechanics	The Double-Slit Experiment 2	Here we illustrate *Complementarity* using the double-slit experiment. We view the path of the electron from the gun to the observing screen as a particle and as a wave. Requires Flash 5; file size is 33K.	View
Quantum Mechanics	Stern-Gelach Filters	Up to three Stern-Gerlach filters with user-controlled orientations are placed in an electron beam. Requires Flash 7; file size is 130K.	View
Relativity	Michelson-Morley Experiment	A simple analogy involving two swimmers that sets up the Michelson-Morley Experiment. Requires Flash 6; file size is 15K.	View
Relativity	Time Dilation	A demonstration that the phenomenon of time dilation from the special theory of relativity necessarily follows from the idea that the speed of light is the same value for all observers. Requires Flash 6; file size is 55K.	View
Relativity	Deriving Length Contraction	A tutorial that shows how relativistic length contraction must follow from the existence of time dilation. Requires Flash 5; file size is 37K.	View
Relativity	Length Contraction is Invisible	This series of animations demonstrates that the relativistic length contraction is invisible. Requires Flash 5; file size is 90K.	View
Relativity	Deriving the Relativity of Simultaneity	A tutorial that shows how the relative nature of the simultaneity of two events must follow from the existence of length contraction. Requires Flash 5; file size is 39K.	View
Relativity	Twin Paradox	There are many ways of approaching this classic "paradox." Here we discuss it as an example of the relativistic Doppler effect. Requires Flash 6; file	View

		size is 116K.	
Relativity	Foucault Pendulum and Mach's Principle	This began as an animation of the Foucault Pendulum, but then I generalized it to illustrate Mach's Principle. Requires Flash 6; file size is **1.5M**.	View
Relativity	NEW Advance of the Perihelion	A simple animation showing Newton's and Einstein's predictions for the orbit of Mercury. Requires Flash 6; file size is 7K.	View
Sound Waves	Beats	Illustrating beats between two oscillators of nearly identical frequencies. Requires Flash 6; file size is 215K.	View
Sound Waves	NEW Doppler Effect: Wave Fronts	Illustrating the wave fronts of a wave for a moving source. There are a few similar animations on the web: this is my reinvention of that wheel. Requires Flash 6; file size is 11K.	View
Sound Waves	Doppler Effect	Illustrating the classical Doppler effect for sound waves. Requires Flash 6; file size is 43K.	View
Sound Waves	Tuning Fork	A small animation of a vibrating tuning fork producing a sound wave. Requires Flash 5; file size is 2.7K.	View
Sound Waves	Pressure and Displacement Waves	This animation shows air molecules vibrating, with each molecule "driving" its neighbor to the right. It is used to illustrate that when the displacement wave is at a maximum, then the density of the molecules, and thus the pressure wave, is at a minimum and vice versa. Requires Flash 5; file size is 30K.	View
Sound Waves	Temperament	A very brief introduction to the physics and psychophysics of music, with an emphasis on temperament, the relationship between notes. Requires Flash 6 and sound; file size is 151K.	View
Vectors	Adding 2 Vectors	A simple demonstration of adding two vectors graphically. Also demonstrates that vector addition is commutative. Requires Flash 5; file size is 7K.	View
Vectors	Adding 3 Vectors	A simple demonstration of adding three vectors graphically. Also demonstrates that vector addition is associative. Requires Flash 5; file size is 10K.	View
Vectors	Subtracting 2 Vectors	A simple demonstration that subtracting two vectors graphically is the same as adding the first one to the negative of the second one. Requires Flash 5; file size is 4.5K.	View

