APPENDIX 2

From CPU: Constructing Physics Understanding Workbook
By Jodi McCullough and Roy McCullough
Published by The Learning Team, Amonk, NY, 2001
The book is no longer available

The CPU simulators run on the MacOS using the Applet Launcher program.

A Brief Description of the CPU Simulation Software

Brief Descriptions of the CPU Software*

The CPU simulators run on the Mac OS using the Applet Launcher program. Links to the simulators are provided on an index page (a snapshot of which is below). Instructions and links to the Applet Launcher program and simulator downloads are available on this site.

CPU SIMULATION SOFTWARE

STATIC ELECTRICITY AND MAGNETISM

Electric & Magnetic Field Patterns
Electrostatic Lab Bench
Indicating Electrophorus
Faraday Pail
Dipole Playground
Coulomb Lab Experiment

ELECTRIC CIRCUITS

Current Electricity
Electric & Magnetic Devices

FORCES AND MOTION

Force & Motion
Interactions & Motion

LIGHT AND COLOR

Shadows & Pinholes
Reflection & Refraction
Mirror Images
Lens Images
Color Beams

WAVES AND SOUND

Ripple Lab
Sound Lab

SMALL PARTICLE THEORY

Microscopic Pressure
Ideal Gas
Gas Simulator
Gas Diffusion
Evaporation
Freezing & Melting

CHEMISTRY

Chemical Analyzer
Chemical Reactor

HELP INDEX

* From the Appendices to the book, CPU: Constructing Physics Understanding Workbook, by Jodi McCullough and Roy McCullough, published by The Learning Team, Armonk NY, 2001.

Appendix 2

A Brief Description of the CPU Simulation Software

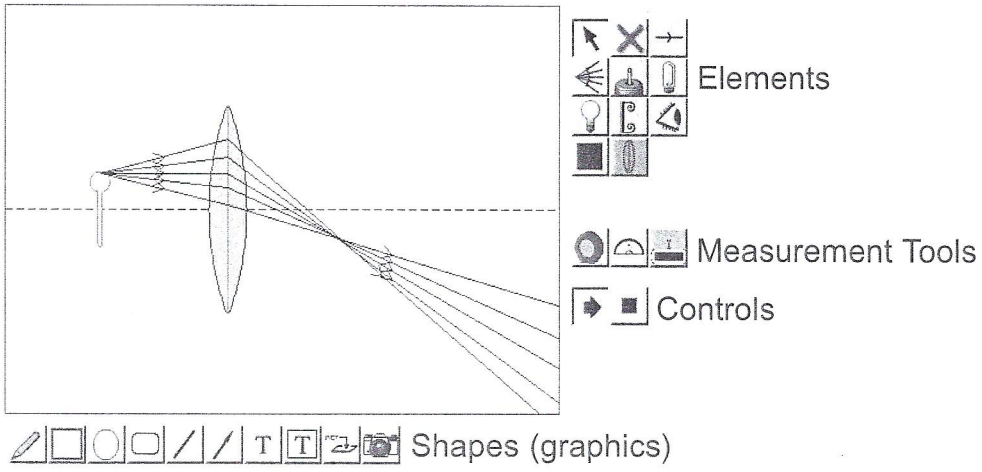
The CPU Software consists of a set of 21 Java applets designed to complement and extend hands-on laboratory activities in physical science in a wide variety of contexts. The software runs under ~~either Windows or~~ the Mac OS WITH APPLET LAUNCHER. The simulators provide students with both phenomenological and conceptual (model-based) evidence to help them develop robust and valid ideas in physical science. Below is a list of the software programs. On the following pages are brief descriptions of some of their features.

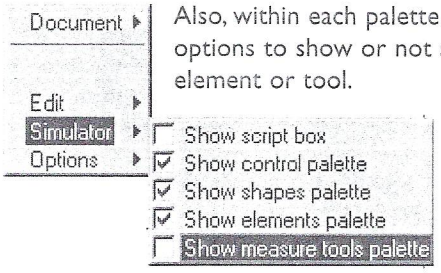
- Five *Light and Color Simulator* applets: Shadows (monochromatic and color) and Pinholes; Reflection and Refraction; Mirror Images; Lens Images; Color beams
- Six *Static Electricity and Magnetism Simulator* applets: Electric and Magnetic Field Patterns; Electrostatic Workbench; Faraday Pail; Electrophorus; Dipole Playground; Coulomb's Law
- Two *Waves and Sound Simulator* applets: Ripple Lab; Sound Lab
- *Force and Motion Simulator* applet
- *Current Electricity Simulator* applet
- Five *Small Particle Model Simulator* applets: Pressure simulator; Ideal Gas; Diffusion; Evaporation and Condensation; Melting and Freezing
- Idea Container applet for recording and keeping track of evolving ideas

General CPU Simulator Features

Each CPU Simulator has a setup region and two or more palettes. Each palette consists of a set of tools and elements with properties that can be set by student or instructor. The instructor also has complete control over which palettes appear on the screen, which elements and tools appear in a given palette, and which properties will be accessible to the student.

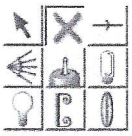
For example, the Light and Color Lens Simulator has an Elements palette, Measurement Tools palette, Control palette (turns propagation of light rays on and off), and a Shapes (graphics) palette. (See picture below.) There are options to show or not show any of these palettes.



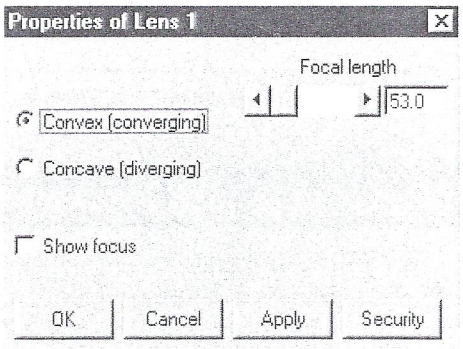


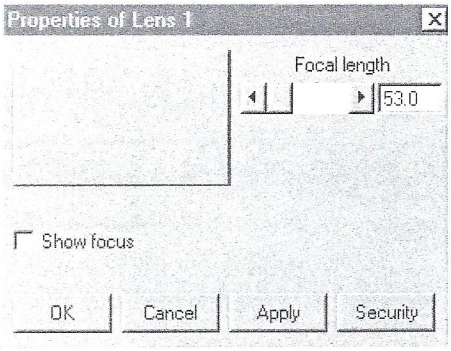
Also, within each palette, there are options to show or not show each element or tool.

This picture shows that the Measurement Tools palette has been hidden, and within the Elements Palette the eye and square obstacle elements have been hidden.



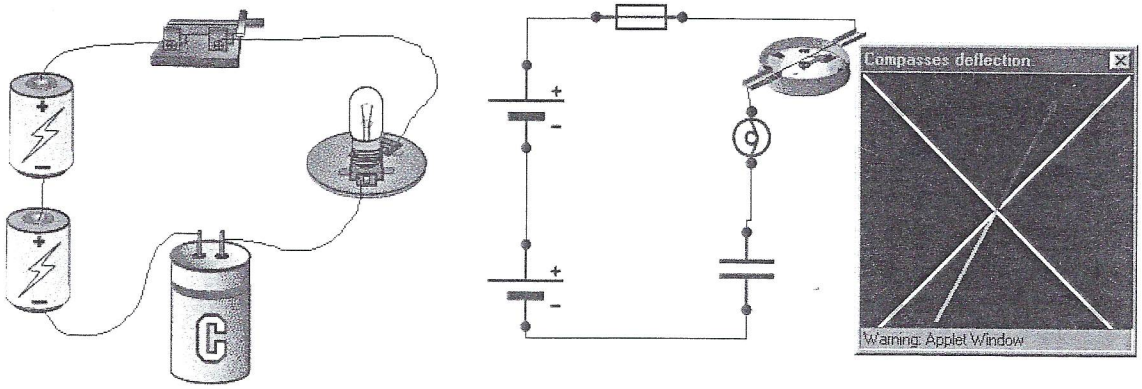
Each element also has a property box, where parameters can be changed. The instructor also has the option of "hiding" some of these properties. For example, the student can normally choose either a convex or concave lens in the lens property box, but the instructor (via a security password) can hide that choice.



