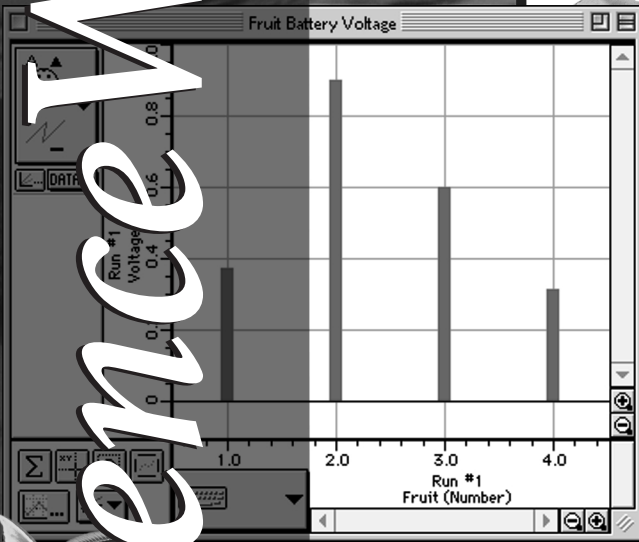
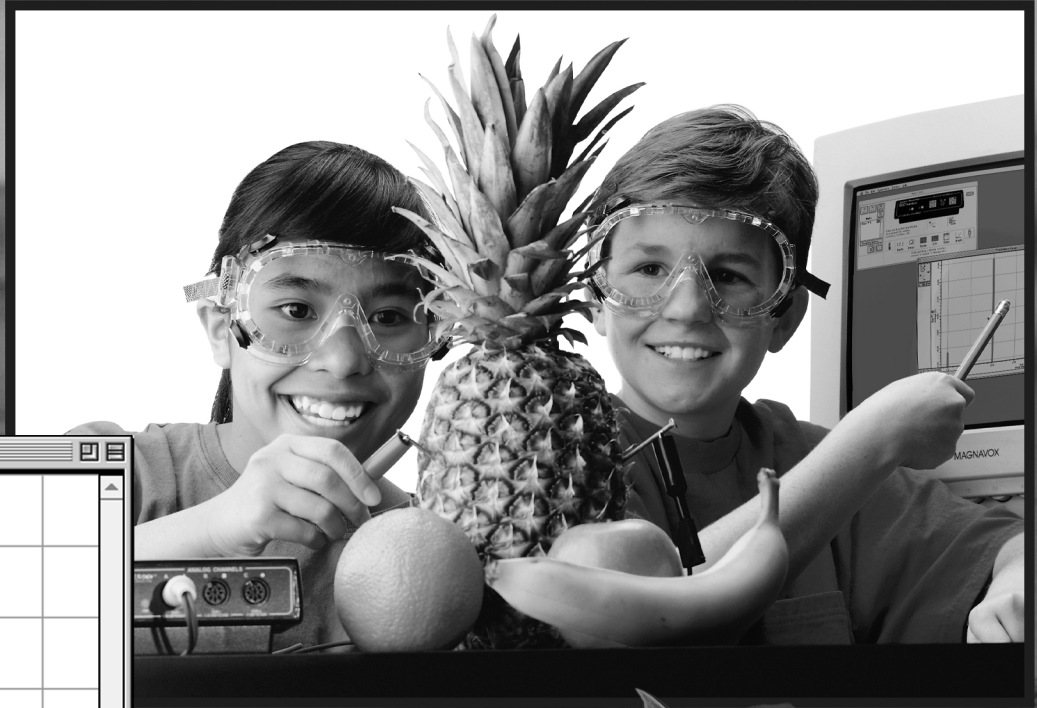


Science Workshop[®]

Middle School Science Labs with Computers

Teacher's Guide



Science experiments using the *ScienceWorkshop[®]* or *DataStudio[™]* program and interfaces from PASCO scientific

PASCO[®]
scientific

10101 Foothills Boulevard • Roseville, CA 95747-7100 • 800-772-8700
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Dear Teacher,

Welcome to *ScienceWorkshop*! You have made an excellent investment in your students' futures, as well as a commitment to technology in your classroom. You may be looking forward to this with enthusiasm, or you may feel somewhat anxious about what lies ahead; let me assure you that you and your students are in for a wonderful, exciting experience.

Please allow me to introduce myself. My name is Elizabeth Kennedy, and I teach middle school science and math at St. John's Notre Dame School in Folsom, California. I have taught in high schools and middle schools for the past twelve years. The challenges and rewards of working with middle school students are very satisfying, especially when I consider the impact I can have on students' future decisions about their education. Each year I have the opportunity to convince more kids that science is so wonderful they can't get enough of it, and they'll want to pursue it through high school and college. I believe every middle school student has the potential to learn and enjoy every type of science. I feel it is my duty to find and to utilize any method available that will send my students to high school considering themselves scientists, *learners*, *doers*, and *collaborators in science*. My classroom motto, "We are a community of learners, engaged in meaningful work," describes the attitude I hope each of my students carries with him or with her into the high school physics lab, the chemistry lab, and the calculus course.

ScienceWorkshop has been in use in our science/math lab for two years. While we still use traditional lab equipment to investigate and experiment, I find that students are liberated from so many constraints by the use of computers for much of their work, that they actually prefer using *ScienceWorkshop* as much as possible. These kids have grown up with computers; they are not intimidated by the notion of learning something new; they take great pride in being the first to figure out a problem, or to come up with an original idea. Computers empower my students, which is important to me because the gap between the high and low achievers narrows dramatically when computers are used as instructional tools. Many of my students who struggle academically, or who have ADD or other learning difficulties, are among the most accomplished users of *Science Workshop*. The instantaneous, graphically represented results are what seem to make the difference; the time between hypothesis and conclusion is shortened because the data collection and observation portions of an investigation are not dependent upon traditional, tedious lab procedures. A PASCO Temperature Sensor can take your temperature literally thousands of times (and record it all neatly) in the few minutes you could do this once with a glass and mercury thermometer. The Temperature Sensor can detect changes in temperature so subtle that activities that would simply be impossible with traditional laboratory equipment are now available to your students. As my students become more sophisticated in their understanding of this powerful tool, their use of it has begun to impact other academic areas in a very positive way as well. Algebra students have a deeper understanding of the X,Y coordinate system; they approach graphing from the frame of reference of the work they have done with *ScienceWorkshop*.

My students and I have learned to use *ScienceWorkshop* together. PASCO's Technical Support staff have been extraordinarily friendly and helpful whenever we have needed an explanation or advice. After two years of having *ScienceWorkshop* as a tool in my classroom, my students believe in their own ability to explore their world. If they wonder about the weather, or their heart rate while they're asleep, or anything else they can imagine, they can design an experiment

to find out. They are inquisitive because they know they have a way to get the answers. As their teacher, I cannot think of a better way to encourage the doing of science as meaningful work than to have *ScienceWorkshop* as my partner.

Sincerely,
Elizabeth Kennedy

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Correlation of Experiments with National Science Education Content Standards (1996)

Experiment	Science Content Standard Reinforced
MSS01 Follow the Leader Graphing	A:1, 2 B:2 E:1, 2
MSS02 Follow the Leader II	A:1, 2 B:2 E:1, 2
MSS03 Investigating Temperature Data	A:1, 2 B:1, 3 E:1, 2
MSS04 Heat of Chemical Reactions I	A:1, 2 B:1, 3 E:1, 2 F:1, 3, 5
MSS05 Heat of Chemical Reactions II	A:1, 2 B:1, 3 E:1, 2 F:1, 3, 5
MSS06 Sand in a Bottle	A:1, 2 B:1 – 3 E:1, 2
MSS07 All in a Day’s Work for the Sun	A:1, 2 B:3 D:1, 3 E:1, 2
MSS08 Temperature Inside a Closed Car	A:1, 2 B:1 C:1 E:1, 2 F:1, 3, 4, 5
MSS09 Sunlight, Bright Light, and Your Eyes	A:1, 2 E:1, 2 F:1, 3, 4, 5
MSS10 Polarizing Light	A:1, 2 B:1 – 3 D:1 E:1, 2
MSS11 Friction on Ice	A:1, 2 B:1 – 3 E:1, 2
MSS12 Power Foods!	A:1, 2 B:1, 3 C:1 E:1, 2 F:1, 5
MSS13 Springy Oscillations	B:1 – 5 D:2 – 5
MSS14 Why Mittens were Invented	A:1, 2 B:1 – 3 C:1, 2 E:1, 2 F:1 – 5
MSS15 Heart Beat	A:1, 2 C:1, 3, 5 E:1, 2 F:1, 3, 4, 5
MSS16 Lungs at Rest, Work, and Play	A:1, 2 C:1, 3, 5 E:1, 2 F:1, 3, 4, 5
MSS17 How Loud is That Bubble?	A:1, 2 E:1, 2
MSS18 Refrigerator Spies!	A:1, 2 B:1, 3 E:1, 2 F:5
MSS19 Feynman’s Magical Sugar Cube	A:1, 2 B:1, 3 E:1, 2
MSS20 Boiling Points	A:1, 2 B:1, 3 E:1, 2 F:1, 3, 5
MSS21 Cooling with Evaporation	A:1, 2 B:1, 3 E:1, 2 F:1, 3, 4, 5
MSS22 How Our Ancestors Kept Their Milk Cold	A:1, 2 B:1, 3 E:1, 2 F:1, 3, 4, 5
MSS23 How Well Insulated is Your Room (House)?	A:1, 2 B:1, 3 E:1, 2 F:1 – 5
MSS24 Electrolytes	A:1, 2 B:1, 3 C:1 E:1, 2 F:1, 3, 5
MSS25 The Beam Team	A:1, 2 B:2, 3 E:1, 2 F:5
MSS26 Michael Faraday’s Discovery	A:1, 2 B:1 – 3 E:1, 2
MSS27 Ocean Floor Mapping	A:1, 2 C:4, 5 D:1, 3 E:1, 2
MSS28 Tunnel Vision	A:1, 2 B:1– 3 E:1, 2 F:3, 5
MSS29 Twenty-Two Cent Battery	A:1, 2 B:1, 3 E:1, 2
MSS30 Eleven Cent Battery	A:1, 2 B:1, 3 E:1, 2
MSS31 Parachute Contest	A:1, 2 B:2 E:1, 2

National Science Education Standards (1996)

Science Education Content Standards, Grades 5 – 8

Standard A: Science as Inquiry

1. Abilities necessary to do scientific inquiry
2. Understandings about scientific inquiry

Standard B: Physical Science

1. Properties and changes of properties in matter
2. Motions and forces
3. Transfer of energy

Standard C: Life Science

1. Structure and function in living systems
2. Reproduction and heredity
3. Regulation and behavior
4. Populations and ecosystems
5. Diversity and adaptations of organisms

Standard D: Earth and Space Science

1. Structure of the earth system
2. Earth's history
3. Earth in the solar system

Standard E: Science and Technology

1. Abilities of technological design
2. Understandings about science and technology

Standard F: Science in Personal and Social Perspectives

1. Personal health
2. Population, resources and environments
3. Natural hazards
4. Risks and benefits
5. Science and technology in society

Standard G: History and Nature of Science

1. Science as a human endeavor
2. Nature of science
3. History of science

Correlation of Experiments with National Science Education Teaching Standards (1996)

Experiment	Science Content Standard Reinforced
MSS01 Follow the Leader Graphing	A:2, 3 B:1 - 5 D:2, 4, 5, 6 E:1, 3, 5
MSS02 Follow the Leader II	A:2, 3 B:1 - 5 D:2, 4, 5, 6 E:1, 3, 5
MSS03 Investigating Temperature Data	B:1 - 5 D:2, 4, 5, 6
MSS04 Heat of Chemical Reactions I	A:2, 3 B:1 - 5 D:2, 4, 5, 6
MSS05 Heat of Chemical Reactions II	A:2, 3 B:1 - 5 D:2, 4, 5, 6
MSS06 Sand in a Bottle	A:2, 3 B:1 - 5 D:2, 4, 5, 6
MSS07 All in a Day's Work for the Sun	A:2, 3 B:1 - 5 D:2, 4, 5, 6
MSS08 Temperature Inside a Closed Car	A:2, 3 B:1 - 5 D:2, 4, 5, 6 E:1, 3, 5
MSS09 Sunlight, Bright Light, and Your Eyes	B:1 - 5 D:2, 4, 5, 6
MSS10 Polarizing Light	A:2, 3 B:1 - 5 D:2, 4, 5, 6
MSS11 Friction on Ice	A:2, 3 B:1 - 5 D:2, 4, 5, 6 E:1, 3, 5
MSS12 Power Foods!	A:2, 3 B:1 - 5 C:1 - 5 D:2, 4, 5, 6 E:1
MSS13 Springy Oscillations	B:1 - 5 D:2, 4, 5, 6
MSS14 Why Mittens were Invented	A:2, 3 B:1 - 5 D:2, 4, 5, 6 E:1, 3, 5
MSS15 Heart Beat	A:2, 3 B:1 - 5 D:1, 2
MSS16 Lungs at Rest, Work, and Play	A:2, 3 B:1 - 5 D:1 - 6 E:1 - 5
MSS17 How Loud is That Bubble?	A:2, 3 B:1 - 5 D:2, 4, 5, 6 E:1 - 5
MSS18 Refrigerator Spies	A:2 - 4 B:1 - 5 D:2, 4, 6 E:1 - 5
MSS19 Feynman's Magical Sugar Cube	B:1 - 5 D:2, 4, 5, 6
MSS20 Boiling Points	A:2, 3 B:1 - 5 D:2, 4, 5, 6
MSS21 Cooling with Evaporation	A:2, 3 B:1 - 5 D:2, 4, 5, 6
MSS22 How Our Ancestors Kept Their Milk Cold	A:2, 3 B:1 - 5 D:2, 4, 5, 6
MSS23 How Well Insulated is Your Room (House)?	A:2, 3 B:1 - 5 D:2, 4, 5, 6, E:1 - 5
MSS24 Electrolytes	A:2, 3 B:1 - 5 D:2, 4, 5, 6
MSS25 The Beam Team	A:2, 3 B:1 - 5 D:2, 4, 5, 6
MSS26 Michael Faraday's Discovery	A:2, 3 B:1 - 5 D:2, 4, 5, 6 E:1, 3, 5
MSS27 Ocean Floor Mapping	A:2, 3 B:1 - 5 D:2, 4, 5, 6
MSS28 Tunnel Vision	A:2, 3 B:1 - 5 D:2, 4, 5, 6 E:1, 3, 5
MSS29 Twenty-Two Cent Battery	A:2, 3 B:1 - 5 D:2, 4, 5, 6
MSS30 Eleven Cent Battery	A:2, 3 B:1 - 5 D:2, 4, 5, 6
MSS31 Parachute Contest	A:2, 3 B:1 - 4 D:2, 4, 5, 6

National Science Education Standards (1996)

Science Education Teaching Standards, Grades 5 – 8

Standard A: Teachers of science plan an inquiry-based science program for their students. In doing this, teachers

1. Develop a framework of yearlong and short-term goals for students.
2. Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experience of students.
3. Select teaching and assessment strategies that support the development of student understanding and nurture a community of science learners.
4. Work together as colleagues within and across disciplines and grade levels.