Vectors	Component Addition	A simple demonstration that to add two vectors numerically, just add the Cartesian components. Requires Flash 5; file size is 16K.	View
Vectors	Unit Vectors	A simple animation of unit vectors and vector addition. Requires Flash 6; file size is 12K.	View
Vectors	Dot Product	A simple demonstration of the relation between the dot product of 2 vectors and the angle between them. Requires Flash 6; file size is 8K.	View
Vectors	Right-Hand Screw Rule	The direction of the angular velocity vector given by a right-hand screw rule. Requires Flash 6; file size is 196K. Also linked to from the *Classical Mechanics* section.	View
Vectors	Cross Product	The direction of the cross product of two vectors is demonstrated. The magnitude shown is correct but not discussed. Requires Flash 6; file size is 44K.	View
Waves	Traveling Waves	Illustrating the sign of the time term for traveling waves, moving from left to right or right to left. Requires Flash 6; file size is 42K.	View
Waves	Reflections from a Barrier	A wave is reflected from a barrier with a phase reversal. This is the behavior for transverse waves and the *displacement* aspect of a longitudinal wave. Requires Flash 5; file size is 42K.	View
Waves	Reflections from Two Barriers	A wave is reflected back and forth between two barriers, setting up a standing wave. Requires Flash 5; file size is 41K.	View
Waves	Standing Waves with a Node on Both Ends	The first three standing waves for nodes at both ends. The frequencies of the waves are proportional to one over the wavelength. Requires Flash 5; file size is 11K.	View
Waves	Standing Waves with a Node on One End	The first three standing waves for a node at one end and an antinode at the other. The frequencies are proportional to one over the wavelength. Requires Flash 5; file size is 18K.	View

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This page turns out to be linked to from a number of other sites. This surprises and delights me. A few of those sites are:

Educational Technology blog from the Univ. of Illiinois

AUTHOR, COPYRIGHT, COPYING

These animations were written by David M. Harrison, Dept. of Physics, Univ. of Toronto, harrison@physics.utoronto.ca.

If you wish to put a copy of an animation on your own web server, you may wish to know that in all cases the name of the animation file is the same as the name of the html file that accesses it, except that the filename extension is .swf instead of .html. Thus, from Netscape or Mozilla, you may use Save As ... to save the html file. Then you may manually change the URL so that it ends in .swf instead of .html, press Enter and use Save As ... to save the swf file. Internet Explorer users will need to erase the entire file name, so that the URL ends with the directory name; then after pressing Enter, the names of the files in the directory will be displayed and you may right-click on the desired swf file name and choose Save Target As....

I will be interested to know if you have downloaded one or more of my animations. If you are so inclined, send me an e-mail message.

This index to the animations was last changed on $Date: 2006/11/17 13:29:45 $ (y/m/d UTC).

Best Physics Websites *by Rebecca Wenning*

Evaluation Tool: Websites receive one star per applying criteria (*). Websites of exceptional quality and teacher/student utility are labeled as gems (GEM).

Depth:	Information enhances what might be found in a typical textbook.
Breadth:	Information put into historical or conceptual context
Sponsorship:	Site sponsored by a reputable state/national/international organization or institution (not personal pages).
Unique Aspect:	Site offers a significant aspect not yet found on any other site (idea, professional development, interactivity).
Usability:	Most links are working, searches and menus easy to use, utility to physics teachers' everyday life, credible site (Would I use it?).

SITES ARE HIGH SCHOOL-FOCUSED, FREE, and NON-COMMERCIAL.

Websites were found via:

- *The Physics Teacher* website column (2004-2006).
- Visiting websites from *TPT* and following links pages.
- Google directory categories.

ORIGINAL SOURCE DOCUMENTS/HISTORY

The NIST Reference on Constants, Units, and Uncertainty **GEM** *****
Most recent published values for constants with uncertainty, bibliographic search for original research articles.
http://physics.nist.gov/cuu/Constants/index.html

A Century of Physics Timeline *****
Clickable timeline with brief explanations of historic physics events from 1890 to the present.
http://timeline.aps.org/APS/Timeline/

History Exhibits/Selected Great Papers *****
Online exhibits on Curie, Einstein, Transistors, Lawrence, Heisenberg, Sakharov, Thomson.
Famous papers by Franklin, Joseph Henry, Michelson, Rowland, Gibbs, Millikan, Compton.
http://www.aip.org/history/exhibits.html

Galileo's Battle for the Heavens *****
Biography, online experiments for falling objects, projectiles, inclined planes, pendulums.
http://www.pbs.org/wgbh/nova/galileo/

Galileo Project *****
Biography, information on science of Galileo's day, student projects (click on "Library").
http://galileo.rice.edu/

Einstein's Big Idea *****
Biography, interactive exhibits on time dilation, light speed, science history.
http://www.pbs.org/wgbh/nova/einstein/

Internet Modern History Sourcebook ****
Original documents by Copernicus, Galileo, Bacon, Descartes, Voltaire, Newton, Franklin, Harvey, Vesalius, Preistley. Some links are unavailable.
http://www.fordham.edu/halsall/mod/modsbook09.html