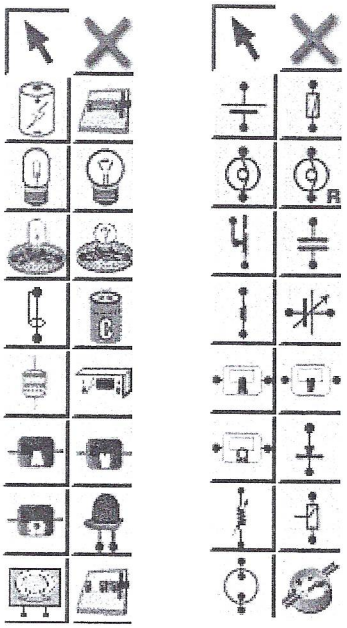


Current Electricity Simulator

Set up circuits in either Realistic or Schematic Mode, and easily switch between the two modes.

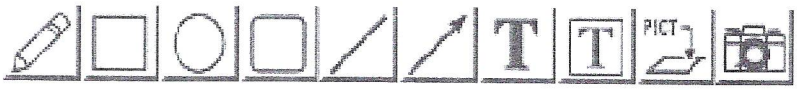


Realistic and Schematic Mode Palettes include a large number of elements: batteries, switches (SPST and SPDT), long and short bulbs (bare and in sockets), nichrome wire slider, capacitor, resistor, DC power supply, ammeter, voltmeter, ohmmeter, neon bulb, variable resistor and compass.



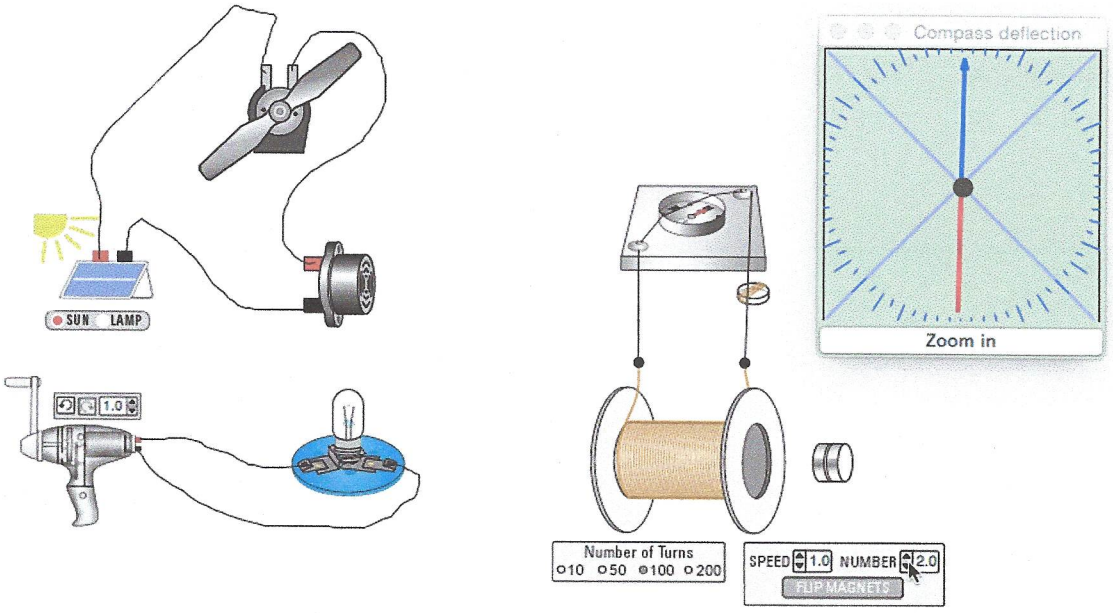
Options include ability to show/hide: arrows to represent current, numbers alongside bulbs to represent current or brightness, and coloring of wires to represent voltage.

Graphics palette, including snapshot tool



Electric & Magnetic Devices Simulator

Set up circuits using electric and magnetic devices not included with Current Electricity Simulator. Examine induction caused by magnets moving into and out of a coil of wire. Keep track of energy.



General palette includes elements not included in the Current Electricity Simulator, including solar battery, hand generator, motor fan, and buzzer, as well as battery, light bulb, ammeter, and compass.

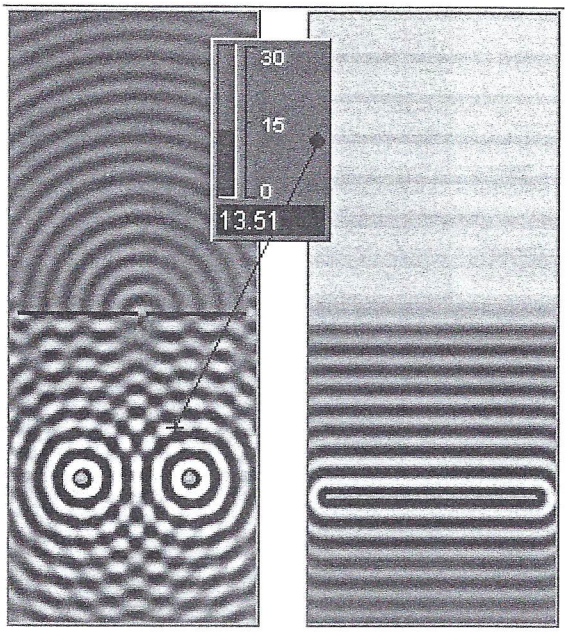
Also includes a wire loop + magnets tool, which automatically loads with wires that are looped around a compass, to allow observation of the compass deflection caused by the current induced by the magnets moving into and out of the wire coil, and the factors that determine the size of the deflection.

The palette also includes an Energy Bars tool to help keep track of energy flow through individual devices or the entire circuit.

Graphics palette, including snapshot tool.

Ripple Lab Simulator

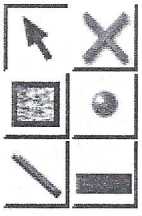
Use point sources and baffles to model diffraction



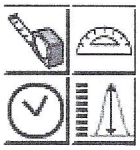
Measure wave amplitudes

Examine wave propagation in tank with varying depth

General palette with tools to place ripple tanks, point sources of sound, line sources, and baffles. Users can also change wave velocity and length of simulation.



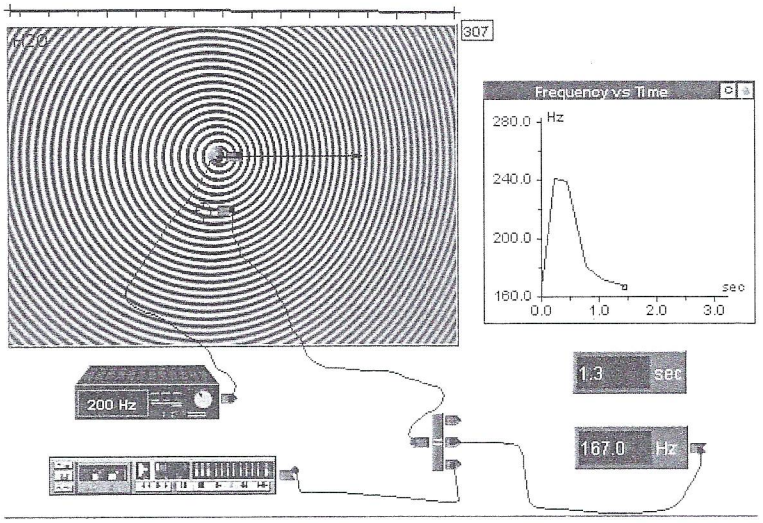
Measurement palette to measure distance, angles, time (using a clock), and wave amplitude.



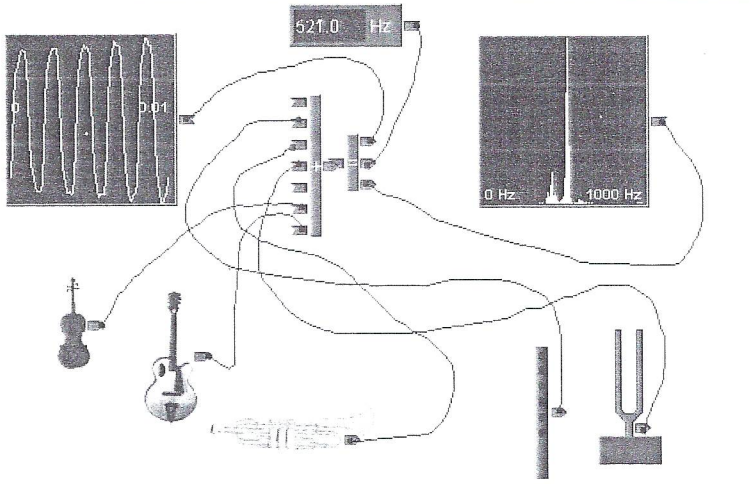
Graphics palette, including snapshot tool and paste tool

Sound Lab Simulator

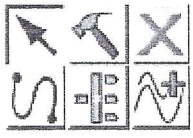
Investigate the Doppler effect. Animate the wave pattern, plot change in frequency vs. time, and listen to the Doppler shift.