Standard B: Teachers of science guide and facilitate learning. In doing this, teachers

1. Focus and support inquiries while interacting with students.
2. Orchestrate discourse among students about scientific ideas.
3. Challenge students to accept and share responsibility for their own learning.
4. Recognize and respond to student diversity and encourage all students to participate fully in science learning.
5. Encourage and model the skills of scientific inquiry, as well as the curiosity, openness to new ideas and data, and skepticism that characterize science.

Standard C: Teachers of science engage in ongoing assessment of their teaching and student learning. In doing this, teachers

1. Use multiple methods and systematically gather data about student understanding ability.
2. Analyze assessment data to guide teaching.
3. Guide students in self-assessment.
4. Use student data, observations of teaching, and interactions with colleagues to reflect on and improve teaching practice.

Standard D: Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science. In doing this, teachers

1. Structure the time available so that students are able to engage in extended investigations.
2. Create a setting for student work that is flexible and supportive of science inquiry.
3. Ensure a safe working environment.
4. Make available the science tools, materials, media, and technological resources accessible to students.
5. Identify and use resources outside the school.
6. Engage the students in designing the learning environment.

Standard E: Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning. In doing this, teachers

1. Display and demand respect for the diverse ideas, skills, and experiences of all students.
2. Enable students to have a significant voice in decisions about the content of their work and require students to take responsibility for the learning of all members of the community.
3. Nurture collaboration among students.
4. Structure and facilitate ongoing formal and informal discussion based on a shared understanding of rules of scientific discourse.
5. Model and emphasize the skills, attitudes, and values of scientific inquiry.

Teacher Notes

MSS02**Follow the Leader II**

Students need some background in plotting coordinates on x- and y-axes in order to do this activity. It may be helpful to give students a paper example of a coordinate plane and have them label the axes for time and position (in meters). They can then draw on the paper what they would like to plot on the graph of the computer. Ordered pairs may be written down for each data point they will need to type in the computer **Experiment Notes** window.

MSS05**Heat of Chemical Reactions II**

If the chemicals in the materials list are unavailable, you can substitute oven cleaner (such as Easy-Off®) for sodium hydroxide pellets. An instant cold-pack, like the kind kept in first aid kits or athletic training supplies, can be carefully dismantled to obtain the ammonium nitrate (pellets), which can be substituted for ammonium chloride. An instant hot-pack can similarly be dismantled to obtain calcium chloride. If a hot-pack is unavailable, plaster of Paris will suffice for an exothermic reaction; however, use a disposable plastic container rather than glass.

MSS09**Sunglasses, Bright Light, and Your Eyes**

For the best comparison from one set of sunglasses to the next, insure that the students keep the distance between the light source and the Light Sensor the same. You may want to tape them down. Also, they should place the sunglasses as close to the Light Sensor as possible to minimize the effects on light from other sources on the measurements.

MSS10**Polarizing Light**

Light polarizers can be purchased very inexpensively from any science supply catalog. You can also collect lenses from polarized sunglasses. It is helpful to mark each polarizer so students have a reference point for rotation. For a friendly, narrative description of the phenomenon of polarization of light, read *The Dancing Wu Li Masters*, by Gary Zukav (pp. 263 – 269).

MSS11**Friction on Ice**

One or more days in advance of this activity, you need to prepare enough blocks of ice for each group to have at least one. The blocks of ice should be at least 15 cm (6 inches) long, 10 cm (4 inches) wide, and 5 cm (2 inches) deep. A suggestion is to use an aluminum bread loaf pan to cast several blocks of ice ahead of time. Larger blocks of ice will give students more “elbow room” to apply greater pressure and friction.

MSS17 How Loud Is That Bubble?

Remind students to keep the Sound Sensor aimed directly at the bubble. If the Sound Sensor is not directly aimed at the bubble, the results will be inaccurate.

MSS20 Boiling Points

Isopropyl alcohol is usually sold as a 70:30 dilution with water. For this experiment, dilute the 70% isopropyl alcohol 50:50 with water for maximum lab safety. Review with students the safety procedures for using the heat source.

MSS21 Cooling with Evaporation

To save time and/or steps, fill containers with water and alcohol before beginning the experiment.

MSS22 How Our Ancestors Kept Their Milk Cold

This can be done as a demonstration by you, or as a student experiment. Ideally it should be done on a warm or hot day when lack of refrigeration would be a problem, and temperature should be recorded for a long period of time (such as all day). For the flower pots, be certain to use fairly large (1/2 gal.) unglazed terra cotta pots that have a drain-hole large enough to accommodate the insertion of a Temperature Sensor. Also make certain that the plate is large enough in diameter to hold the inverted flower pot. Emphasize to students the need for the pot to be soaking wet.

MSS24 Electrolytes

Since the voltages generated in this experiment are between +1 and -1 volts, you can experiment with setting the channel sensitivity to medium. To do this, open the DataStudio™ or *ScienceWorkshop*® file MSS24, and double-click the Voltage Sensor icon. Select **Med (10X)** in the **Sensitivity** dialog box, and click **OK**.

MSS25 The Beam Team

This activity requires teams of students to have at least 2 mirrors per team. Small hand mirrors can be purchased at craft supply stores or removed from cosmetics cases. Larger mirrors can be purchased from glass suppliers, in the form of 6 or 12 inch square tiles. It is important that the beam of the flashlight be focused as tightly as possible. A large MagLight® or laser pointer is recommended for each team of students. Darkening the room during this activity will improve the results.

**If your school participates in the *Science Olympiad*, this activity is known as “Reflection Relay” in the Elementary (Grades 4–6) competition.

MSS28 Tunnel Vision

A ramp may be constructed of 2 or 3 meter sticks temporarily taped together. If you don't have kinetic carts, ask students to bring toys from home to serve as cars.

MSS29 Twenty-two Cent Battery

Each of the pennies and dimes needs to have a small hole drilled or punched in it near the edge of the coin. (For an alternative way to do the experiment without drilling holes or using sandpaper, see experiment MSS30.) The holes will be used to attach the copper wire to the coins. This should be done for the students, to avoid safety hazards. Make certain that students sand the coins to remove all oxidation and expose the metal completely. For the salt water solution, dissolve as much salt as possible at room temperature.

MSS30 Eleven Cent Battery

Make certain that students remove all oxidation from the coins with the eraser, exposing the metal completely. For the salt water solution, dissolve as much salt as possible at room temperature.

MSS31 Parachute Contest

Have students construct the parachutes first, before doing the rest of the activity. Parachutes can be constructed one or more days in advance and saved until you are ready to do the "drop" activity with *ScienceWorkshop*.

The "drop zone" can be a stairway, a ladder, or even a tree which may be climbed. The height merely needs to be consistent for each parachute drop.

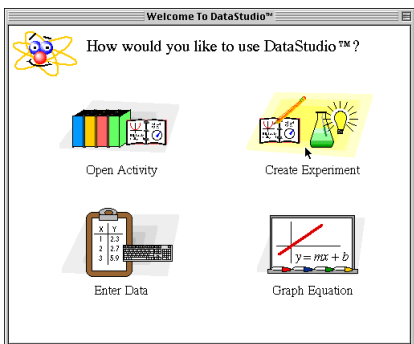
Students should be allowed at least one practice drop of their parachutes, in order to make necessary adjustments, and to ensure that the parachutes drop in a fairly straight trajectory.

Materials can consist of dry cleaning bags, thread, empty soda cans, or milk cartons from lunch. Cereal boxes, etc., can be recycled and used for cardboard. Students can help bring these supplies from home.

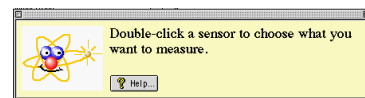
Make certain that the *ScienceWorkshop 500* Interface box has fresh batteries before disconnecting from the power supply.

Quick Reference Guide for *DataStudio*

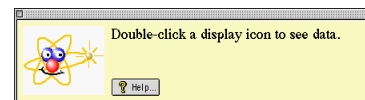
Create an Experiment

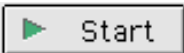
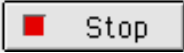









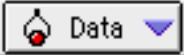


(1) Double-click a sensor.



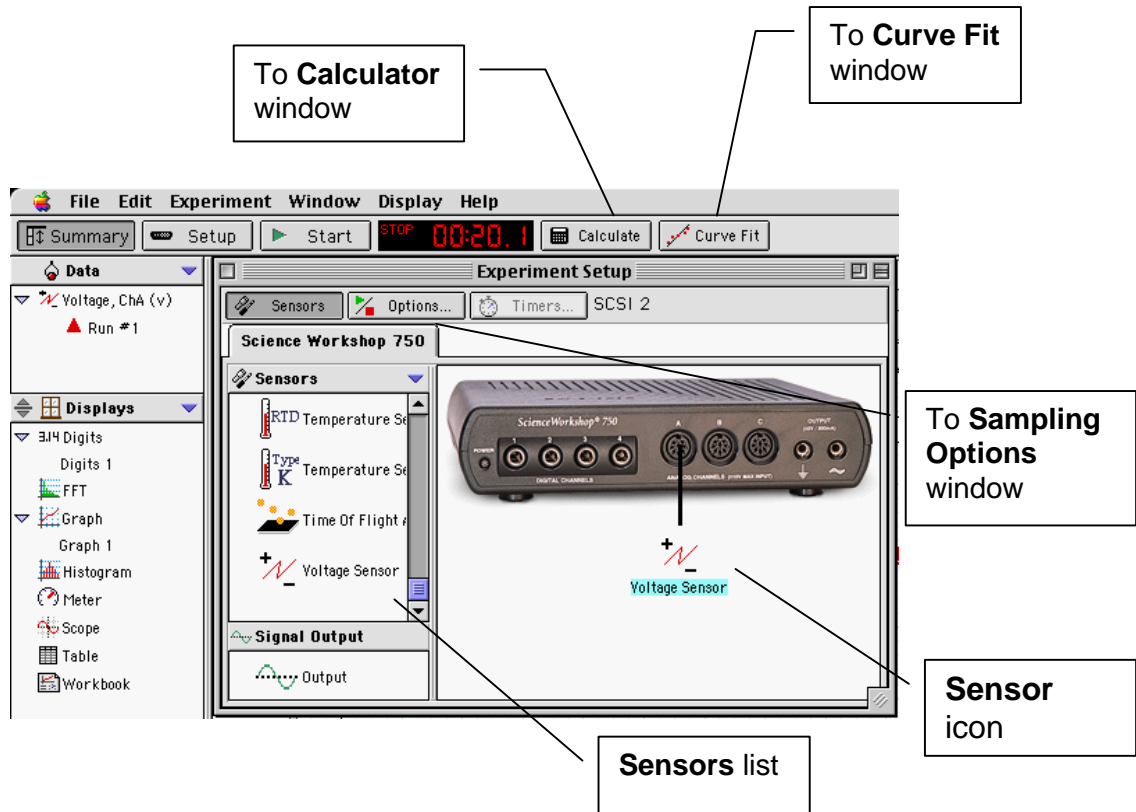
(2) Double-click a display.



What You Want To Do	How You Do It	Button
Start recording data	Click the Start button or select Start Data on the Experiment menu [or on the keyboard press CTRL - R (Windows) or Command - R (Mac)].	
Stop recording (or monitoring) data	Click the Stop button or select Stop Data on the Experiment menu [or on the keyboard press CTRL - . (period) (Win) or Command - . (Mac)].	
Start monitoring data	Select Monitor Data on the Experiment menu [or on the keyboard press CTRL - M (Win) or Command - M (Mac)].	none

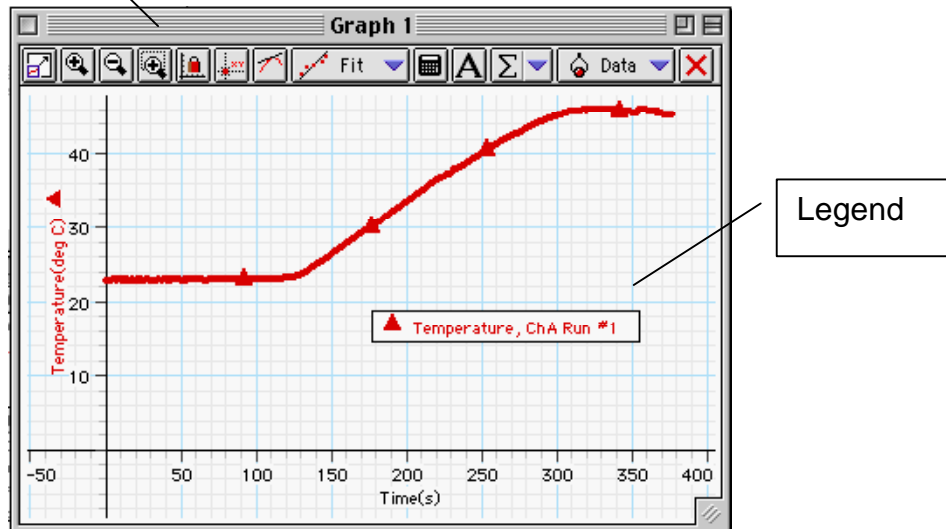
On the Graph Display	In the Graph Toolbar	Button
Re-scale the data so it fills the Graph display window	Click the Scale to Fit button.	
Pinpoint the x- and y-coordinate values on the Graph display	Click the Smart Tool button. The coordinates appear next to the 'Smart Tool'.	
"Zoom In" or "Zoom Out"	Click the Zoom In or Zoom Out buttons.	
Magnify a selected portion of the plotted data	Click the Zoom Select button and drag across the data section to be magnified.	
Create a Calculation	Click the Calculate button.	
Add a text note to the Graph	Click the Note button.	
Select from the Statistics menu	Click the Statistics menu button.	
Add or remove a data run	Click the Add/Remove Data menu button.	
Delete something	Click the Delete button.	
Select Graph settings	Click the Settings menu button.	