Selected Classic Papers from the History of Chemistry ****
Excellent collection of papers about gases, kinetics, thermodynamics, etc.
http://web.lemoyne.edu/~giunta/papers.html

Contributions of 20th Century Women to Physics ****
Biographies of 86 women physicists, documents regarding women in physics.
http://cwp.library.ucla.edu/

Niels Bohr Library ****
Very comprehensive search engine for original physics documents. Library contents are not loaned out of the building—photocopies can be made at a cost.
http://www.aip.org/history/nblbro.htm

Benjamin Franklin as My Lab Partner ****
Original documents about experiments on electrostatics by Franklin with modern explanation.
http://www.tufts.edu/as/wright_center/fellows/bob_morse_04/06_Franklin_Lab_Part_VI.pdf

"Physics" by Aristotle ****
Original document by Aristotle.
http://classics.mit.edu/Aristotle/physics.html

"The Theory of Sound" by Lord Raleigh ****
Original document by Raleigh. First chapter only.
http://www.measure.demon.co.uk/docs/Theory.html - note1

"Reflections on the Motive Power of Heat" ****
Original document by Carnot
http://www.history.rochester.edu/steam/carnot/1943/

"On Scientific Method" ***
Excerpt from Percy W. Bridgman's *Reflections of a Physicist,* 1955.
http://hackensackhigh.org/~nelsonb/bridgman.html

GENERAL PHYSICS SITES for Teachers (Curriculum, Tests, Worksheets, Assistive Programs, Online Textbooks, Physics Encyclopedias)

Modeling Instruction Program **GEM** *****
Modeling Curriculum: Mechanics, Models of Light, Mechanical Waves and Sound, Microscopic E&M, CASTLE. Some files only accessible with password from workshops.
http://modeling.asu.edu/

Diagnoser Tool **GEM** *****
Physics diagnostic tool with "corrective" lesson suggestions for description of motion, nature of forces, forces to explain motion, and sound/light/waves. Diagnostic tests very critical thinking-oriented, but displayed results are somewhat difficult to interpret holistically.
http://www.diagnoser.com/diagnoser/

Annenberg Media **GEM** *****
The Mechanical Universe, 52-Part Series (videos approximately 20–60 minutes long). On-demand video, requires fast computer connection.
http://www.learner.org/resources/series42.html

Internet Archive (Physics B/C) **GEM** *****
Excellent introductory minutes-long videos for most physics subjects. Click on chosen lesson; to start video, click on "Click here to begin lesson" found in upper left corner.
http://www.archive.org/details/ap_physics_b
http://www.archive.org/details/ap_physics_c

National Center for Case Study Science **GEM** *****
Case study teaching method, comprehensive case collection, case ideas, assessment plans, professional development.
http://ublib.buffalo.edu/libraries/projects/cases/case.html

Physics Teaching Resources (Illinois State University) *****
Curriculum, resources. Some searching required, but lots of great resources found embedded in "Methods Courses: Syllabi."
http://www.phy.ilstu.edu/pte/resources.html

ClassNotesOnline.com ****
Free database to create teacher website and grade book.
http://www.classnotesonline.com/index.php

Socratic Dialogue Inducing Labs ****
Inquiry labs in mechanics.
http://www.physics.indiana.edu/~sdi/

Dolores Gende Homepage ****
Personal teacher page with traditional labs, innovative projects (equilibrium mobiles, lawn mower science), and great resources.
http://dgende.homestead.com/

Activity-Based Physics ****
Online books, alternative (real-world application) homework assignments, thinking problems, estimation problems, problem collection from *The Physics Suite*.
http://www.physics.umd.edu/rgroups/ripe/perg/abp/

The Physics Hypertextbook ***
Online book/workbook under construction. Many topics missing, but what can be found is generally high quality. For practice problems and high-quality worksheets, click on "Problem Sets," choose a topic, and browse pages to find "worksheets."
http://hypertextbook.com/physics/

Physics Education Research Group ***
Research information and publications on latest trends in physics teaching.
http://umperg.physics.umass.edu/

How Stuff Works ***
Explanations of how a myriad of things work.
http://www.howstuffworks.com/