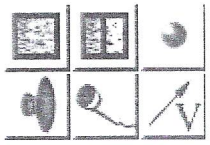
Play musical instruments. Listen to them and observe their wave patterns and frequency spectra.



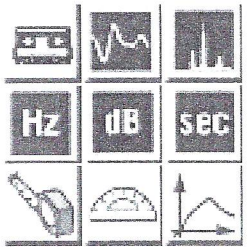
Tool Palette to play instruments, connect devices, and multiply and combine signals.



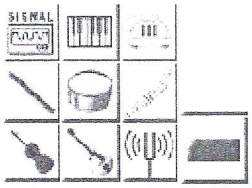
Media Palette includes rooms with option to select different media; connecting rooms; output devices; microphone; and velocity vector.



Measurement Palette to record/play sound; display wave forms and spectra; and record frequency, sound level, and time; wavelengths and angles; and plot variables.

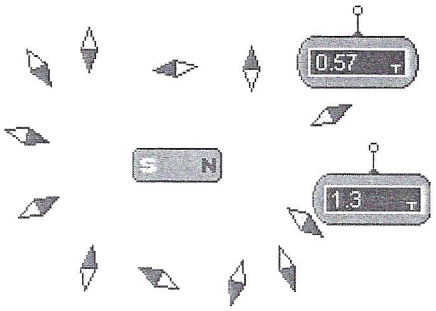


Instruments Palette features several musical instruments and wave generator.

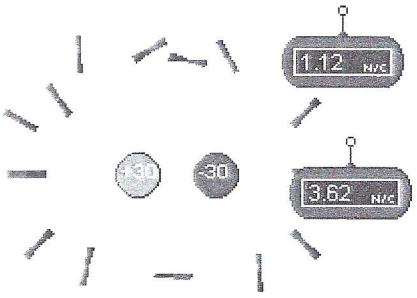


Electric and Magnetic Patterns Simulator

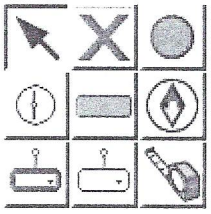
This picture shows several compass imprints and magnetic field meters in the region surrounding a magnet.



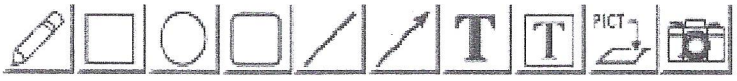
This picture shows several versorium imprints and electric field meters in the region surrounding equal and opposite monopole charges.



General palette with monopole charges, versorium (electrostatic analog of magnetic compass), magnet, compass, electric field intensity meter, magnetic field intensity meter, and tape measure.

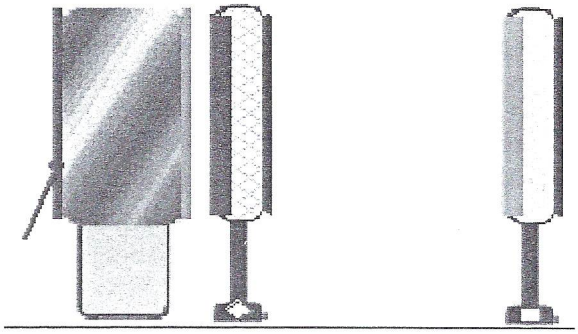


Graphics palette, including snapshot tool



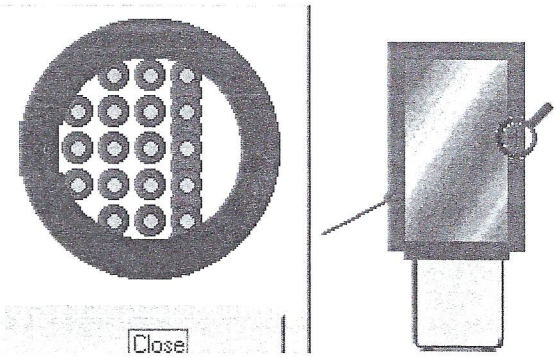
Electrostatic Workbench Simulator

The surfaces of two different insulators, when rubbed, are charged differently. A charged insulator polarizes a conductor.

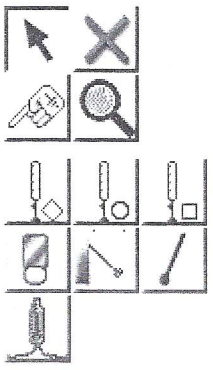


There is an option to color surfaces red and blue to represent two charge conditions.

A special viewer provides a simple microscopic model of the charged conductor.



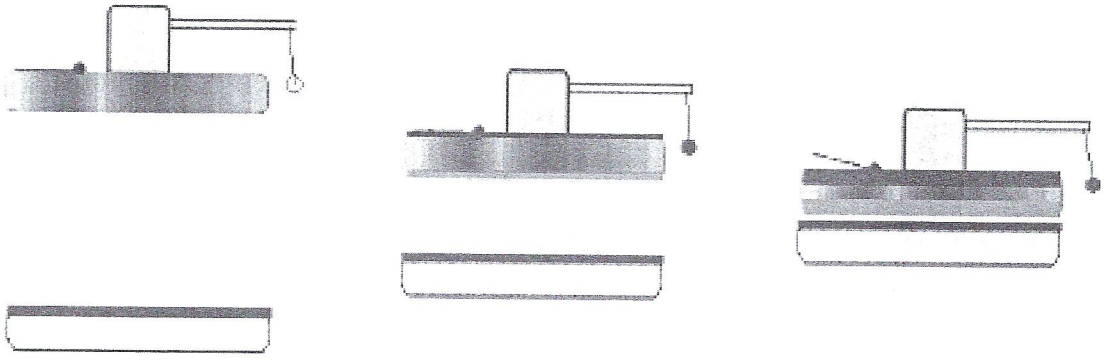
General palette with grounding hand, microscopic model viewer, three different insulators, conductor, flag for conductor, pendulum, and neon bulb.



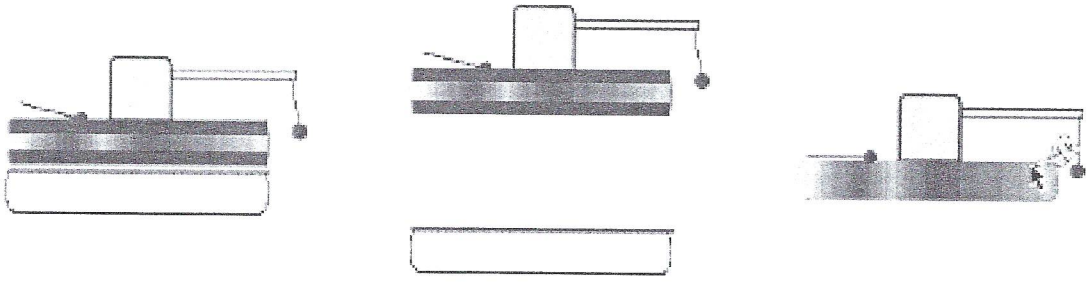
Graphics palette, including snapshot tool

Indicating Electrophorus Simulator

In this simulator you can explore the behavior of the Electrophorus. You can attach both a flag (thin conducting strip) and a pendulum as indicators of the surface charge state of the Electrophorus. An option to color charged surfaces red and blue provides a model view of the process. Below, the Electrophorus is brought closer to a blue charged insulator. The changing thickness of the red and blue coloring on the lower and upper surface of the Electrophorus suggest the polarization that is occurring.