Experiment Setup Window






Graph tool bar

Graph Display












Quick Reference Guide for *ScienceWorkshop*

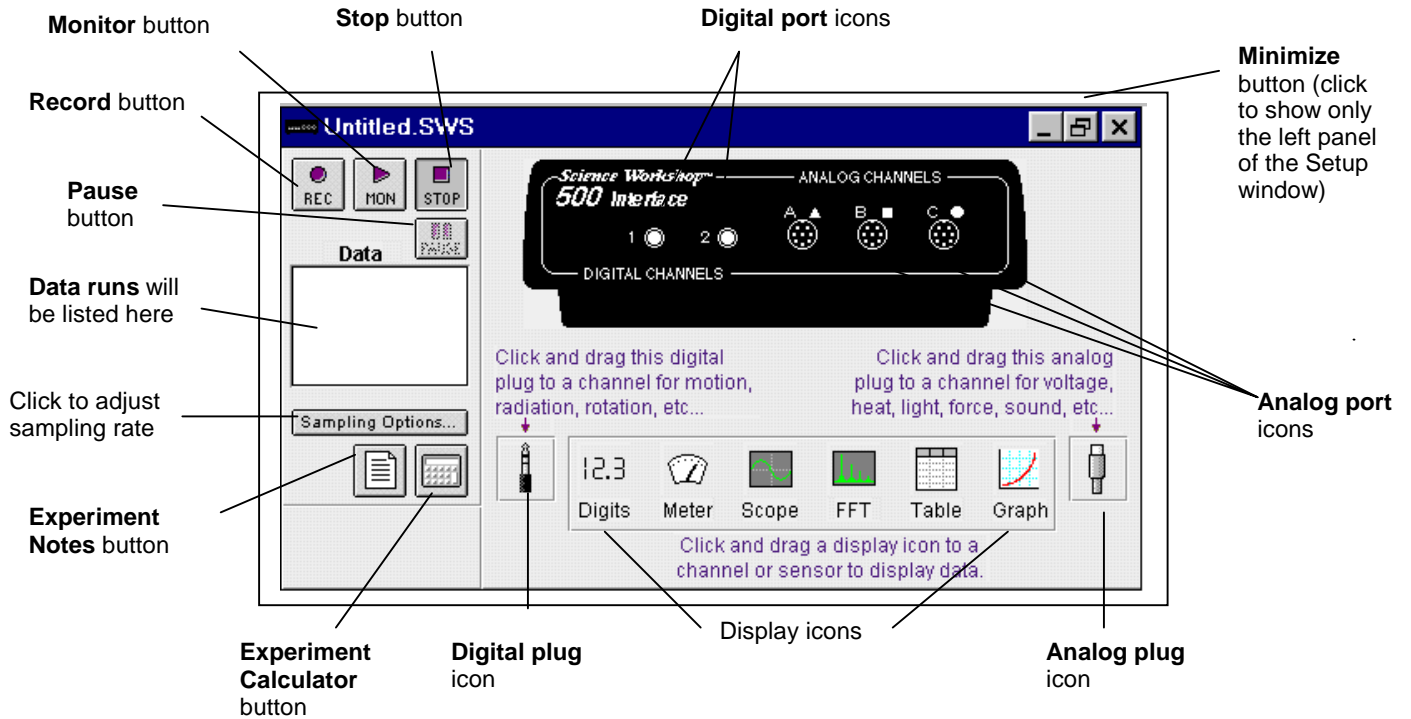
In the Experiment Setup Window:

What You Want to Do	How You Do It	Button
Begin recording data	Click the Record (REC) button or select Record on the Experiment menu [or on the keyboard press CTRL - R (Windows) or ⌘ - R (Mac)].	
Stop recording (or monitoring) data	Click the Stop (STOP) button or select Stop on the Experiment menu (or on the keyboard press CTRL - . (period) (Win) or ⌘ - . (Mac))	
Begin monitoring data	Click the Monitor (MON) button or select Monitor on the Experiment menu (or on the keyboard press CTRL - M (Win) or ⌘ - M (Mac))	

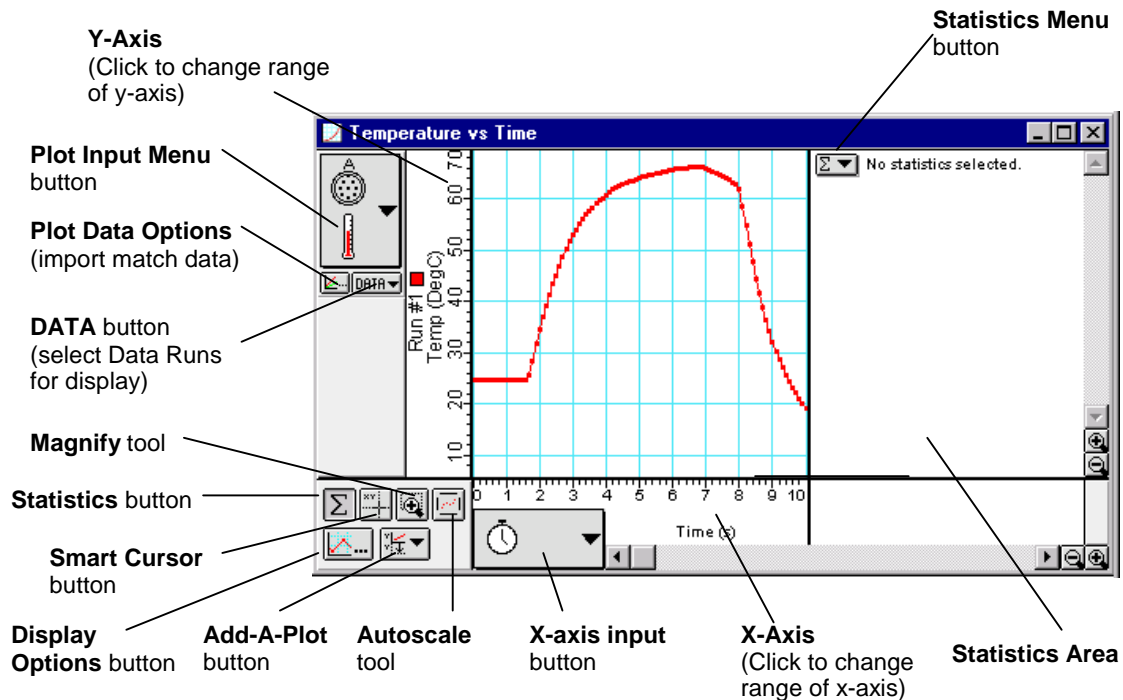
On the Graph Display:

What You Want to Do	How You Do It	Button
Re-scale the data so it fills the Graph display window	Click the Graph display and click the Autoscale button.	
Pinpoint the x- and y-coordinate values on the Graph display	Click the Smart Cursor button and move the cross hairs onto the graph (the exact values for the coordinates will appear next to each axis label)	
Magnify a selected portion of the plotted data	Click the Magnify button, and drag across the data section to be magnified	
Activate the Statistics Menu	Click the Statistics button	
Open the Statistics Menu	Click the Statistics Menu button	
See a list of all your Data Runs	Click the Data button	
Select Data Runs for display	Click the Run # in the Data menu (Shift-click to select more than one run)	
Add another plot to your Graph display	Click the Add-A-Plot button and select the desired input from the pop-up menu	
Import match data and plot it on the Graph display	Copy the match data to the clipboard, click the Plot Data Options button, and click Paste, OK, OK.	

Experiment Setup Window



Graph Display



Overview

Using the *Science Workshop*® Interface and System

There are several features that make *Science Workshop* a unique and powerful teaching tool for science and math. The mechanics of the hardware are discussed in section #1, the software tools in section #2 (*DataStudio*™ - #2A, *ScienceWorkshop* - #2B) and the mathematical tools in section #3 (*DataStudio* - #3A, *ScienceWorkshop* - #3B).

Section # 1: Experiment Setup

The 500 Interface Box	
<p>The 500 interface box</p>	
<p>The LOG button is used when you disconnect the interface from the computer and take it into the field for data collection. Pressing it once begins data collection, and pressing it a second time ends that run. Repeating this sequence collects another set of data points that will be called “RUN #2”, RUN #3, etc. If the interface box will be disconnected from the power supply, be sure that you have 4 AA batteries installed in the bottom of the interface. (The switch on the back of the interface must be pushed to the ON position.)</p> <p>Caution: In the remote data logging mode, the ON switch in the back of the box must remain on at all times. Loss of power will result in loss of data runs.</p>	

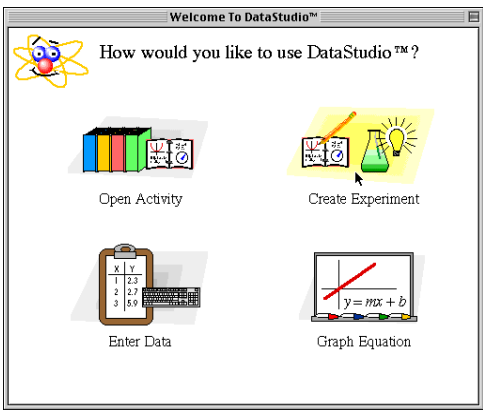
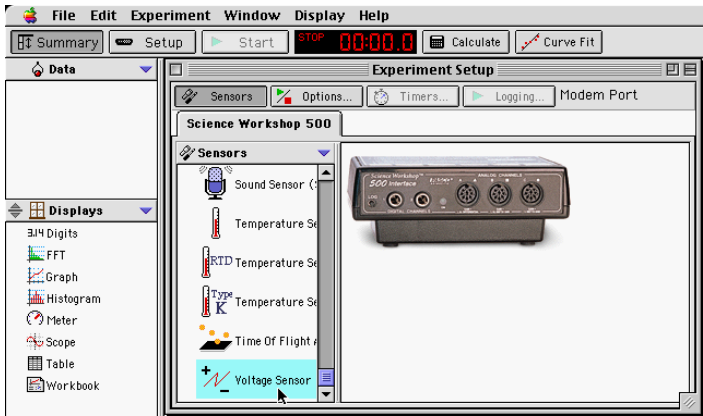
The **green LED light** on the front of the interface box indicates the mode of the interface box. A green light indicates that the power is on. When the interface is disconnected for remote data logging the light will flash slowly when in the sleep mode and rapidly when collecting data. (Refer to the label on the top of the interface box for details).

The analog channel ports A, B, and C allow analog sensors to be plugged into the 500 interface. The DIN connector of the sensor is matched to the port on the box and can only be plugged in one way. The analog sensors contained in the Middle School Science Bundle are the Temperature, Sound, Voltage, and Light Sensors, with optional Heart Rate and Respiration Rate Sensors.

The digital channel ports 1 and 2 allow digital sensors to be plugged into the 500 interface. The digital sensor in the Middle School Science bundle is the Motion Sensor.

Section #2A: Experiment Setup (For Users of DataStudio™ Software)

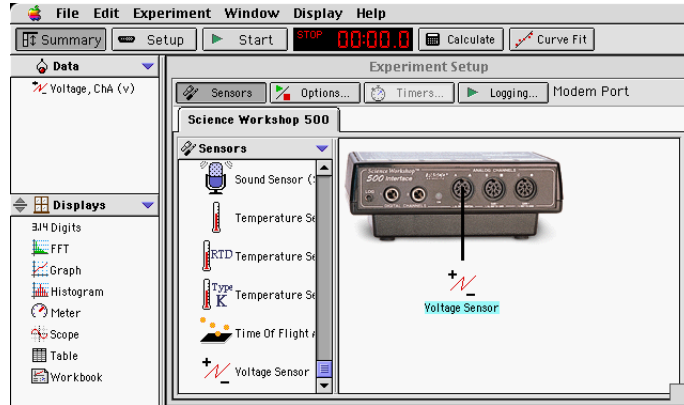
The first step to becoming proficient with DataStudio™ software is to understand the Summary List and the Experiment Setup window. The Summary List shows runs of data (under “Data”) and the available displays (under “Displays”).


Experiment Setup with DataStudio™ Software	
<p>1. Start DataStudio. In the “Welcome to DataStudio™” window, click “Create Experiment.”</p> <p>The Experiment Setup window shows the list of sensors (under “Sensors”) and the interface that is connected.</p>	
<p>2. Select a sensor. The sensors are listed by name. Scroll through the list to find the “Voltage Sensor” and then double-click the sensor to select it.</p> <p>The Voltage Sensor icon appears below Channel A of the interface, and “Voltage, ChA (v).” appears in the Data list.</p>	

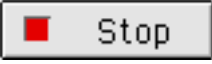
Experiment Setup with DataStudio (Continued)

- Now select a display.
Double-click “Graph” in the Displays list.