Experiment Problems ***
Real-world inquiry problems easily implemented into classic labs.
http://www.physics.ohio-state.edu/~physedu/index2.html

comPADRE ***
Science partnership information. Search lesson plans, activities, and labs. Search categories very specific, but some results are commercial.
http://www.compadre.org/portal/index.cfm

The Physics Front ***
Search engine from comPADRE. New teacher focus.
http://www.thephysicsfront.org/

Physical Science Resource Center ***
Same search engine as from comPadre. No significant difference from The Physics Front.
http://psrc.aapt.org/

Movie Physics ***
Movie reviews with physics ratings. Physics concepts explained, but few suggestions for teaching.
http://intuitor.com/moviephysics/index.html

Physics Central **

Physics news, ask a physicist, how things work.
http://www.physicscentral.com/

Physlink.com **

Physics news, careers, higher education, Internet hub, but little information of its own.
http://www.physlink.com/Education/Index.cfm

Physics Teaching Technology Resource **

Videos of traditional demonstrations. Click on side menu after selecting category.
http://paer.rutgers.edu/PT3/index.php

Video Analysis Investigations for Physics and Mathematics **

Videos of traditional demonstrations. Allow time for video to load.
http://www.science.tamu.edu/CMSE/videoanalysis/index.htm

Lecture Demonstrations **

List/diagrams of classic demonstrations.
http://www.mip.berkeley.edu/physics/index.html

PASCO Physics Online Experiments **

Traditional labs to be used with PASCO equipment.
http://www.pasco.com/experiments/physics/

Dr. Hoselton's Physics Pages **

Traditional labs, applets, worksheets.
http://faculty.trinityvalleyschool.org/hoseltom/?

National Science Digital Library *

Web search, general science focus.
http://nsdl.org/

Discovery *

Search for upcoming TV shows about physics (check Mythbusters).
http://www.discovery.com/

Low-Cost Physics Activities *

Traditional labs and worksheets for the low-budget teacher.
http://www.science.tamu.edu/CMSE/LowCostPhysicsActivities.htm

IB Physics *

Step-by-step visuals of traditional labs, accompanying questions.
http://www.saburchill.com/physics/practicals/contents.html

GENERAL PHYSICS SITES for Students (Interactive Applets, Online Activities, Tutorials)

Physics Education Technology **GEM** *****
Free simulation programs (Circuit Construction, Masses and Springs, Radio Waves and Electromagnetic Fields, Wave on a String, Balloons and Static Electricity, Gas Properties, Balloons and Buoyancy, The Moving Man, Sound, Projectile Motion).
http://www.colorado.edu/physics/phet/web-pages/index.html

Physics.org **GEM** *****
"Physics Life" interactive program to discover physics in the everyday world, "Physics Evolution" clickable map, equation toolbox, common questions, careers.
http://www.physics.org/

The Physics Classroom *****
Tutorials, online textbook.
http://www.physicsclassroom.com/

Nobelprize.org *****
List of Nobel Prize winners by year. Click under winner's name in lower right corner to access other resources, including online tutorials and games regarding the winner's work.
http://nobelprize.org/nobel_prizes/physics/laureates/

HyperPhysics ****
Extremely thorough concept map encyclopedia, calculators for common physics problems.
http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

Fear of Physics **
Visual physics, homework help, answers to common questions. Be wary about giving this link to students—the "homework help" section has calculators for multiple common physics problems, possibly resulting in cheating. It may be a good review or problem-checking tool, however.
http://www.fearofphysics.com/

Virtual Physics Laboratory (I) **
Most comprehensive applet site so far (traditional physics phenomena).
http://www.phy.ntnu.edu.tw/java/indexPopup.html

Concept Simulations **
Audio with applets (traditional physics and applications).
http://www3.interscience.wiley.com:8100/legacy/college/cutnell/0471151831/concepts/

Flash Animations for Physics **
Very catchy flash applets (physics and mathematical processes).
http://www.upscale.utoronto.ca/GeneralInterest/Harrison/Flash/ - misc

Computer Animations **

Applets of physical processes and famous experiments. Not seemingly appropriate for showing to entire class—images not big enough.
http://physics.nad.ru/Physics/English/index.htm

SPECIFIC PHYSICS CONTENT

Mechanics and Energy

U.S. Department of Energy: Energy Efficiency and Renewable Energy *****

Grade-appropriate worksheets about types of energy and conservation.
http://www.eere.energy.gov/education/science_projects.html