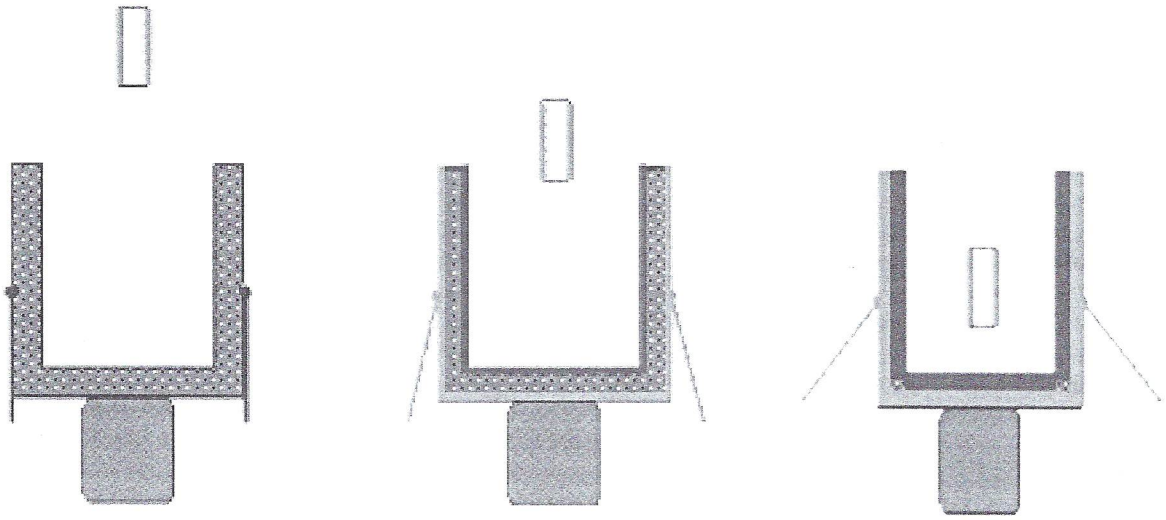
Below, the Electrophorus is touched to the charged insulator, and is then removed. The Electrophorus now has a net blue charge. The last picture shows a grounding hand discharging the Electrophorus.



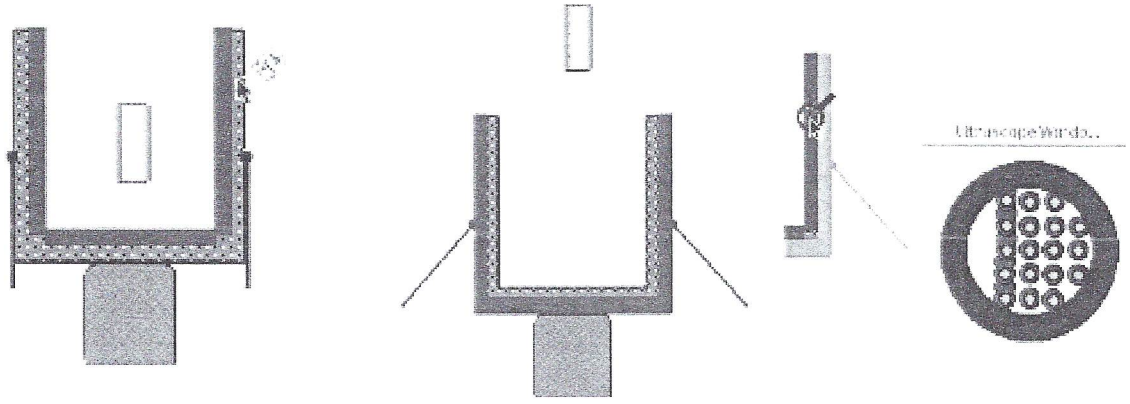
A Graphics palette includes tools that enables you to annotate and draw on the simulator, and to take snapshots.

Faraday Pail Simulator

In this simulator you can explore the behavior of the Faraday Pail. An option to color charged surfaces red and blue provides a model view of the process. Below, a red charged insulator is lowered into the uncharged Faraday Pail. The changing thickness of both the inside blue coloring and outside red coloring of the Pail suggest the polarization that is occurring.



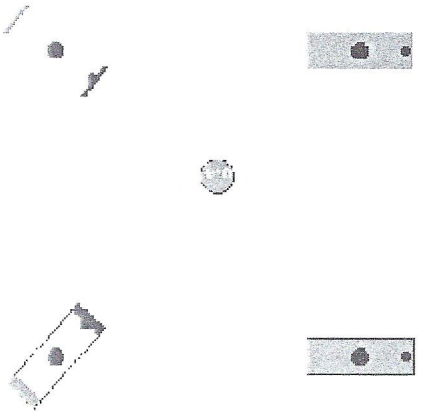
Below, a hand "grounds" the Pail. When the red-charged insulator is removed, the Faraday Pail becomes blue-charged. On the right is a snapshot of an ultrascope tool that provides a simple microscopic model of the charge distribution on any surface.



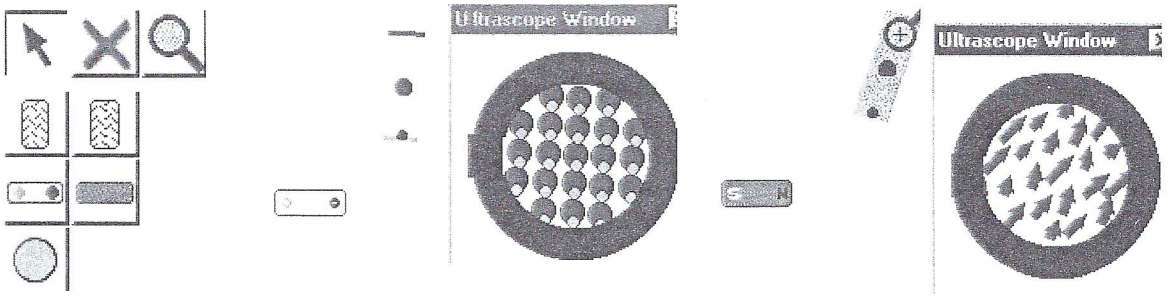
A Graphics palette includes tools that enables you to annotate and draw on the simulator, and to take snapshots.

Dipole Playground Simulator

The set-up area of the simulator consists of four pivot points. On each pivot you can place a temporary electric dipole (insulator or conductor), a permanent electric dipole (electret), a temporary magnetic dipole, or permanent magnetic dipole (magnet). Three types of sources can be placed anywhere in the set-up window: permanent electric monopoles and dipoles, and a permanent magnetic dipole. When the simulator is turned on, all the pivoted dipoles respond to sources.



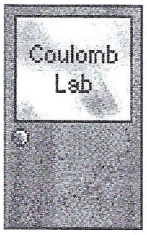
You can also represent the positive and negative surface charge on the pivoted electric dipoles by turning on a special color function: red for positive, blue for negative. There is also a simple microscopic model view for both the electric and magnetic pivoted dipoles.

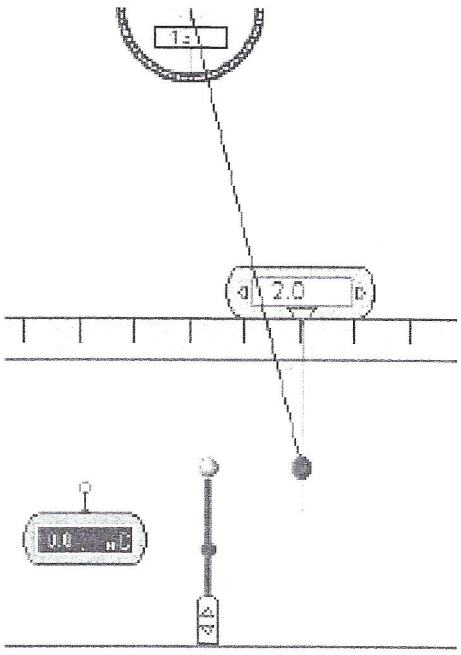


The Graphics palette is also available, including the snapshot tools, to enable students to represent their own predictions.

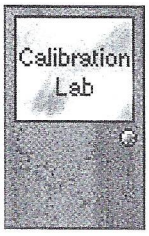
Coulomb Force Simulator

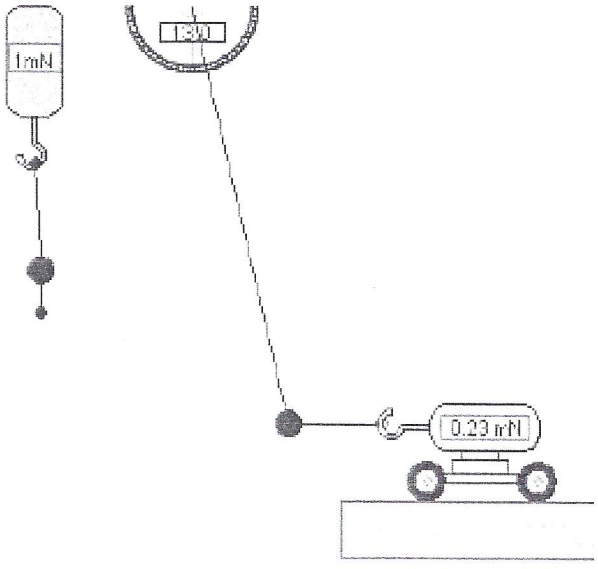
In the "Coulomb Lab" you can electrically charge a sphere on a stand and a pendulum bob, then measure both the angle of deflection of the bob and its horizontal displacement from the sphere.