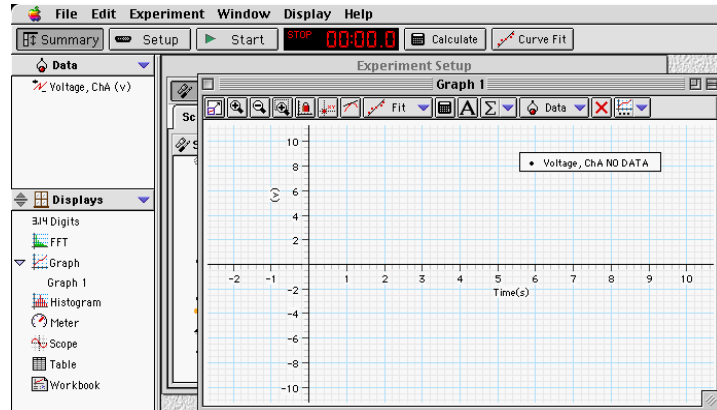
Graph 1 opens, and “Graph 1” appears in the Displays list. Also, “Voltage, ChA NO DATA” appears in the Graph’s legend.



- Click the **Start** button () to begin recording data..”

Note: The Start button changes to the **Stop** () button.

When you are finished, click “Stop.”






Features of the DataStudio™ Experiment Setup Window

The Menu Bar

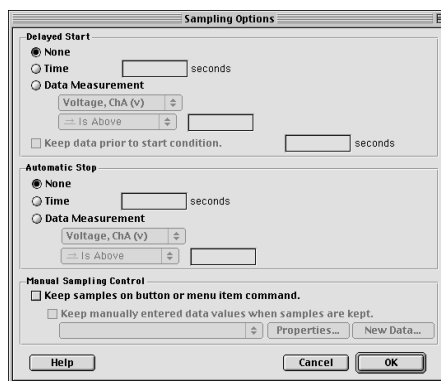
The **menu bar** at the top of the Experiment Setup window is very similar to menus bars found in Macintosh® and Windows® programs.

- **File** menu – use this menu to make a new activity, open an activity, save an activity, save an activity with a specific filename or in a specific location, import data, export data, select options (for saving *to* or opening *from* a particular directory), setup the page for printing, print, or quit.
- **Edit** menu – use this menu to undo, cut, copy, paste, delete, or select all.
- **Experiment** menu - use this menu to control the data collection, delete the last data run, disconnect for data logging or re-connect after data logging, set sampling options, open a new empty data table, or add a display.
- **Window** menu – use this menu to close, minimize or maximize a window, tile or cascade windows, or select a window so it "pops-to-the-top."
- **Display** menu - use this menu to export data or a picture of a display, or to activate any of the buttons in a display's toolbar.
- **Help** menu - use this menu to open the online help files, see the most recent help message, turn on or off the tips and confirmation windows, or change the license key.

In addition to the “Sensors” list, the Experiment Setup window has a button to open the Sampling Options window () , a button to open the Timers window () (for use with Photogates) and a Logging button () for use when you disconnect the interface for data logging.

Note: After you click the Logging button, a **Connect** button appears. If you disconnect for data logging and then reconnect after collecting data, click the Connect button *after* you reconnect the interface to the computer and power supply.






Example: Clicking the Options button opens the Sampling Options window. Use the Sampling Options window to set a “Delayed Start,” an “Automatic Stop,” or to set the “Manual Sampling Control.”

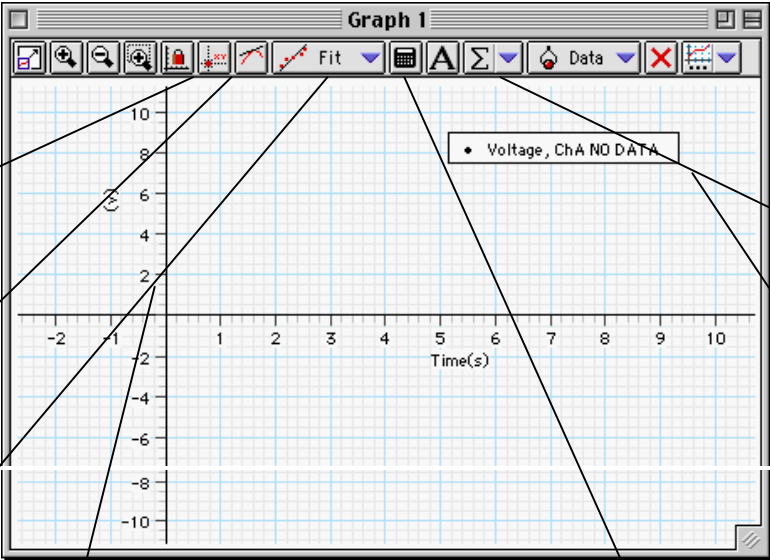


Section #3A: Data Analysis with DataStudio™

DataStudio offers several ways to analyze data:

- Use the built-in analysis tools in the Graph display toolbar.
- Use the “Calculator” to create calculations based on your measured data or on a range of numbers that you select.
- Use the “Curve Fit” to compare your data to mathematical models.

In the Graph display toolbar, the built-in analysis tools include the Smart Tool button () , the Slope Tool () button, the Fit menu button () , the Calculate button () , and the Statistics menu button. 



Use the “Smart Tool” to see the coordinates of any point.

Use the “Slope Tool” to see the slope of a line tangent to a point on a curve.

Use the “Fit” menu button to select a mathematical model.

Use the Calculate button to create a calculation on the data in your graph.

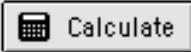
Use the Statistics button to select basic statistics such as “Minimum” or “Maximum” or to find the area under a curve.

Fit ▾

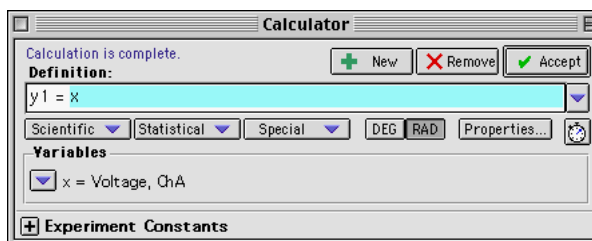
- Proportional
- Linear
- Quadratic
- Polynomial
- Power
- Inverse
- Inverse Square
- Inverse Nth Power
- ✓ Natural Exponent
- Natural Logarithm
- Base-10 Exponent
- Base-10 Logarithm
- Inverse Exponent
- Sine
- Sine Series
- User Defined
- No Curve Fits

- ✓ Minimum
- ✓ Maximum
- ✓ Mean
- ✓ Standard Deviation
- ✓ Count
- Show All
- Hide All
- Area

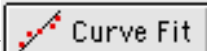
Using the DataStudio™ Calculator Feature

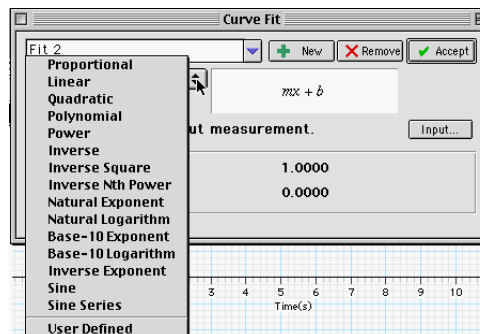
In the main toolbar, click the Calculate button () to open the Calculator window.

Use the “Definition” area to create your own calculation, or use the “Scientific,” “Statistical” or “Special” menus to select a specific calculation to apply to your data. After you have created the calculation, click “Accept.” Your calculation will appear in the Data list. You can drag your calculation to a Graph Display.



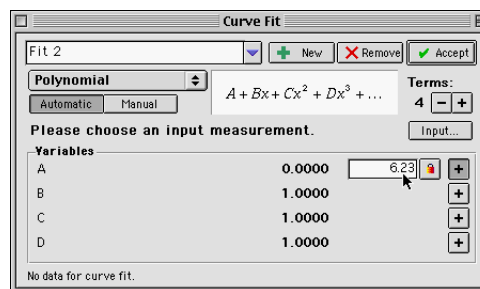
Using the DataStudio™ Curve Fit Feature

Click the **Curve Fit** button () in the main toolbar to open the Curve Fit window. Click the “New” button. Select a mathematical model, or select “User Defined” to create your own.



After you have created the mathematical model, click “Accept.” Your curve fit will appear in the Data List.

For example, you can drag your curve fit to a graph display.



Note: You can use the online help file to learn about any button, icon, menu, control, function or feature of the program. To open the online help file, click “Contents” or “Search...” in the Help menu.

Section #2B: Experiment Setup (for Users of ScienceWorkshop® Software)

Hint: Working at a computer with *Science Workshop* up and running while reading these instructions will bring a “hands-on” experience to the user and enhance the learning process. The user should keep the *Quick Reference Guide for Science Workshop* (pages xv and xvi) available to refer to for buttons, icons, and setup windows.

Experiment Setup Window - ScienceWorkshop	
<p>Experiment Setup window</p>	
<p>The first step to becoming proficient with <i>Science Workshop</i> is to understand the various icon and buttons in the Experiment Setup window. The window is automatically displayed whenever a new <i>Science Workshop</i> file is opened. If you get a “Can’t find interface box” message, the interface is either missing or not properly connected. Be sure that the power to the interface box is ON and that the connector cables are secure.</p>	
File Edit Experiment Display	
<p>The Experiment Setup window menu bar: The menu bar is at the top of the Experiment Setup window. Mac and Window users will find that it is very similar to menus contained in other Mac and Windows programs. The File menu is used to open, close, save, print, and import data. The Edit menu is used to copy, cut, clear, and paste data or runs of data. The Experiment menu can be used to control the data collection. Selecting items on this menu does the same thing as clicking the Record, Monitor, Pause, or Stop buttons in the Experiment Setup window. This menu also allows you to access the sampling options, disconnect/connect (for remote logging), display the Experiment Setup window or go to the Experiment Notes and Calculator windows. The Display menu allows you to select any of the six display windows (either to set up a new display or toggle to a display already in use).</p>	

Features of the *ScienceWorkshop* Experiment Setup Window



Starting in the top left corner of the Experiment Setup window is the **Record button**. Pressing this button initiates the data collection and stores the data in memory. You will know when *Science Workshop* is collecting data by the presence of a flashing bar just below the button.



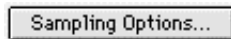
The **Monitor Data button** is next to the **Record** button. When this button is selected, the interface will collect and display data in a view mode only. None of the data is saved in memory. This feature is used mainly when the user wishes to check to see if a sensor is working properly, and also when viewing sound data with the Sound Sensor.



The **Stop button** does just that. It stops the data collection in both the record and monitor modes.



The **Pause button** interrupts data collection temporarily, and recording is re-established when the **Pause** button is pressed again.



The **Sampling Option button** opens a window that is used to select the sampling rate and options. The sampling rate is set to a default setting of 10 samples per second for an analog sensor and 10,000 samples per second for a digital sensor. The user can vary the analog rate of sampling from once per hour to 20,000 per second.

Suggested sampling rates for common measurements:

Temperature Sensor	2 – 10 Hz
Sound Sensor	100 – 200 Hz
Light Sensor	10 Hz
Voltage Sensor	10 Hz
Motion Sensor	(preset, no sample rate required)



The **Experiment Calculator button** opens the Experiment Calculator window that allows you to do mathematical operations on collected data, or you can use it as a stand-alone calculator.



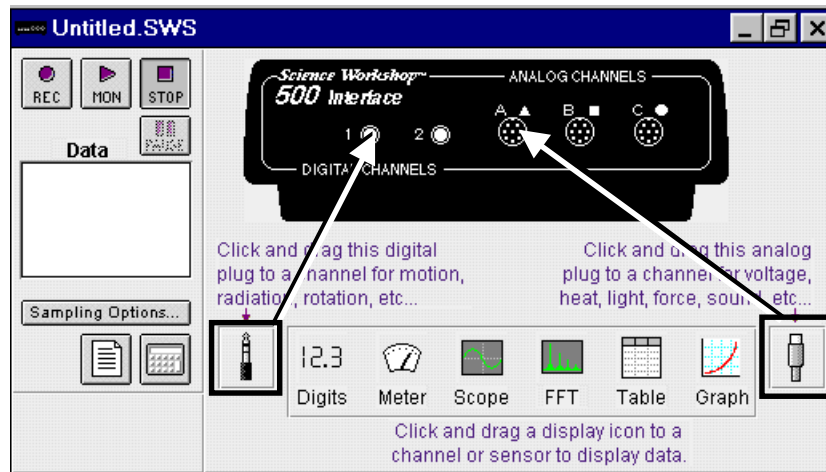
To add a digital sensor to the experiment setup, drag the **digital plug icon** to digital channel 1 or 2, and then select the correct digital sensor from the list. Click **OK**.



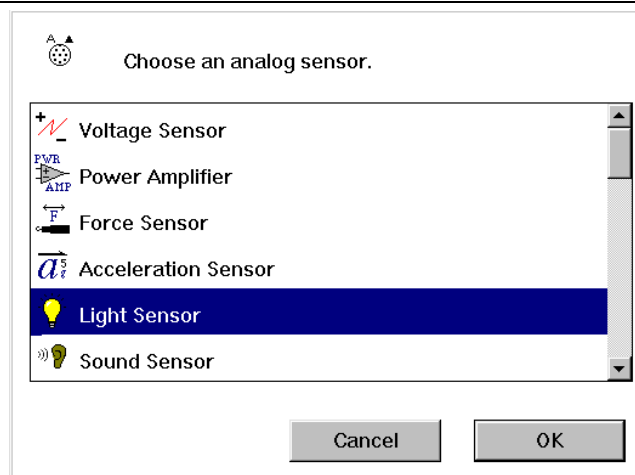
To add an analog sensor to the experiment setup, drag the **analog plug icon** to analog channel A, B, or C, and then select the correct analog sensor from the list. Click **OK**.