Amusement Park Physics ****

Tutorials about roller coasters, carousels, bumper cars, free fall, pendulums, and ride safety. Activities include Design a Roller Coaster (and receive a safety and fun rating), and Colliding Cars prediction quiz.
http://www.learner.org/exhibits/parkphysics/

Roller Coaster Physics (Virginia Instructors of Physics) ****

Roller coaster science articles, labs, and tests.
http://www.vast.org/vip/book/HOME.HTM

Beginner's Guide to Aerodynamics ****

Physics of airplanes, activities, lessons, assessments.
http://www.lerc.nasa.gov/WWW/K-12/airplane/bga.html

Exploratorium (Skateboarding) ****

Conceptual physics behind skateboarding tricks.
http://www.exploratorium.edu/skateboarding/

Forces, Accelerations, and Car Crashes ****

Impressive car crash videos showing various seat-belt and no-belt scenarios.
http://regentsprep.org/Regents/physics/phys01/accident/

The Math and Physics of Soccer ***

Humorous site with short articles describing physics of soccer.
http://www.oceansiderevolution.com/EINSTEIN.HTM

Animated Engines ***

Applets of internal combustion, steam, and Stirling engines.
http://www.keveney.com/Engines.html

Babe Ruth Problem ***
Babe Ruth home run problem.
http://168.229.236.6/~rkc1/p4.pg73.n63.html

Mr. Fizzix Trebuchet Project ***
Integrated lessons on trebuchet physics.
http://mrfizzix.com/trebuchet/index.htm

Physics of Medieval Archery **
Basic archery physics, historical background.
http://www.stortford-archers.org.uk/medieval.htm

Archery Physics **
More complex archery physics.
http://www.student.utwente.nl/%7Esagi/artikel/bas/archghh.html

Physics of Weight Training **
Physics of weight lifting, click on "Part 2," etc., for more information.
http://www.bodybuilding.com/fun/becker2.htm

Electricity and Magnetism

Transistorized *****
Tutorials, build a transistor game.
http://www.pbs.org/transistor/

Exploring Electric Fields ***
Map electric fields by placing charges and finding lines of electric field.
http://www.gel.ulaval.ca/~mbusque/elec/

Light and Vision

Atmospheric Optics (I) ****
Photographs of atmospheric optics with conceptual physics explanations.
http://www.atoptics.co.uk/light.htm

Atmospheric Optics **
Photographs categorized by physics phenomena, but no physics explanations.
http://www.weather-photography.com/gallery.php?cat=optics

Optical Illusions **
Fun optical illusions with explanations, but not much physics.
http://www.michaelbach.de/ot

Wave Optics **
Applet (Interference experiment)
http://vsg.quasihome.com/interf.htm

Sound and Hearing

Music Acoustics *****
Physics of various instruments, hearing test.
http://www.phys.unsw.edu.au/music/

Soundry ****
Tour the ear, physics of music, history of sound.
http://library.thinkquest.org/19537/Main.html

Modern Physics

RadTown USA *****
Clickable city showing common sources of radiation.
http://www.epa.gov/radtown

Particle Physics *****
Tutorials on particle physics.
http://particleadventure.org/particleadventure/

Cosmic Evolution *****
Clickable timeline, movies, activities.
http://www.tufts.edu/as/wright_center/cosmic_evolution/

Nuclear Pathways ****
Hub for sites with digital libraries, Hiroshima remembered.
http://nuclearpathways.org/

Nuclear Energy Institute ****
Article resources. For lessons, click on "Science Club."
http://www.nei.org/

Antimatter ****
Tutorials, physics news, history of antimatter.
http://livefromcern.web.cern.ch/livefromcern/antimatter/

Understanding Radiation in Our World ***
Free kit for teachers.
http://www.nsc.org/ehc/rad/radbroch.htm

General Atomics Fusion Education ***
Curriculum workbooks, posters.
http://fusioned.gat.com/classroom.html

PROFESSIONAL ORGANIZATIONS/JOURNALS

American Association of Physics Teachers *****
Professional development opportunities, *The Physics Teacher, American Journal of Physics*.
http://www.aapt.org
http://www.aapt.org/tpt
http://www.aapt.org/ajp

Physics Teacher Education Coalition *****
Professional development opportunities, national science education reports (Go to "Links"), curricula (Go to "Links").
http://www.phystec.org/