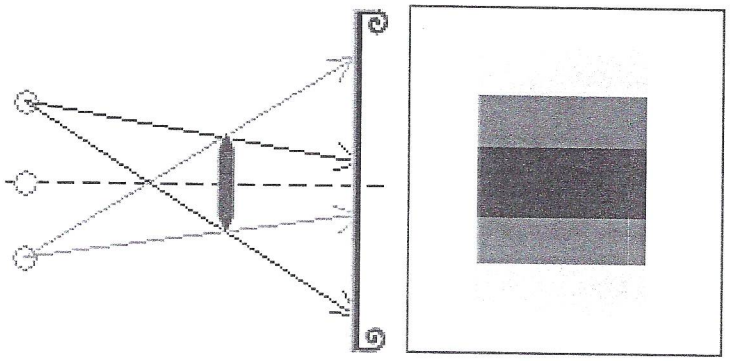
Then, in the "Calibration Lab," you can use a special force meter to determine the horizontal component of force on a pendulum bob held at the same angle of deflection.



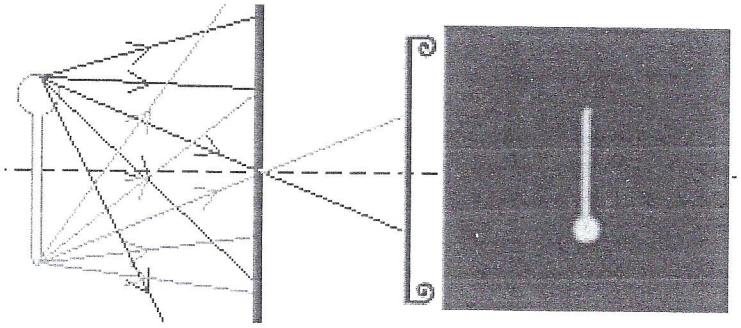


Shadows and Pinholes Simulator

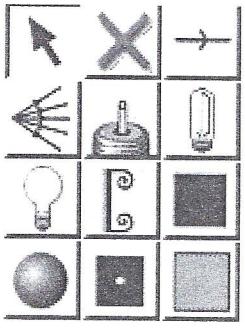
Use point sources to investigate complex shadows.



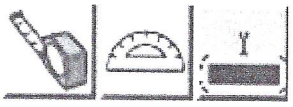
Use extended sources to investigate pinholes.



General palette with tools to draw single light rays and sprays of light rays, point sources, line sources and extended sources, screen rectangular blocker, spherical blocker, variable aperture and colored filters (to explore colored shadows).



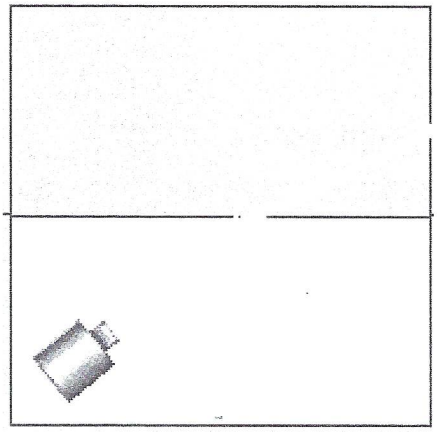
Measurement palette to measure distances, angles and light intensity.



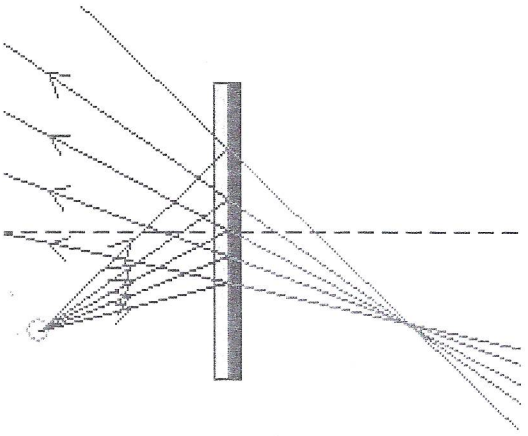
Graphics palette, including snapshot tool

Reflection and Refraction Simulator

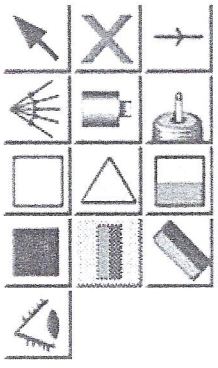
Embed a beam projector inside a container, vary the media in the upper and/or lower half, and rotate the projector to study refraction. (Here the beam is going from water into air.)



Drag a spray of rays outward from a point source, turn on the "backward extension of rays option" and investigate the formation of an image in a mirror.



General palette with tools to draw single light rays and sprays of light rays, beam projector, point source, rectangular medium, prism, two-media container, blocker, plane mirrors and an eye.

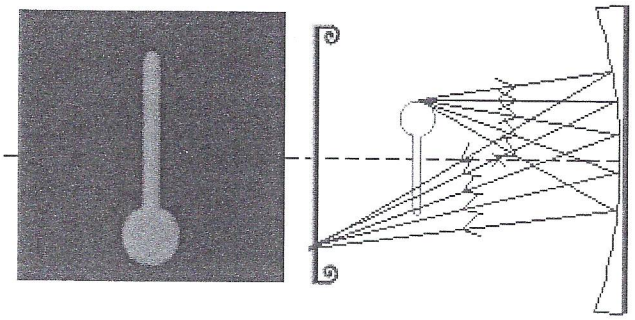


Measurement palette to measure distances, angles and light intensity.

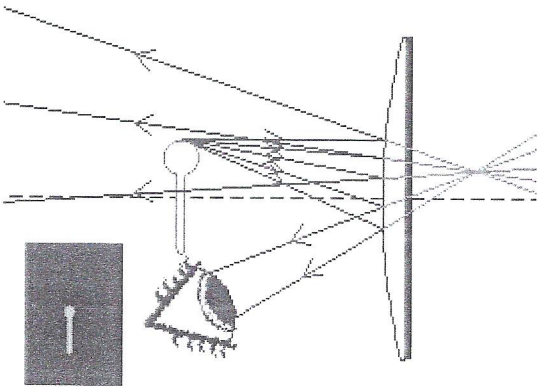
Graphics palette, including snapshot tool

Mirror Images Simulator

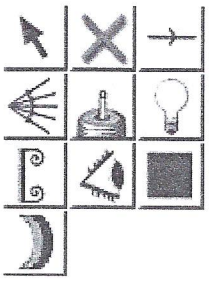
Study image formation with concave mirrors. The screen view shows the pattern of illumination on the screen, regardless of its location.



Study virtual image formation with convex (or plane) mirrors. The eye view shows what the eye "sees."



General palette with tools to draw single light rays and sprays of light rays, point sources, complex sources, screen, eye, blocker and mirror (concave, convex or plane).

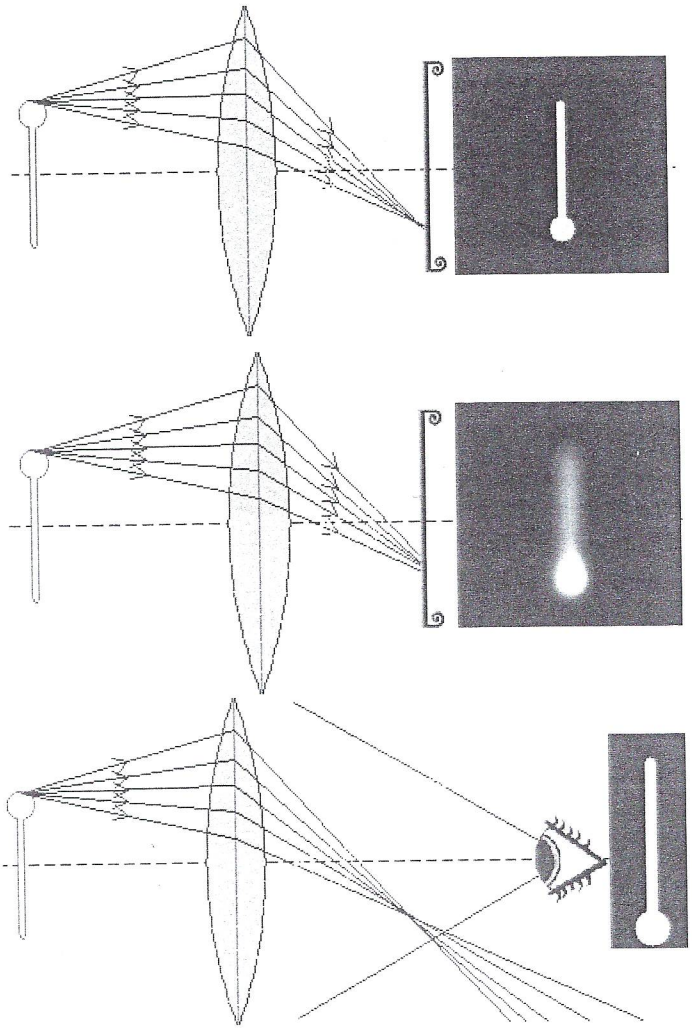


Measurement palette to measure distances, angles and light intensity.