Setting up Your Own Experiment in ScienceWorkshop

1. Drag an **analog plug icon** or a **digital plug icon** to the icon that corresponds to the port on the 500 Interface box that you have plugged the sensor into.

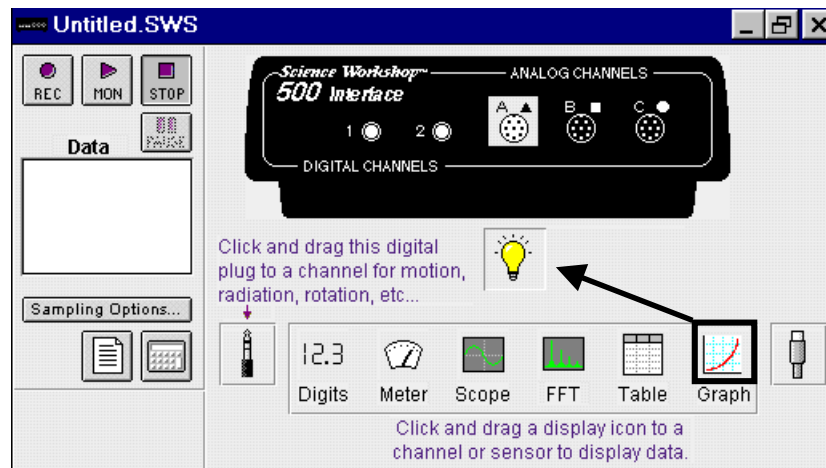


2. Choose the sensor from the sensor list that pops up. Click **OK**.






3. Drag a display icon to the Sensor icon.

You are ready to collect data!




➤ **Note:** ScienceWorkshop has many advanced features, such as the FFT and Scope displays, that are outside the scope this manual and thus are not discussed.

Section #3B: Data Analysis with *ScienceWorkshop*

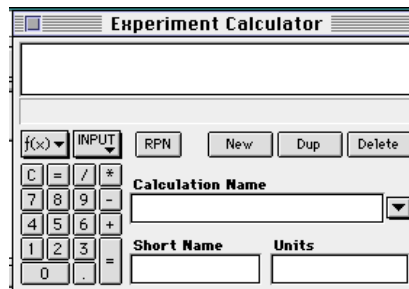
The Analyze Tool: Smart Cursor 	
The Smart Cursor allows you to investigate individual points on a graph.	
<p>Procedure: Select the Analyze Tool (Smart Cursor) button by clicking on it. The cursor will change to a cross hair, and the y and x values for that individual position will be displayed on the y-axis and x-axis. If you want to have the change in y or x coordinates displayed, click and drag the Smart Cursor over the desired area. The difference ($y_2 - y_1$ and $x_2 - x_1$) will be displayed on the y-axis and x-axis. (This ability to display the change in x and the change in y in a selected area is called the <i>delta feature</i>.)</p>	
Statistics Features (For advanced activities)	
When working with a Table or a Graph display, click the Statistics button to open the statistics area. 	
In the Graph display, click the Statistics Menu button to see the statistics options. 	
Statistics menu for a Graph display	<div style="border: 1px solid black; padding: 5px;"> Count Minimum Maximum Mean Standard Deviation All Of The Above Curve Fit Integration Derivative Histogram <input checked="" type="checkbox"/> No Stats </div>
Statistics menu for a Table display	<div style="border: 1px solid black; padding: 5px; text-align: center;"> Min Max Mean Std. Dev </div>
Curve Fit submenu	<div style="border: 1px solid black; padding: 5px;"> Linear Fit Logarithmic Fit Exponential Fit Power Fit Polynomial Fit Sine Series Fit </div>
<p>Linear Fit will generate a basic slope equation with the slope of the best-fit line being the a_2 value in the display.</p>	

Experiment Calculator

The **Experiment Calculator** feature of *Science Workshop* allows you to create a new calculation that is based on the input data. For example, if data is displayed in degrees Celsius, you could use the calculator to create a calculation to display the temperature data in degrees Fahrenheit or degrees Kelvin.

To set up a calculation, click the **Calculator button**  in the Experiment Setup window. You can also open the Experiment Calculator by selecting **Calculator Window** from the **Experiment** menu.

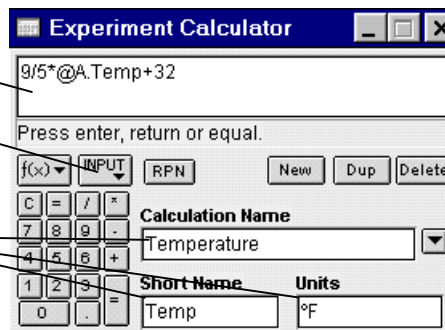
Experiment Calculator window



Example:

Converting the temperature data from degrees Celsius to degrees Fahrenheit for plotting on the Graph display.

1. Type the formula here.
(Select the variable to be modified from the Input Menu).
2. Fill in these dialog boxes.
3. Click = or press ENTER.



Changing the plotting parameters of the Graph display

4. On the Graph display, click the **Plot Input Menu** button, and select **Calculations ► Temperature, (Temp °F)**



(Temperature will be plotted in °F)

► **Note:** The values for this calculation can also be displayed in any Table, Digits, or Meter display. To do this, select **Calculations ► Temperature (Temp °F)** on the **Input** menu of the display.

Tutorial Activities

Exploration of Sensors

Purpose: In this activity, you will explore the 5 sensors included in the Middle School Science Bundle. You will use them in a very general nature to establish a comfort level with the sensors and the software.

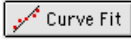
Procedure: The individual activity for each sensor is pre-configured. That is, each display and sampling rate is set for you. All you need to do is to open the document labeled for that sensor.

EXAMPLE: Open the file **t_temp**.


The pre-configured Experiment Setup window with the displays will appear on the screen. Plug the Temperature Sensor into analog channel A and click **Start** (DataStudio™) or **REC** (*ScienceWorkshop*®), or select **Start Data** (DataStudio) or **Record** (*ScienceWorkshop*) on the Experiment menu. Observe the data in the display windows.

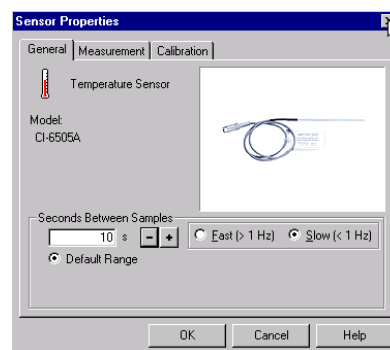
Temperature Sensor Exploration:

1. Open the file **t_temp**. Plug the DIN connector of the Temperature Sensor into analog channel A and start recording data. [Click **Start** (DataStudio) or **REC** (*ScienceWorkshop*) or select **Start Data** (DataStudio) or **Record** (*ScienceWorkshop*) on the Experiment Menu]. Vary the temperature at the location of the Temperature Sensor (hot and cold water work just fine). Allow the program to collect data for approximately 90 seconds, and then stop recording data (click **STOP** or select **Stop** on the Experiment menu).
2. Observe the data in the three displays.
 - The Digits display shows the last temperature recorded.
 - The Table display shows a record of the temperatures vs. sample number.
 - To change the Table display to temperature vs. time, click the **clock icon** in the Table display. The table will display the time (show time in tenths of a second) vs. temperature at that point.
 - The Graph display shows the temperature vs. time graph of the data. Use the **Smart Tool** (DataStudio) or **Smart Cursor** (*ScienceWorkshop*) to investigate specific coordinates on the graph. Use the **Statistics** mode to have the software calculate statistical information about the run.
 - Use the **Curve Fit** ► **Linear Fit** mode of the statistics feature to calculate the slope of any portion of the plotted data. To do this, highlight the data of


interest and select the  button (DataStudio) on the toolbar or **Curve Fit ► Linear Fit** (*ScienceWorkshop*) on the statistics menu.

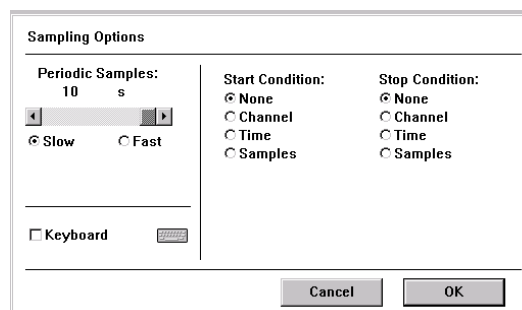
3. After you complete step 2, highlight Run 1 in the Data window in the Experiment Setup window and press the **Delete** key on the keyboard. (Run 1 data will be deleted.)
4. You will now set the sampling options.

In DataStudio: Double-click the Temperature Sensor icon (the one that points to the interface) in the Setup window. The Sensor Properties window displays. In the Sensor Properties window, click the **Slow** radio button. Then repeatedly click the  button to select 10 seconds. Click **OK** to return to the setup window.



In ScienceWorkshop: Click **Sampling Options**

() in the Experiment Setup window. In the dialog window, click the **Slow** radio button. Then click the arrow above “Slow” to select 10 seconds. Click OK to return to the setup window.



► This feature can be used to set the sampling rate from 20,000 samples per second to one sample per hour. A typical use of this feature would be to collect temperature data in the room over an extended time period (i.e. 24 hours) and then later analyze the conditions in the room.

5. Start recording data [click **Start** (DataStudio) or **REC** (*ScienceWorkshop*) or select **Start Data** (DataStudio) or **Record** (*ScienceWorkshop*) on the Experiment menu] and notice that the data is collected once every 10 seconds.

Sound Sensor Exploration:

1. Open the file **t_sound**. Plug the DIN connector of the Sound Sensor into analog channel A.
2. Start recording data. (Click **Start** (DataStudio) or **REC** (*ScienceWorkshop*) or select **Start Data** (DataStudio) or **Record** (*ScienceWorkshop*) on the Experiment menu).
3. Snap your fingers a few times.
4. Stop recording data (click **STOP** or select **Stop** on the Experiment menu).
5. Check the table to find the loudest snap—it will have the greatest intensity.

Motion Sensor Exploration:

1. Open the file **t_motion**.
2. Plug the Motion Sensor into the digital channels 1+ 2 (yellow-banded plug into #1).
3. Lay the Motion Sensor on the table pointing toward the ceiling and start recording data. (Remember: Click Start or REC.)
4. After 5 seconds, move the Motion Sensor toward and then away from the ceiling. (You can modify this procedure by mounting the Motion Sensor and walking toward and away from it.)
5. Stop recording data after 30 seconds and observe the data. The distance data can be used to find the height of the ceiling, and the velocity data can be used to show the velocity of the Motion Sensor.
6. The Graph display will show the statistics for the event. The **Smart Tool** (DataStudio) or **Smart Cursor** (*ScienceWorkshop*) can be used to locate the minimum and maximum values.

Light Sensor Exploration:

1. Open the file **t_light**.
2. Set the sensitivity switch on the top of the Light Sensor to 1.
3. Plug the DIN connector of the Light Sensor into analog channel A.
4. Start recording data. Wave your hand over the Light Sensor, point it at different light sources, and note the intensity changes on the Graph display. Stop recording data.

Voltage Sensor Exploration:

1. Find a 1.5V battery.
2. Open the file **t_volt**.
3. Plug the DIN connector of the Voltage Sensor into analog channel A, and start recording data.
4. Touch one end of the battery with the negative electrode and the other end with the positive electrode.
5. Check the voltage of the battery on the meter display.

►Note: We highly recommend that teachers work through the tutorials contained in this manual. These tutorials will reinforce the use of the powerful teaching features of the software.

Follow the Leader Graphing I

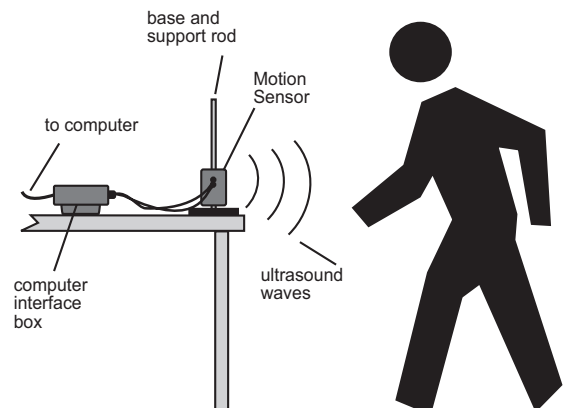
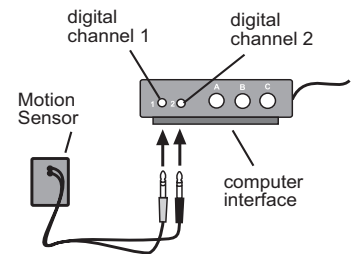
Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• masking tape (optional)
• Motion Sensor	
• meter stick	
• support stand (optional)	

Purpose

The purpose of this activity is to use the Motion Sensor to see how closely you can follow a path that has been “drawn” for you by the computer.

Procedure

- 1 Turn on the *ScienceWorkshop 500* Interface box and the computer.
- 2 Insert the yellow plug of the Motion Sensor into digital channel 1 of the interface box and the black plug into digital channel 2.
- 3 Mount the Motion Sensor on its stand —or set it on a table so it is stable and facing you — and adjust its height so that the metal screen is aimed right at the middle of your shirt.



4 Set up your area so that you can *back away from the Motion Sensor's metal screen, without running into anything for 2 meters*. Ask your teacher's permission before putting any tape on the floor.

5 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS01	MSS01 Follow the Leader.ds



In *ScienceWorkshop*, you can close or minimize the Experiment Notes window that is on the screen when you first open the file. To open this window again, select Notes Window from the list at the end of the Experiment menu.



You will need to be able to look at your computer's monitor while you are backing away from the Motion Sensor.

6 Notice the Graph display on the computer, titled **Position versus Time – Match Graph**. The black, zigzag line has been drawn for you by the computer. The y-axis shows how far away you need to be from the Motion Sensor. The x-axis shows how many seconds each part of your travel should last.