Illinois State University Physics Teacher Education *****
Journal of Physics Teacher Education Online
http://www.phy.ilstu.edu/jpteo

National Science Teacher Association *****
Professional development with general science focus, *The Science Teacher*.
http://www.nsta.org

American Institute of Physics *****
Career information, online history of physics exhibit hall, *Physics Education*.
http://www.aip.org/
http://www.iop.org/EJ/journal/PhysEd

American Physical Society ****
Career information, physics news, *Physics Education Research*.
http://www.aps.org
http://prst-per.aps.org

Phys-L (Online Community) ***
Forum – Physics teachers talk about a variety of subjects.
https://carnot.physics.buffalo.edu/

PROFESSIONAL STANDARDS

National Science Education Standards *****

National Science Education Standards
http://www.nap.edu/readingroom/books/nses/html/

Inquiry and the National Science Education Standards *****

Inquiry and the NSES (Click on "Read this Book Online, Free!")
http://newton.nap.edu/catalog/9596.html

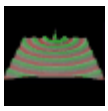
AAAS/Project 2061 *****

Science for All Americans, Benchmarks, Blueprints for Reform
http://www.project2061.org/publications/toolWeb.htm

These are some educational Java applets I wrote to help visualize various concepts in math, physics, and engineering. You should be able to view them with any Java-capable browser.

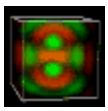
If you don't have Java, get the Java plug-in.

Oscillations and Waves

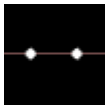


Ripple Tank (2-D Waves) Applet
Ripple tank simulation that demonstrates wave motion, interference, diffraction, refraction, Doppler effect, etc.

2-D Waves Applet
Demonstration of wave motion in 2-D.

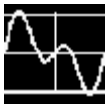


3-D Waves Applet
Demonstration of wave motion in 3-D.



Coupled Oscillations Applet
Demonstration of longitudinal wave motion in oscillators connected by springs.

Acoustics



Loaded String Applet
Simulation of wave motion of a string.

Rectangular Membrane Waves Applet
Vibrational modes in a 2-D membrane.

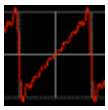
Circular Membrane Waves Applet
Vibrational modes in a 2-D circular membrane (drum head).

Bar Waves Applet
Bending waves in a bar.

Box Modes Applet
Acoustic standing waves in a 3-D box.

Acoustic Interference Applet
Generates audio interference between your speakers.

Signal Processing

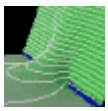


Fourier Series Applet
Frequency analysis of periodic functions.

Digital Filters
Filters digital signals and plays the output on your speakers.

Electricity and Magnetism: Statics

2-D Electrostatics Applet
Demonstrates static electric fields and steady-state current distributions.



2-D Electrostatic Fields Applet
Demonstrates electric fields in various 2-D situations; also shows Gauss's law.

3-D Electrostatic Fields Applet
Demonstrates electric fields in various 3-D situations.

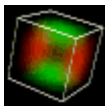
3-D Magnetostatic Fields Applet
Demonstrates magnetic fields in various situations.

Electrodynamics

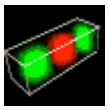
2-D Electrodynamics Applet (TE)
Demonstrates electromagnetic radiation.

2-D Electrodynamics Applet (TM)
Demonstrates electromagnetic radiation, induction, and magnetostatics.

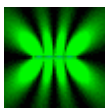
Analog Circuit Simulator Applet
Demonstrates various electronic circuits.



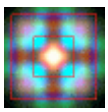
Cavity Modes Applet
Electromagnetic waves in a 3-D rectangular cavity.



Waveguide Modes Applet
Electromagnetic waves in a waveguide.

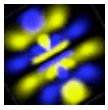


Antenna Applet
Generates antenna radiation patterns.

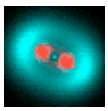


Fresnel Diffraction Applet
Generates Fresnel diffraction patterns.

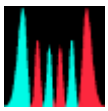
Quantum Mechanics



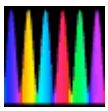
Hydrogen Atom Applet
Shows the orbitals (wave functions) of the hydrogen atom.



Molecular Orbitals Applet
Shows the orbitals (wave functions) of the hydrogen molecular ion.



1-D Quantum Mechanics Applet
Single-particle quantum mechanics states in one dimension.