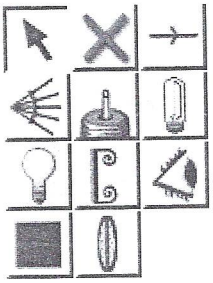
Graphics palette, including snapshot tool

Lens Images Simulator

Study image formation with lenses. The screen view shows the pattern of illumination on the screen, regardless of its location. Also, the eye view shows what the eye sees, without the screen. (The eye also has a "near point," so if it gets too close, the image blurs).



General palette with tools to draw single light rays and sprays of light rays, point sources, line and complex sources, screen, eye, blocker and lens (converging or diverging).

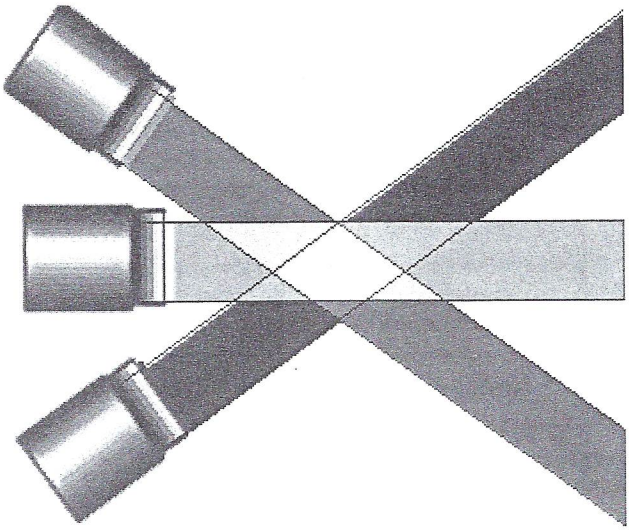


Measurement palette to measure distances, angles and light intensity.

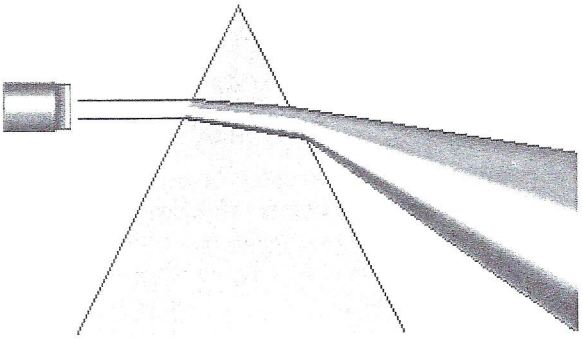
Graphics palette, including snapshot tool

Color Beams Simulator

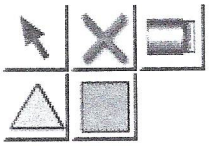
By overlapping up to three beam projectors, and placing any of six different colored filters in front of each, you can study color mixing.



The prism disperses white light passing through it. You can also place filters in front of the projector to pick out a portion of the spectrum.



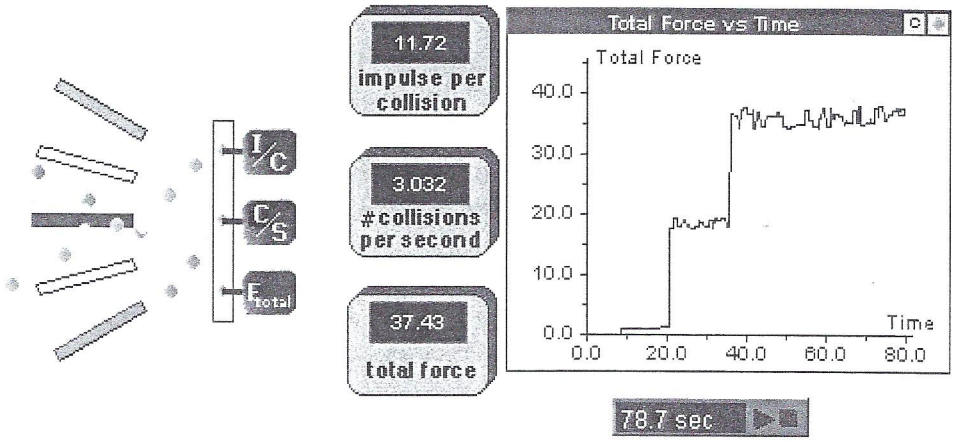
General palette has beam projectors, prism (for dispersion) and colored filters (red, green, blue, yellow, cyan and magenta).



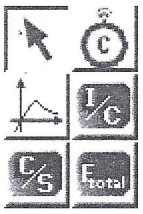
Graphics palette, including snapshot tool

Pressure Simulator

Explore the microscopic dynamics underlying pressure. Use cannons to shoot balls against wall. Measure the impulse per collision, number of collisions per second, and the total force on the wall.



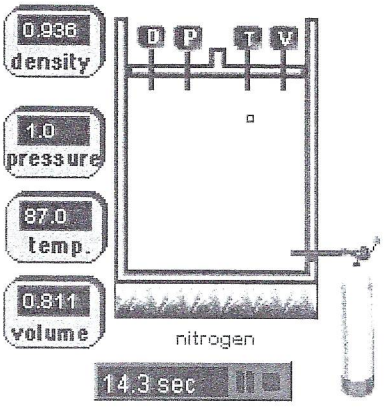
General palette with clock; graphing tool; and impulse per collision, collisions per second, and total force meters.

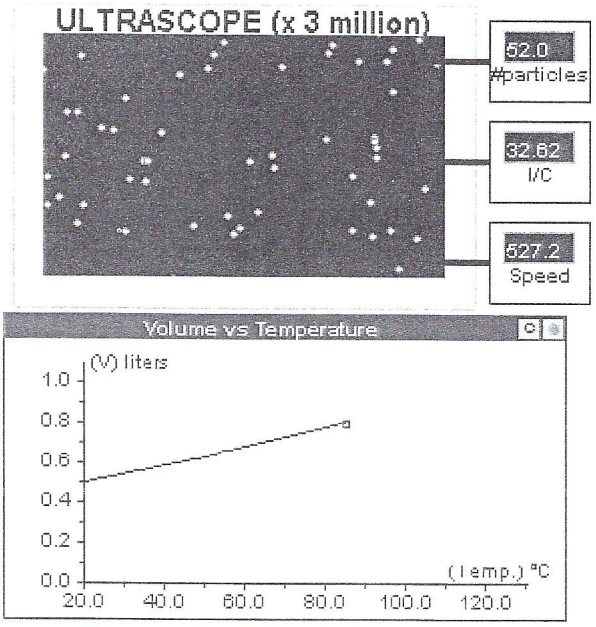


Graphics palette, including snapshot tool

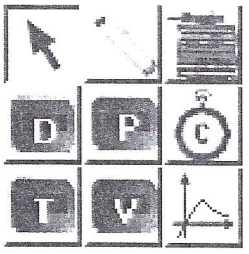
Ideal Gas Simulator

Investigate Ideal Gas relationships. Observe microscopic dynamics. Measure and plot both microscopic and macroscopic properties. Cool or heat gas. Movable piston.

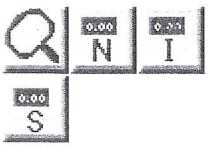




General palette with gas tank and vacuum pump to fill or deplete container; density, pressure, temperature, and volume meters; clock; and graphing tool.