Can you predict how close to the Motion Sensor you should be before you begin to record? Can you predict how far to back away from the Motion Sensor before stopping? Write down your predictions in your notebook.

- 7** When you are ready to begin, have a partner start recording data. (*Hint: Click **REC** (ScienceWorkshop) or **Start** (DataStudio).* Another way to begin recording data is to select **Record** (DataStudio) or **Start Data** (*ScienceWorkshop*) on the Experiment menu.) The Motion Sensor will make a faint clicking sound while it is recording. (*Note: There is a 5-second “countdown” in DataStudio.*) Watch the monitor, and try to match your motion to the line on the monitor.
- 8** The computer will automatically stop recording after 10 seconds. You may now look at your graph and analyze your data and compare yourself to the “leader.” To do this, re-scale your graph so the data fills the whole window. [*Hint: Click the **Autoscale** button (ScienceWorkshop) or the **Scale to Fit** button (DataStudio).*]
- 9** In *ScienceWorkshop*, click the **Statistics** button and examine the **total abs. difference** (total absolute difference) number. For DataStudio, check the “Match Score.” The closer this number is to zero, the more closely you have followed the leader and matched your motion to the computer’s graph.
- 10** Repeat the data recording process several more times. Each time, try to improve how closely your motion matches the computer.
- 11** To choose runs of data, click the **Data** menu. To clear all runs of data from the graph, click the **Data** menu button and select **No Data**.



Write a description of your motion in your notebook, using terms such as *constant speed* and *no motion*.



How was your first attempt at matching the graph different from your last attempt? Are there some students in your class who are especially good at matching the computer?



Be sure to follow your teacher's instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new file name.

Follow the Leader Graphing II

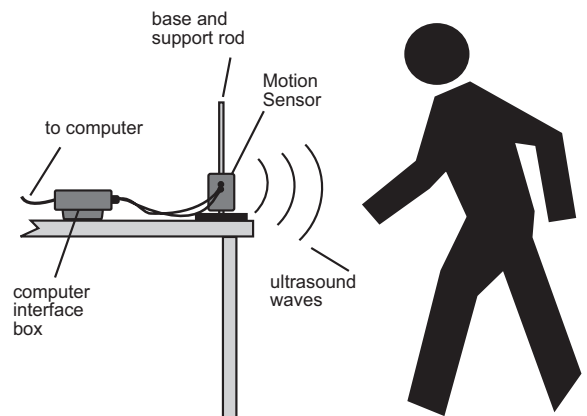
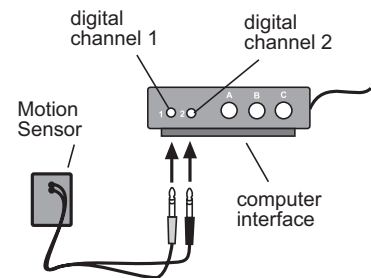
Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• masking tape (optional)
• Motion Sensor	
• meter stick	
• support stand (optional)	

Purpose

The purpose of this activity is to use the Motion Sensor to see how closely you can follow a NEW path that has been “drawn” for you by the computer with input from a classmate.

Procedure

- 1 Turn on the *ScienceWorkshop 500* Interface box and the computer.
- 2 Insert the yellow plug of the Motion Sensor into digital channel 1 of the interface box and the black plug into digital channel 2.
- 3 Position the Motion Sensor so the height of the metal screen is aimed right at the middle of your shirt. Set up your area so that you can *back away from the Motion Sensor's metal screen, without running into anything*, for 4 meters.





You may wish to put tape on the floor to mark your path, or to mark 1-meter intervals. Ask your teacher's permission before putting any tape on the floor.

4

Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS02	MSS02 Follow the Leader II.ds

5

Data Entry Instructions for *ScienceWorkshop*

The **Experiment Notes** window will appear on the screen when you first open the file. Use the slider bar to move to the bottom of the text in the Notes window. In the blank area of the Experiment Notes window, type a value (0 or higher) for the x-axis (time, in seconds). Press the TAB key on the keyboard, and type a value (.4 or higher) for the y-axis (distance, in meters). Press ENTER. Type another value for the x-axis; press the TAB key; type another value for the y-axis; press ENTER. You may type in as many pairs of values as you like. A sample set of values might look like:

0	0.6
3	0.8
6	0.4
10	0.4




Remember to hit the ENTER key after each pair.

After entering your pairs of values, use the cursor to highlight (select) all the pairs. On the Edit menu, select **Copy**.

On the Graph display, click the **Plot Data Options** icon, located under the Motion Sensor icon at the top of the y-axis. Click **Paste** in the pop-up window. (The number of ordered-pair values you typed will appear under the words Match Data: as the number of points now plotted on the graph.) Click **OK**. (You will now see an entirely different graph on the monitor. This is now the “Leader” graph to follow, and will require a whole new type of motion.

5

Data Entry Instructions for DataStudio

Click on the window labeled Table 1 to make it active. In the toolbar at the top of this window, click the **Edit Data** button (). Use the arrow keys or your mouse to select cells within the table. You may enter different values for time and position, such as those listed above.

When you are finished entering your time and position values, click the **Edit Data** button again to turn it off.

Click again on the window labeled **Graph 1** to make it active. You will see the plot of the data you just entered in the data table. This is now the “Leader” graph to follow, and will require a whole new type of motion

6

Click the **Maximize** button on the Graph display.



You will need to be able to look at your computer’s monitor while you are backing away from (or moving toward) the Motion Sensor.

7

Click the **Magnify** tool (*ScienceWorkshop*) or **Zoom Select** tool (DataStudio), and drag a box around the plotted data. (The graph will be re-scaled so the data plot will fill the screen.) If necessary, repeat this procedure to re-scale the graph so the plotted data completely fills the screen.




Can you predict how your motion will be different from the original “Follow the Leader” motion? **Write down your predictions in your notebook.**

8

When you are ready to begin, have a partner start recording data. The Motion Sensor will make a faint clicking sound while it is recording. (Note: This is a 5-second “countdown” in DataStudio.) Watch the monitor, and try to match your motion to the NEW line on the monitor.

9

The computer will automatically stop recording after 10 seconds. You may now look at your graph and analyze your data and compare yourself to the “leader.” In *ScienceWorkshop*, click the Statistics () button. Examine the total abs. difference (total absolute difference) number under **Match Data**. For DataStudio, check the “Match Score.” The closer this number is to zero, the more closely you have followed the NEW leader and matched your motion to the computer’s graph.



Compare the direction and speed of the new motion to the original motion of **Follow the Leader Graphing I**. What would the new graph have looked like if you had typed a negative value for the x-axis? Would such a graph be possible to follow?



Be sure to follow your teacher’s instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new file name.

Investigating Temperature Data

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• ice
• Temperature Sensor	• hot water
• glass container, 250 ml (two)	
• graduated cylinder or measuring cup	

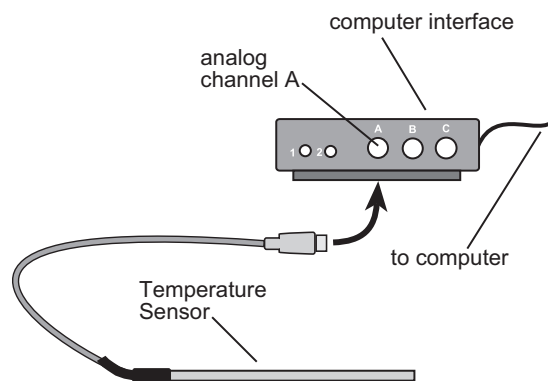
Purpose

The purpose of this activity is to use the Temperature Sensor to record the temperature of cold and hot liquids *before* and *after* they are mixed.

Procedure

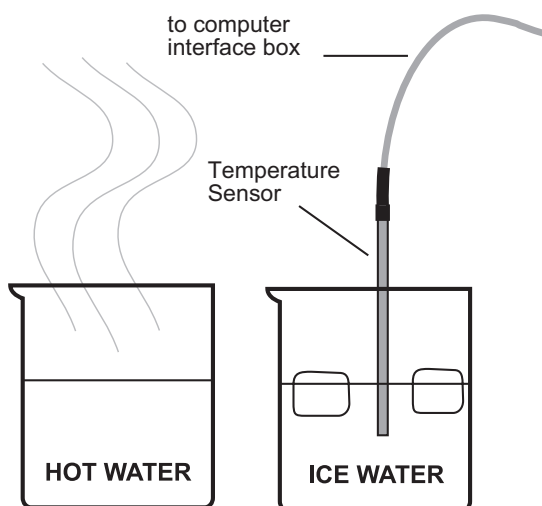
- 1 Turn on the *ScienceWorkshop 500* Interface box and the computer.
- 2 Plug a Temperature Sensor into analog channel A of the interface box.
- 3 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS03	MSS03 Investigating Temp.ds



4 Use the graduated cylinder to measure 100 ml of ice water. Pour the 100 ml of ice water into one of the glass containers. Use the graduated cylinder to measure 100 ml of hot water. Pour the hot water into the other glass container.

5 Place the Temperature Sensor into one of the containers of water. Start recording data. To do this, click **REC** (*ScienceWorkshop*) or **Start** (*DataStudio*). Watch the graph for about 10 seconds.



6 Move the Temperature Sensor to the other container and watch the graph for another 10 seconds or so. Stop recording data. (To do this, click the **STOP** button).

7 Try different ways of changing the temperature, such as putting the tip of the sensor directly on an ice cube, mixing the hot and cold water in several different ways, or taking the sensor out of the water and blowing on the tip of it.



In your notes, keep a list of the things you try. For each thing you try, write down your predictions about what will happen to the temperature *before* you do the experiment.

8 When you have finished collecting your temperature data, you are ready to analyze it. To do this, click the graph to make it active.

9 Re-scale the graph so the data fills the whole window. (*Hint:* Click the **Autoscale** button (*ScienceWorkshop*) or the **Scale to Fit** button (*DataStudio*).

10 Pinpoint the exact values for your temperature data. (*Hint:* Click the **Smart Cursor** button (*ScienceWorkshop*) or the **Smart Tool** (*DataStudio*) and move the cross hairs in the graph. Notice how the coordinates of the cursor are shown near the origin of the axes.)



Find the lowest temperature you recorded (this is the y-coordinate of the lowest point on your graph). Write down this temperature in your notes.

Find the highest temperature you recorded (this is the y-coordinate of the highest point on your graph). Write down this temperature in your notes.



What was the most amount of change you were able to produce in the temperature?

Which temperature change took the least amount of time? Which took the longest?

Which of your predictions turned out as you expected? Which predictions did not agree with the results?



Be sure to follow your teacher's instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new file name.

Heat of Chemical Reactions I

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• two Alka-Seltzer tablets
• Temperature Sensor	• water
• glass container, 250 ml	

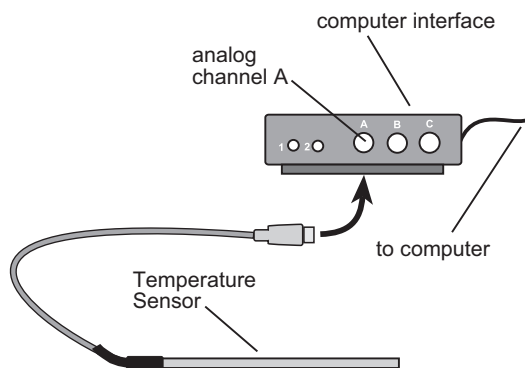
Purpose

The purpose of this activity is to use the Temperature Sensor to record the change in temperature of a chemical reaction.

Procedure

- 1 Turn on the *ScienceWorkshop 500* Interface box and the computer.
- 2 Plug a Temperature Sensor into analog channel A of the interface box.
- 3 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS04	MSS04 Heat of Chem React I.ds





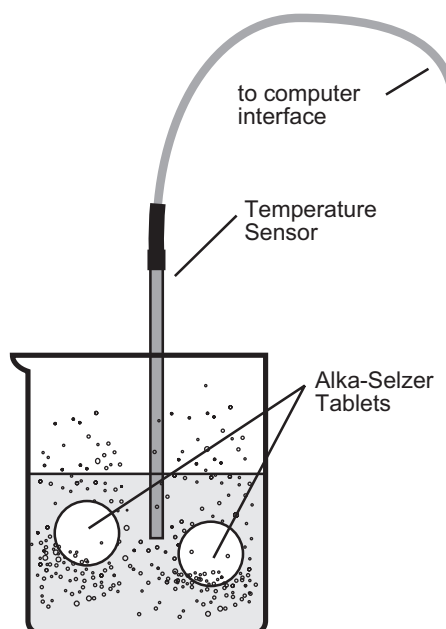
A chemical reaction that feels cooler is called an endothermic reaction. A chemical reaction that feels warmer is called an exothermic reaction. In your science notebook, write down your prediction about what will happen to the temperature of the water when it reacts with the Alka-Seltzer tablets.

4 Pour approximately 200 ml of water into the glass container.

5 Place the Temperature Sensor into the container of water.

6 Start recording data. [*Hint:* Click **REC** (*ScienceWorkshop*) or **Start** (*DataStudio*).]







7 While recording, drop in both Alka-Seltzer tablets. Continue recording for about one minute after the tablets have dissolved.



Feel the container of water during the reaction, using the back of your hand. If you observe a change of temperature with your own sense of touch, write this down in your notes.

8 Stop recording data. (*Hint:* Click **Stop**.)

Analyzing the Data

-  When you have finished collecting your temperature data, you are ready to analyze it. To do this, click the Graph display to make it active.
-  Re-scale the graph. [*Hint:* Click the **Autoscale** button (*ScienceWorkshop*) or the **Scale to Fit** button (*DataStudio*).]
-  Pin-point the exact values for your temperature data. [*Hint:* Click the **Smart Cursor** button (*ScienceWorkshop*) or the **Smart Tool** (*DataStudio*), and move the cross hairs in the graph. Notice how the coordinates are shown.]
-  Click the **Statistics** button to display the Statistics menu. Use the menu to display the minimum and maximum temperatures.
-  Click the **Zoom** button (*ScienceWorkshop*) or **Zoom Select** button (*DataStudio*), and drag a box around the area of your temperature data graph that shows the greatest change in temperature.
-  Re-scale the graph again.