1-D Quantum Crystal Applet NEW
Periodic potentials in one dimension.

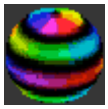
1-D Quantum Transitions Applet
Radiative transitions (absorption and stimulated emission) in one dimension.

Atomic Dipole Transitions Applet
Radiative transitions (absorption and stimulated emission) in atoms.

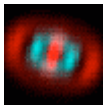
2-D Rectangular Square Well Applet
Rectangular square well (particle in a box) in two dimensions.

2-D Circular Square Well Applet
Circular square well in two dimensions.

2-D Quantum Harmonic Oscillator Applet
Harmonic oscillator in two dimensions.



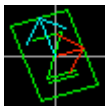
Quantum Rigid Rotator Applet
Particle confined to the surface of a sphere.



3-D Quantum Harmonic Oscillator Applet
Harmonic oscillator in three dimensions.

Linear Algebra

Dot Product Applet
Demonstrates the dot product or scalar product of two vectors.



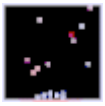
Matrix Applet
Demonstrates 2-D transformations using a matrix.

Vector Calculus

2-D Vector Fields Applet
Demonstrates various properties of vector fields, including divergence and curl, etc.

3-D Vector Fields Applet
Demonstrates vector fields in three dimensions. Includes the Lorenz Attractor and Rossler Attractor.

Thermodynamics

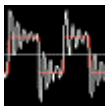


Gas Molecules Simulation Applet
Demonstrates the kinetic theory of gases.

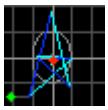
Thermal Camera Pictures
Some sample pictures taken with a thermal (infrared) camera. (This is not an applet, but I thought I'd include it here anyway.)

Miscellaneous

A Sense of Scale
Provides a visual comparison of various distances, from very small objects like protons and electrons, to distances between galaxies. (This is not an applet, but I thought I'd include it here anyway.)



Ordinary Differential Equations Applet
Visual differential equation solver.



Euler's Equation Applet
Demonstrates Taylor series expansion of complex exponentials.

Links to other educational sites with math/physics-related information or Java applets useful for teaching:

- **Particle World**
- **Physlets**
- **Resonata - A Wave Machine**
- **Lissajous Lab**
- **Flows of Vector Fields**
- **A Complex Mapping Viewer**
- **Teslamania**
- **Dean Dauger's Home Page**
- **Wondermagnet.com**

- **Powers of 10 Applet**
- **Another Kinetic Theory Applet**
- **Another Fresnel Diffraction Applet**
- **Another Slit Diffraction Applet**
- **Acoustics and Vibration Animations**
- **Animations of Physical Processes**
- **Quantum Mechanical Scattering**
- **Forced Oscillations (Resonance)**
- **Field of a Moving Point Charge**
- **Harmonic Phasors and Fourier Series**
- **MyPhysicsLab Simulations**
- **Physics 2000**
- **Earth-Moon Distance**
- **An Atlas of the Universe**
- **Finding the Speed of Light with Marshmallows**
- **Sky Chart**
- **Snowflakes**
- **Errors and Misconceptions**
- **Sound Lab**
- **Wave Packets in Classical Limit**
- **Funny Cartoon**

And when you get tired of learning, here is some fun stuff:

- **Java Pong Applet**
  A cute little Pong game I wrote a while ago
- **Java Maze Applet**
  3-D perspective maze
- **Acorn Envelope Applet**
  Cool videogame sounds

java@falstad.com

Simulation Name	Rating Key	Size	Java™ or Flash™	Notes
Arithmetic	β+	68 kb	Flash	
Balloons and Buoyancy	☆	1737 kb	Java	
Balloons and Static Electricity	β+	108 kb	Java	mac
Band Structure	β+	907 kb	Flash	
Battery Voltage	β-	99 kb	Java	
Battery-Resistor Circuit	β	352 kb	Java	
Blackbody Spectrum	β	26 kb	Flash	
Charges and Fields	β	17 kb	Flash	
Circuit Construction Kit	☆	596 kb	Java	
Circuit Construction Kit, virtual lab version	☆	596 kb	Java	
Circuit Construction Kit (AC+DC)	⚠	596 kb	Java	
Circuit Construction Kit (AC+DC), virtual lab version	⚠	596 kb	Java	
Color Vision	β+	235 kb	Java	
Conductivity	β	135 kb	Java	
Davisson-Germer: Electron Diffraction	β	1516 kb	Java	
Double Wells and Covalent Bonds	β+	907 kb	Java	
Electric Field Hockey	β+	232 kb	Java	
Electric Field of Dreams	⚠	58 kb	Java	
Energy Skate Park	β	920 kb	Java	
Equation Grapher	β	12 kb	Flash	
Estimation	β	76 kb	Flash	
Faraday's Electromagnetic Lab	β	346 kb	Java	
Faraday's Law	⚠	18 kb	Flash	
Forces in One Dimension	β	388 kb	Java	mac
Fourier: Making Waves	☆	954 kb	Java	
Friction	β	8 kb	Flash	