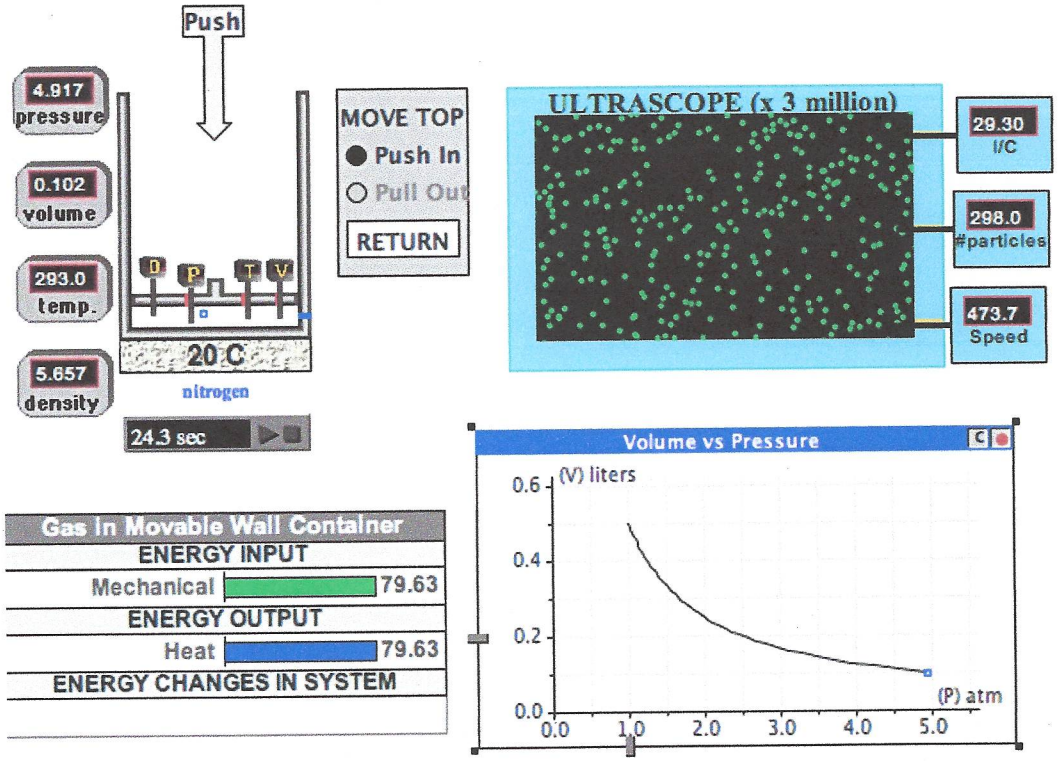
Microscopic palette with option to show micro view; and number density, average impulse and average speed/energy meters.



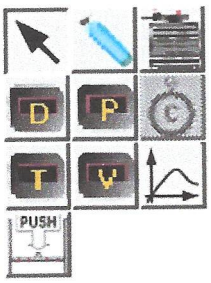
Graphics palette, including snapshot tool

Gas Simulator

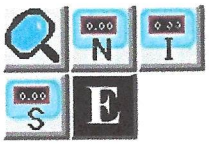
Investigate Ideal Gas relationships. Observe macroscopic dynamics. Measure and plot both macroscopic and microscopic properties. Cool or heat gas. Keep track of energy. Apply upward or downward force to move the piston. (Similar to the Ideal Gas Simulator.)



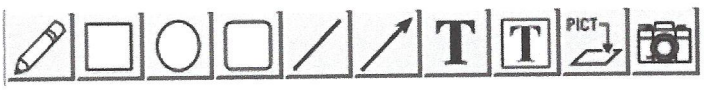
General palette identical to Idea Gas Simulator, with the addition of a tool to push in or pull out the top of the container (piston).



Microscopic palette identical to Ideal Gas Simulator, with Energy tool, which now comes with all small particle model simulators.

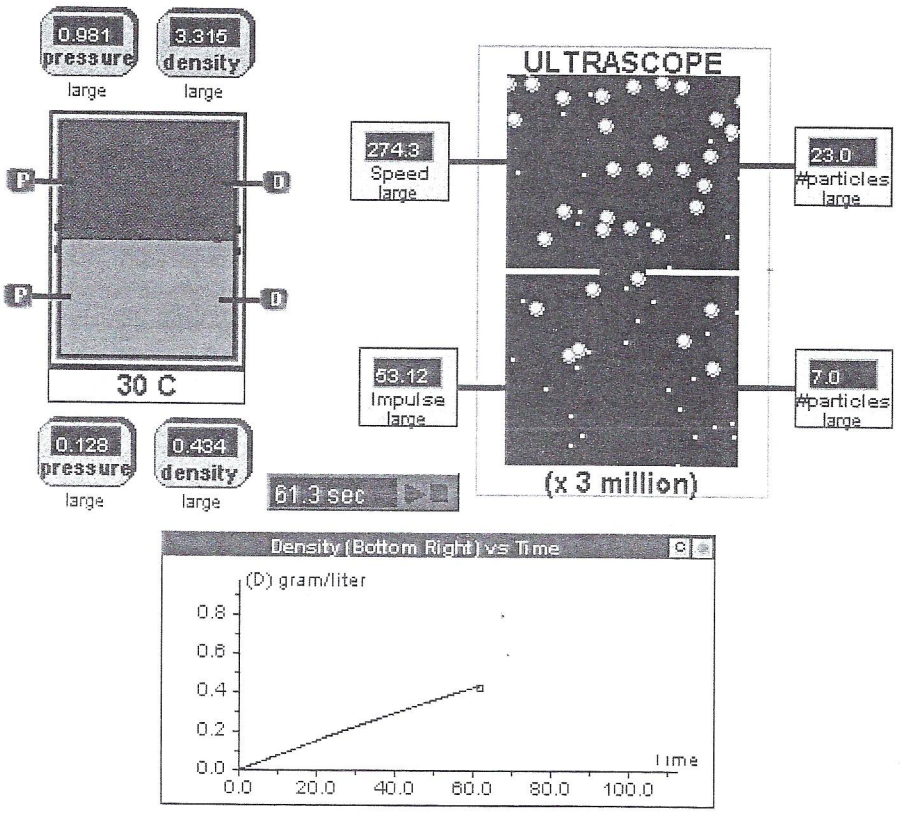


Graphics palette, including snapshot tool.

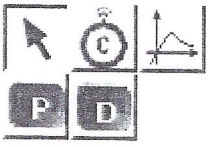


Gas Diffusion Simulator

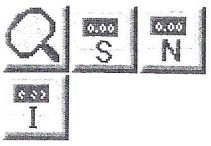
Explore gas diffusion across interface. Optional membrane. View microscopic dynamics. Measure and plot density, pressure, and microscopic parameters. Choose particle size.



General palette with clock, graphing tools, and density and pressure meters.



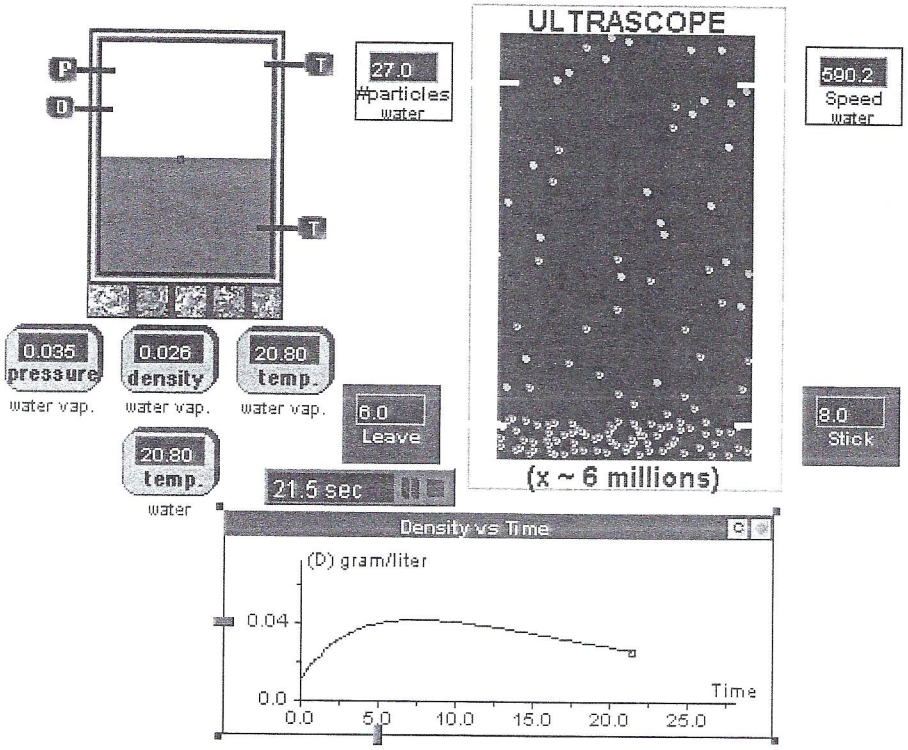
Microscopic palette with option to show micro view, and average speed/energy, number density, and average impulse meters.