What type of change did this chemical reaction produce in the temperature? Describe in words what happened to the temperature of the water during the reaction with the Alka-Seltzer.

Which of your predictions turned out as you expected? Which predictions did not match your experimental results?

How do your predictions compare to the data?



Be sure to follow your teacher's instructions for putting away your equipment, disposing of the chemicals, and shutting down the computer. If you are saving your data on a disk, remember to give it a new file name.

Heat of Chemical Reactions II

Teacher Demonstration

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• water
• Temperature Sensor	• 4 g sodium hydroxide
• glass containers, 125 ml (three)	• 4 g ammonium chloride
• wash bottle and lint-free tissues	• 4 g calcium chloride

Purpose

The purpose of this activity is to use the Temperature Sensor to record the change in temperature of several chemical reactions.

Procedure

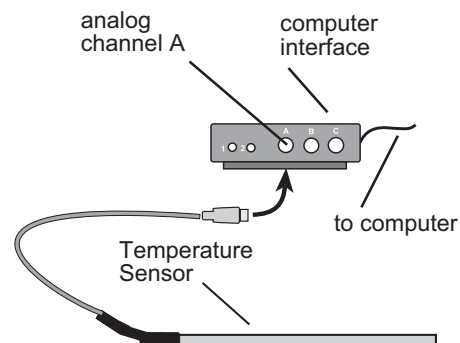
1 Turn on the interface box and the computer. Plug a Temperature Sensor into analog channel A of the interface box.

2 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS05	MSS05 Heat of Chem React II.ds

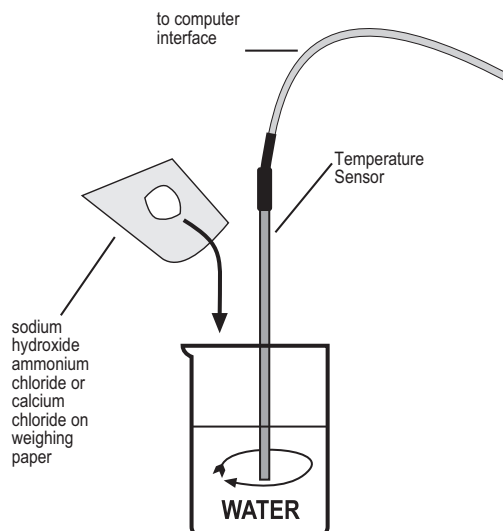
3 Maximize the Graph display window.

4 Pour 30 ml of water into each of the glass containers.



5 Place the Temperature Sensor into the first container of water. Start recording data.

6 While recording data, add the 4 g sodium hydroxide to the water and use the Temperature Sensor to mix the solution. Continue recording the temperature for about three minutes. Stop recording data. Rinse and wipe the Temperature Sensor.




7 Place the Temperature Sensor into the second container of water; begin recording temperature data. While recording data, add the 4 g ammonium chloride to the water and mix with the Temperature Sensor. Continue to record temperature for about three minutes. Stop recording data. Rinse and wipe the Temperature Sensor.

8 Place the Temperature Sensor into the third container of water; begin recording temperature data. Add the 4 g calcium chloride to the water and mix with the glass stirring rod. Continue recording the temperature for about three minutes. Stop recording data. Rinse and wipe the Temperature Sensor.

Analyzing the Data

1 When you have finished collecting your temperature data for all three reactions, you are ready to analyze it. To do this, click the graph to make it active. You can display all three runs of data on the same graph or display individual runs of data. To select the runs you want to display, click the Data menu. Click on the run to select or deselect it.

-  Use the **Statistics** menu to display the minimum and maximum temperatures. Click the **Magnify** button (*ScienceWorkshop*) or **Zoom** button (DataStudio), and drag a rectangle around an area of the graph that is of particular interest.



Dispose of the chemicals by pouring them down the drain and running water for a few minutes afterwards.

Sand in a Bottle

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• sand
• Temperature Sensor	
• glass jar with lid	

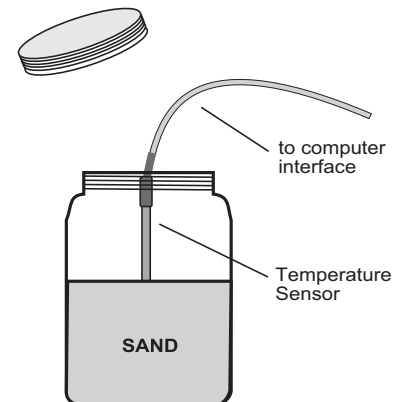
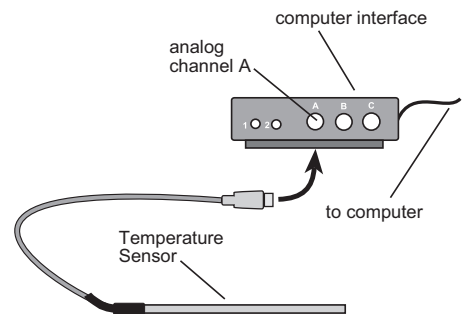
Purpose





The purpose of this activity is to use the Temperature Sensor to record the temperature of sand *before* and *after* friction has been applied to it.

Procedure

- 1 Turn on the interface box and the computer.
- 2 Plug a Temperature Sensor into analog channel A of the interface box.
- 3 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS06	MSS06 Sand in a Bottle.ds
- 4 Fill the glass jar about two-thirds full with dry beach sand.



-  5 Place the Temperature Sensor into the sand in the jar. Start recording data and watch the graph for about 10 seconds. Stop recording data.
-  6 Take the Temperature Sensor out of the sand and put the lid on the jar. Shake the jar *vigorously* for 5 or 6 minutes. You may want to take turns shaking.
-  7 Open the jar and place the Temperature Sensor down into the sand again. Start recording data and watch the graph for about 10 seconds. Continue recording for another 2 minutes, and then stop recording data.
-  8 When you have finished collecting your temperature data, you are ready to analyze it. To do this, click the graph to make it active. Re-scale the graph by clicking the **Autoscale** button (*ScienceWorkshop*) or the **Scale to Fit** button (*DataStudio*).



What was the effect of shaking on the temperature of the sand?

What type of energy transformation(s) occurred?



Be sure to follow your teacher's instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new filename.

All In a Day's Work for the Sun

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] 500 Interface	• None required
• Light Sensor	

Purpose

The purpose of this activity is to use the Light Sensor to record the intensity of the sun's light during a 24-hour cycle.

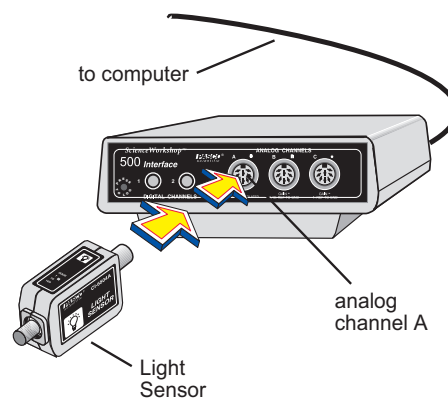
Procedure

- 1 Turn on the interface and the computer.
Plug a Light Sensor into analog channel A of the interface box.

- 2 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS07	MSS07 All in a Day's Work.ds

- 3 You are now ready to disconnect the interface box and move the Light Sensor (if necessary). To do so, on the Experiment menu, click **Disconnect for Logging** (*ScienceWorkshop*) or click the **Logging** button on the Setup toolbar (DataStudio).





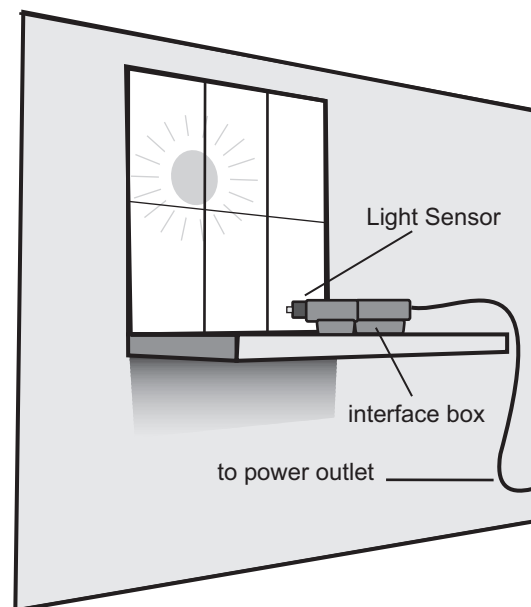
Follow your teacher's instructions about whether or not to print out the checklist.

4

Disconnect the computer cable and the power cord from the back of the interface box. **Leave the interface box turned on and the Light Sensor plugged in.** The *ScienceWorkshop 500* Interface will let you know when it is ready to begin recording data remotely. When it is ready, a green light on the front will flash once every 5 seconds. This means it is in a “Sleep Mode” to save the batteries for actual data logging.

5

If the interface box and Light Sensor are not already near a window, take them to a window. Be sure you still have access to a power outlet, because you will not be able to use batteries for this experiment. When the equipment is in position, reconnect the power supply. **Be sure to plug the AC adapter into the wall outlet before plugging it into the interface box.**



6

Begin logging data. To do so, “wake up” the interface box by pushing—and holding down for a second—the **LOG** button on the front of the box. The green light will flash 10 times and then begin to flash rapidly. It is now recording data.

7

Allow the interface to log data for a complete 24-hour period of time. At the end of the cycle, press the LOG button to end recording. Return the interface box to the computer and reconnect the computer and power cables. Be sure to plug the power supply into an electric outlet before connecting it to the interface.



On the Experiment menu, click **Connect to Interface** (*ScienceWorkshop*) or click **Connect** on the Setup toolbar (DataStudio). Your data will appear on the screen on a Time vs. Light Intensity graph. Re-scale the graph to see the entire 24-hour cycle in the window.



How long was the darkness between sunset and sunrise?

What other types of information can you infer from this graph?

Temperature Inside a Closed Car

Equipment Needed	Consumables
<ul style="list-style-type: none"> • <i>ScienceWorkshop</i>[®] 500 Interface with fresh batteries 	<ul style="list-style-type: none"> • Access to a parked car (for several hours)
<ul style="list-style-type: none"> • Temperature Sensor 	

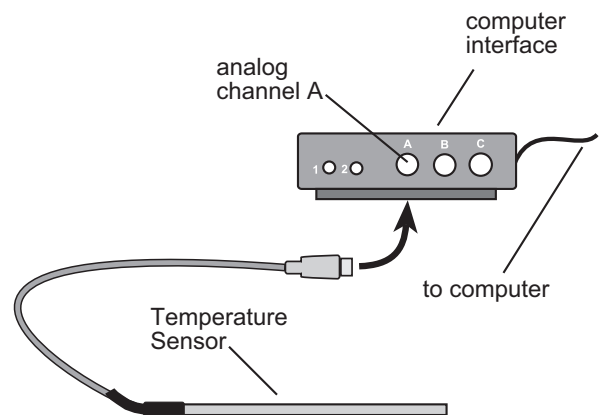
Purpose

The purpose of this activity is to use the Temperature Sensor and the *ScienceWorkshop* 500 Interface to record temperature data in the field. This data will lead us to some conclusions about the temperatures inside a closed car, compared to the temperature in the outdoor environment at the same time.

Procedure

- 1 Turn on the interface box and the computer.
- 2 Plug a Temperature Sensor into analog channel A of the interface box.
- 3 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS08	MSS08 Temp Inside a Car.ds



4 You are now ready to disconnect the interface box from the computer and move the interface box and the Temperature Sensor to the outdoors. To do so, on the Experiment menu, select **Disconnect for Logging** (*ScienceWorkshop*) or click the **Logging** button on the Setup toolbar (DataStudio).

5 Disconnect the computer cable and the power cord from the back of the *ScienceWorkshop 500* Interface. ***Leave the interface box turned on and the Temperature Sensor plugged in.***



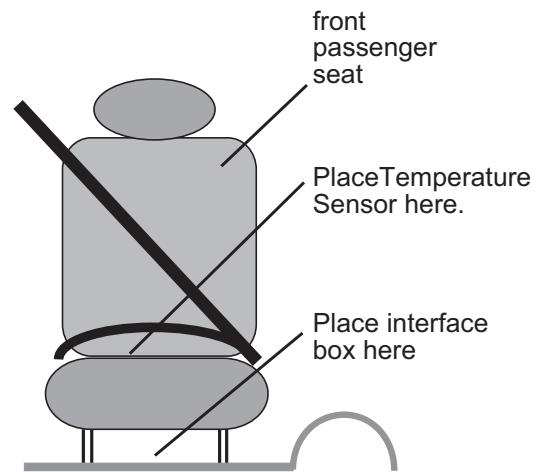
Printing the checklist is an option. Follow your teacher's instructions about whether or not to print the checklist.

6 The *ScienceWorkshop 500* Interface will let you know when it is ready to begin recording data remotely. When it is ready, a green light on the front will flash once every 5 seconds. This means it is in a “Sleep Mode”, which saves the batteries for actual data logging.

7 Carry the interface box and sensor outdoors. Before placing the equipment in the car, record some data on the current temperature conditions outside. To do this, “wake up” the interface box by pushing (and holding down for a second) the **LOG** button on the front of the box. The green light will flash 10 times, and will then begin to flash rapidly. It is now recording data.

8 Allow the interface box and sensor to record the temperature in the shade and sun, in the wind if there is any, etc. Record the outside temperature for about 5 minutes.

- 9** Place the interface box and Temperature Sensor in the car to which you have access. Make sure the windows are up. If there is direct sunlight, place the sensor in it, but place the interface box in the shade.



- 10** Close the door and leave the equipment in the car for at least an hour. Fresh batteries will last for about 3 or 4 hours.