Gas Properties	☆	1737 kb	Java	
Geometric Optics	β	167 kb	Flash	
The Greenhouse Effect	β	269 kb	Java	
John Travoltage	☆	102 kb	Java	
Lunar Lander	⚠	133 kb	Flash	
Lasers	☆	1210 kb	Java	
Masses and Springs	☆	84 kb	Flash	
Maze Game	β+	240 kb	Java	mac
Microwaves	☆	294 kb	Java	
Models of the Hydrogen Atom	β-	710 kb	Java	
Motion in 2D	β-	347 kb	Java	
The Moving Man	☆	308 kb	Java	
The Moving Man, older version	☆	253 kb	Java	
My Solar System	β	82 kb	Java	
Neon Lights and Other Discharge Lamps	β+	1680 kb	Java	
Nuclear Physics	β	595 kb	Java	
Ohm's Law	β	18 kb	Flash	
Optical Quantum Control	β	1111 kb	Java	
The Photoelectric Effect	☆	1871 kb	Java	
Projectile Motion	☆	124 kb	Flash	
Quantum Bound States	β+	907 kb	Java	
Quantum Tunneling	☆	889 kb	Java	
Quantum Wave Interference	☆	571 kb	Java	
Radio Waves and Electromagnetic Fields	☆	117 kb	Java	
The Ramp	β+	1129 kb	Java	
Reactions and Rates	β-	990 kb	Java	
Resistance in a Wire	β	20 kb	Flash	
Reversible Reactions	⚠	1737 kb	Java	
Salts and Solubility	β+	693 kb	Java	

Self Driven Particle Model	β	2176 kb	Java	
Semiconductors	β	240 kb	Java	
Signal Circuit		73 kb	Java	
Simplified MRI	β+	538 kb	Java	
Sound		249 kb	Java	
Stern-Gerlach Experiment		153 kb	Flash	
Vector Addition	β	26 kb	Flash	
Wave Interference	β+	983 kb	Java	
Wave on a String		34 kb	Flash	

General Physics Java Applets

New Applets
Transverse Waves - Reflection and Transmission
Thomson's Positive Ray Analysis
Doppler Effect - Source Motion

Some Math
Vector Addition
Cross Product
Instantaneous Speed
Instantaneous Velocity
Integration - 1
Integration - 2
Cartesian Coordinates
Spherical Polar Coordinates
Latitudes and Longitudes

Kinematics
Reference Frames
Apply the Brakes
Catch Up
Avoid Crash
Boat and River
Relative Motion
Racing Blocks
Roll Away
Circle Plus

Moving on a Disc
Chase - 1
Chase - 2

Dynamics
Block on an Inclined Plane
Collisions
Center of Mass
Rolling and Slipping
Roll, Hit and Slip
Conservation of Energy
Angular Momentum
Laws of Kepler
Projection of a Satellite
One Particle in a Central Field
Many Particles in a Central Field

Oscillations
Simple Harmonic Motion
Phase
Phase Difference
Forced Oscillations
Lissajous Figures

Waves
Transverse Waves
Adding Transverse Waves
Reflection and Transmission
Polarized Wave
Longitudinal Waves
Adding Longitudinal Waves
Harmonics
Beats

Ripple Tank
Doppler Effect

Heat
Molecular Motion

Electricity
Electric Field Lines
Charge in a Magnetic Field
Charge in Electric and Magnetic Fields

Optics
Refraction through a Prism
Spherical Mirrors and Lenses
Young's Double-Slit Experiment
Single-Slit Diffraction

Miscellaneous
Physics Java Applets on the Web
About Me