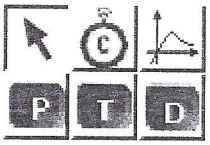
Graphics palette, including snapshot tool

Evaporation Simulator

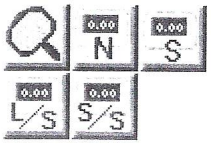
Explore evaporation in open or closed containers. View microscopic dynamics. Cool or heat liquid. Measure and plot density, pressure, temperature, and microscopic parameters.



General palette with clock, graphing tool, and density, pressure, and temperature, meters.



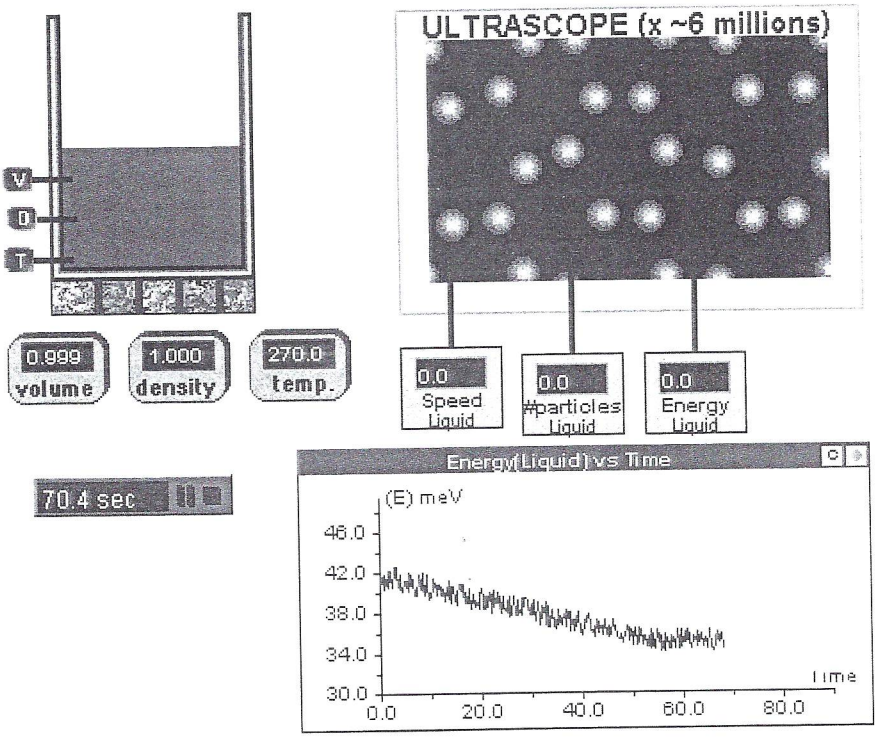
Microscopic palette with option to show micro view; and meters showing the number density, average speed/energy, and the number of particles sticking to or leaving the liquid surface.



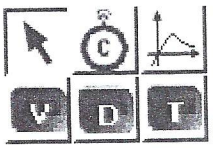
Graphics palette, including snapshot tool

Freezing & Melting Simulator

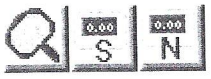
Examine liquids freezing or melting as water or a different substance is heated or cooled. Watch liquid particles form a solid lattice. Measure and plot both macroscopic and microscopic parameters.



General palette with clock; graphing tool; and density, volume and temperature meters.



Microscopic palette with option to show micro view, and number density and average speed/energy meters.

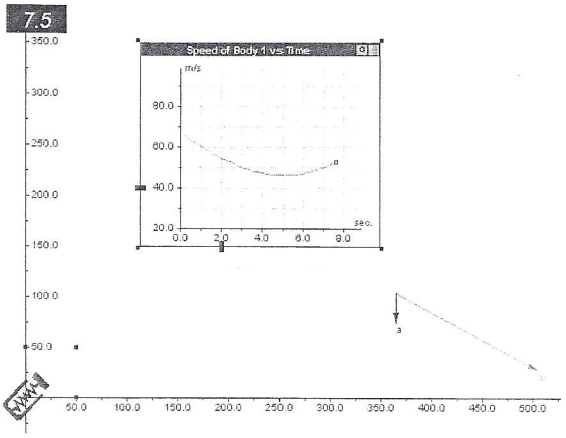


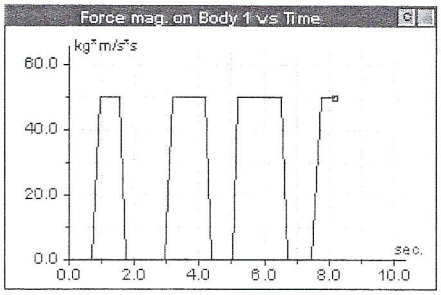
Graphics palette, including snapshot tool

Force and Motion Simulator

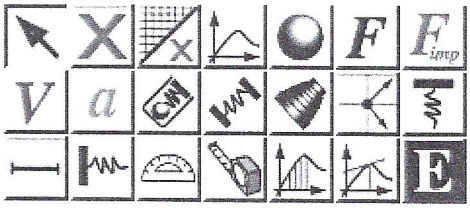
Launch an object and study its trajectory. Many options are available for representing its motion (graphs, strobes, motion vectors).

Attach a thruster to the object and study its motion under an impulsive force (controlled from the keyboard).





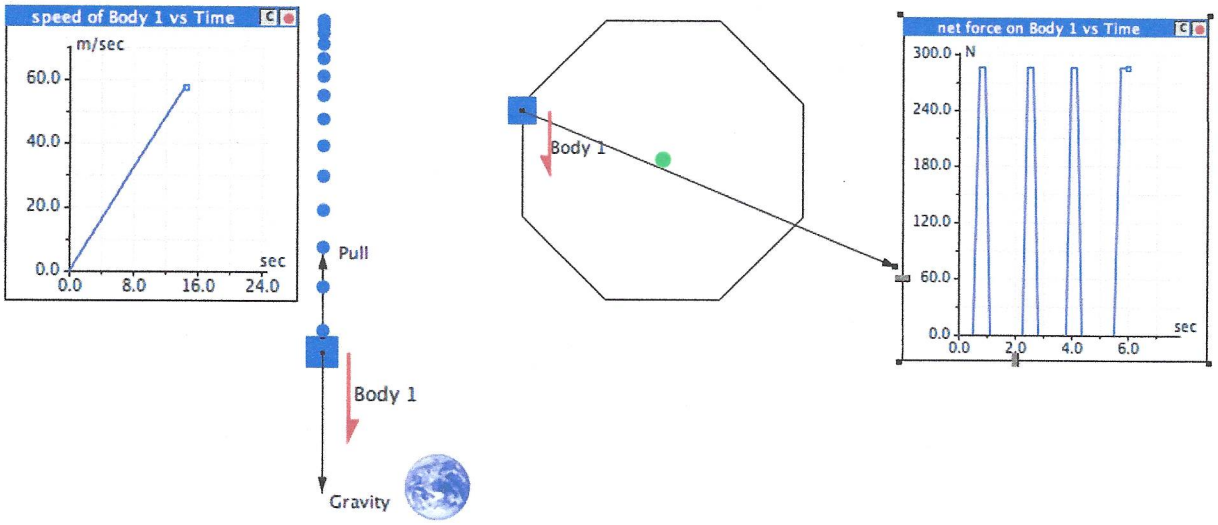
The Force and Motion Elements Palette allows you to show/hide the background coordinate system, draw graphs of various quantities, place objects (and change its mass and what it looks like), apply constant or impulsive forces, and attach initial velocities and accelerations (if no additional forces are applied). There are also elements to launch objects, explore explosions between two objects, and apply thrusts to objects. There are vertical and horizontal springs, a multiple section track (with variable friction), tools to measure angles and lengths, a slope meter and an accumulation meter (area under curve). Finally, there is an Energy Bar Tool that compares work done on a system to energy changes within the system, and a force diagram window option that can display the individual forces and net force acting on an object. Many options (e.g., gravity) are also available through a background property window.



Graphics palette, including snapshot tool

Interactions & Motion Simulator

Similar to the Force & Motion Simulator, but with different representations (e.g., gravity includes an image of a planet) and extra tools, such as the Central Force tool, which allows the study of motion along a circular or polygonal path.



The Interactions & Motion general palette allows you to show/hide the background coordinate system, draw graphs of various quantities, place objects (and change their mass and appearance), apply constant forces—pushes or pulls—or impulsive forces (the "rocket"), include gravity ("Earth" tool), add a ground element (to stop objects moving downward), add a constant speed, use a launcher, and apply a central force tool (as shown above). There is also an Energy Bar tool that tracks kinetic energy, mechanical energy, gravitational potential energy, and thermal energy (for collisions with the ground tool). Other options are also available through a background property window.

Graphics palette, including snapshot tool.