In your science notebook, write your predictions about what will happen to the temperature in the car. You have probably heard how unsafe it is to leave pets or children in a car on a warm day. Why do you think this is so?

- 11** After an hour or so, retrieve the equipment from the car. Allow the interface box and sensor to record the temperature in the shade and sun, in the wind if there is any, etc. Record the outside temperature again, for about 5 minutes.
- 12** Press **LOG** button to end recording.
- 13** Return the 500 Interface box to the computer and reconnect the computer and power cables.
- 14** On the Experiment menu in the Experiment Setup window, click **Connect to Interface** (*ScienceWorkshop*) or click the **Connect** button on the Setup toolbar (DataStudio). (Your data will appear on the screen on the Time vs. Temperature graph.)
- 15** Re-scale the graph so the data will fill the window.

- 16** Pinpoint exact values for your temperature data. (*Hint:* Click the **Smart Cursor** button (*ScienceWorkshop*) or the **Smart Tool** button (*DataStudio*), and move the cross hairs into the graph. Notice that the coordinates of the cursor are shown.)



What was the highest temperature recorded during the remote data recording?

Does this temperature appear in the first five minutes or the last five minutes of the data?

What is the temperature ten minutes after the sensor has been put into the closed car? Fifteen minutes after?

How many minutes does it take for the temperature to raise by one degree?

How do your predictions compare to the data?



Compare your data to the predictions that you wrote down. How could you use this data you collected to convince someone not to leave a dog or cat in the car during a shopping trip?



Be sure to follow your teacher's instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new file name.

Sunglasses, Bright Light, and Your Eyes

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• None required
• Light Sensor	
• several pairs of sunglasses and goggles	
• flashlight	

Purpose

The purpose of this activity is to use the Light Sensor to record the intensity of light *before* and *after* it is shined through your sunglasses and/or goggles.

Procedure



Turn on the interface and the computer.
Plug a Light Sensor into analog channel A of the interface box.



Open the Experiment Library template file:

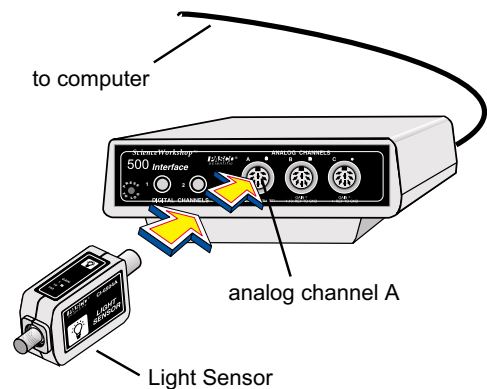
<i>ScienceWorkshop</i>	DataStudio™
MSS09	MSS09 Sunglasses Light.ds



Turn on the flashlight, or other light source, and position it so the brightest part of the light is shining directly into the Light Sensor. This is a simulation of your eyes looking directly into sunlight (perhaps on a bright day at the beach or at the mountains in the snow!).



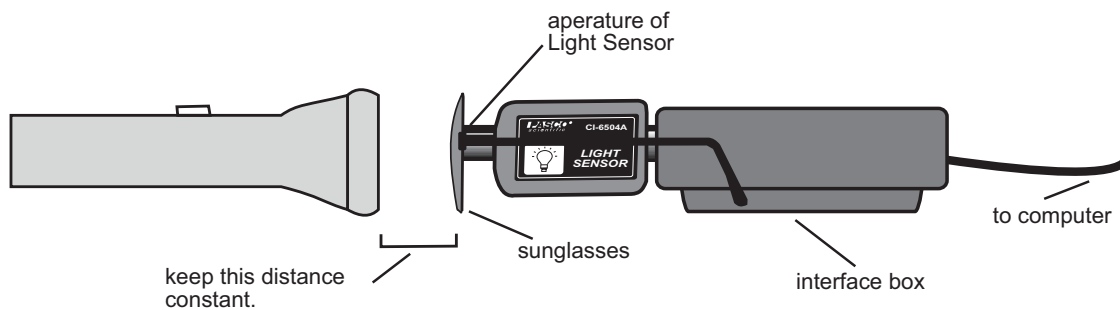
Begin recording data on the intensity of this beam of light.






In your notes, write down your predictions about what will happen to the intensity of the beam of light once it is “seen” by the Light Sensor through a pair of sunglasses. If you have several pairs available, make some predictions about which ones will be better at blocking light. Write down all of your predictions in your notes.

- 5 After you have collected about 10 seconds of data from the beam of light, begin recording data for a pair of sunglasses. To do this, place a pair of sunglasses or goggles between the beam of light and the Light Sensor, *as close as possible to the Light Sensor aperture*. Record until you have collected about 10 seconds of data from this pair of glasses.



- 6 Stop recording data.
- 7 Collect data to on as many pairs of sunglasses and goggles as you can. Keep the distance between the light source and the sunglasses the same each time.

 If the Light Sensor does not detect a difference in light intensity transmitted by different pairs of sunglasses, the light intensity may be too great for the Light Sensor. Try moving the flashlight back to 8 to 10 inches away from the Light Sensor. Remember to keep the distance you choose constant when you switch sunglasses.

- 8 When you have finished collecting you light intensity data for all of the glasses, you are ready to analyze this data. To do this, click the graph to make it active, and re-scale it.

If you have more than one recording, or “run” of data, you will need to select which run you want to analyze. To do this, click the run in the **Data** list in the Experiment Setup window. Each run of data is color-coded.



Find the lowest light intensity you recorded (this is the y-coordinate of the lowest point on your graph). Write down this intensity in your notes.

Find the highest light intensity you recorded while using sunglasses (this is the y-coordinate of the highest point on your graph). Write down this intensity in your notes.



Which glasses or goggles produced the greatest drop in light intensity?

Which of your predictions turned out as you expected? Which predictions gave unexpected results?

Polarizing Light

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• None required
• Light Sensor	
• set of 3 polarizers	
• light source	

Purpose

The purpose of this activity is to use the Light Sensor to record the effects of various combinations of light polarizers on the intensity of a beam of light.

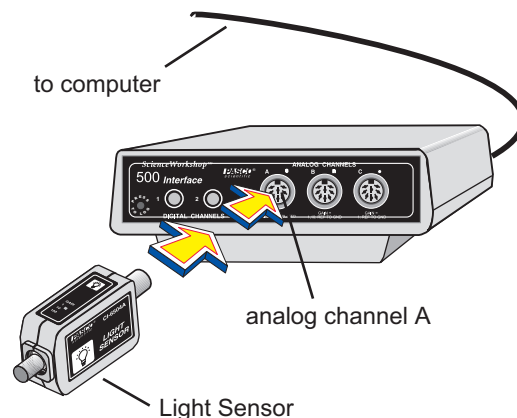
Procedure

1 Turn on the interface box and the computer. Plug a Light Sensor into analog channel A of the interface box.

2 Open the Experiment Library template file:

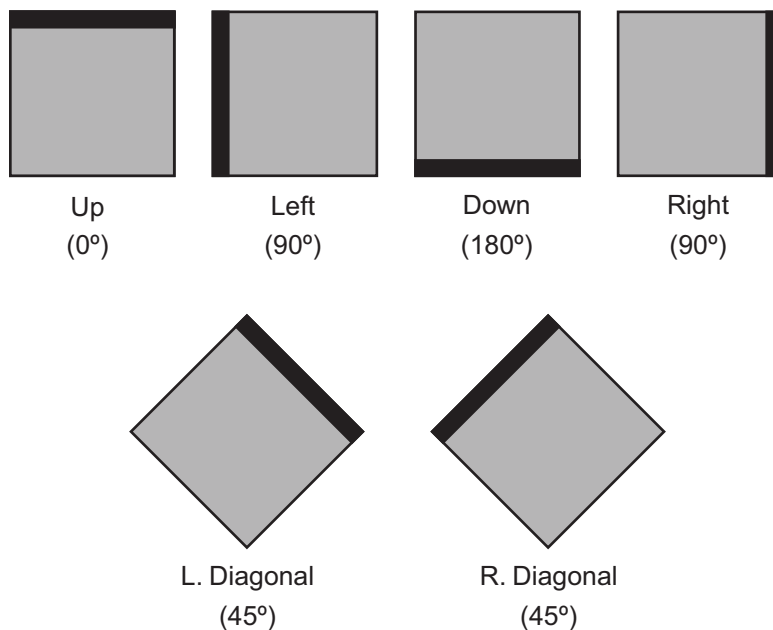
<i>ScienceWorkshop</i>	DataStudio™
MSS10	MSS10 Polarizing Light.ds

3 Turn on the flashlight, or other light source, and position it so the brightest part of the light is shining directly into the Light Sensor, about 2 cm from the sensor's opening. Begin recording data on the intensity of this beam of light.



4

Collect about 10 seconds of data from the beam of light. Continue recording, and place one piece of polarizer between the light and the opening of the Light Sensor. Rotate the polarizer so the top becomes the bottom. Use the diagram to decide how to rotate the three polarizers:



5

Place a second polarizer between the light and the opening of the Light Sensor. Rotate both pieces of polarizer. Try to get as many different combinations of positions as possible. Finally, place the third polarizer between the light and the Light Sensor. Investigate various combinations of rotations of all three polarizers. Try placing two at right angles (such as “Up” and “Left”), and placing a third between the two, diagonally at a 45° angle to them.

6

Stop recording data.

7

When you have finished collecting light intensity data for all combinations of polarizers, you are ready to analyze this data. To do this, re-scale the graph. Pinpoint exact values for your light intensity data using the **Smart Cursor** (*ScienceWorkshop*) or **Smart Tool** (*DataStudio*).



What happened to the intensity of the light when you positioned two polarizers at right angles to each other?

What happened to the intensity of the light when you placed a third polarizer in between the two at right angles, while the third one was at a 45° angle to them both?

What if the 45° polarizer was in front of the other two, or behind the other two?



Be sure to follow your teacher's instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new file name.

Friction on Ice

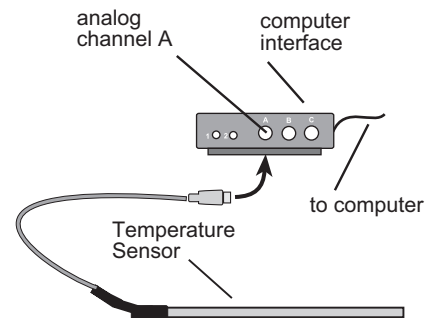
Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• one large block of ice
• Temperature Sensor	

Purpose

The purpose of this activity is to use the Temperature Sensor to record data on the effects of friction upon temperature.

Procedure

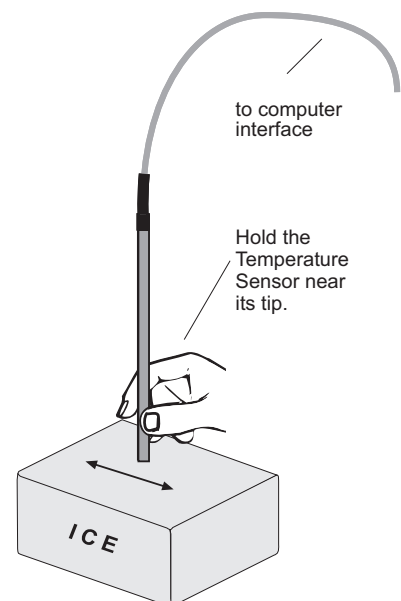
- 1 Turn on the interface box and the computer. Plug a Temperature Sensor into analog channel A of the interface box.



- 2 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS11	MSS11 Friction on Ice.ds

- 3 Place the tip of the Temperature Sensor on the block of ice and start recording data. Watch the graph of the temperature for about 20 seconds.



- 4** Move the tip of the Temperature Sensor back and forth across the surface of the ice, applying pressure as you do. This should seem like drawing with a crayon as heavily as you can. **Hold the Temperature Sensor near the tip, to avoid damaging it.**
- 5** After 20 to 30 seconds of applying friction to the ice block, place the tip of the Temperature Sensor on your computer's mouse pad and do the same friction motion. Observe what happens to the temperature. Stop recording data.
- 6** Record a new run of temperature data. This time, increase the pressure you apply with the Temperature Sensor to the block of ice to increase the friction.
- 7** For the last 30 seconds of this run of data, leave the tip of the Temperature Sensor on one spot on the ice, without moving it. Stop recording data. You are now ready to analyze your friction and temperature data.
- 8** Re-scale the graph. Pinpoint exact values for your temperature data using the **Smart Cursor** (*ScienceWorkshop*) or **Smart Tool** (*DataStudio*).



Find the lowest and highest temperatures you recorded. Write down these temperatures in your notes.

Can you tell when the tip of the sensor was NOT on the block of ice?

If you can tell when the tip of the sensor WAS on the block of ice, find the highest temperature recorded while on ice.

Were you able to bring the temperature of the ice above the melting point by applying friction?

Which type of friction had the greatest effect on the temperature?



Describe what happens to the temperature of the surface of the ice when you apply friction to it.



Be sure to follow your teacher's instructions for putting away your experiment, disposing of the ice blocks, and shutting down the computer. If you are saving your data on a disk, remember to give it a new file name.

Power Foods!

Collecting Data on the Voltage Produced by Fruit

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• medium sized apple
• Voltage Sensor	• orange (optional)
• copper wire, 10-15 mm long	
• zinc (galvanized) nail	

Purpose

The purpose of this activity is to use the Voltage Sensor to measure the voltage produced by a piece of fruit, and then compare this to the voltage of an actual D-cell battery.

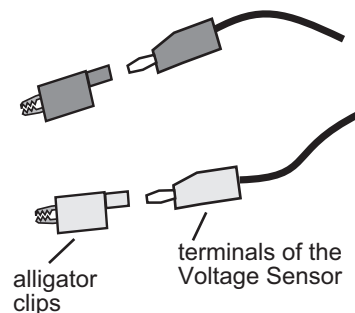
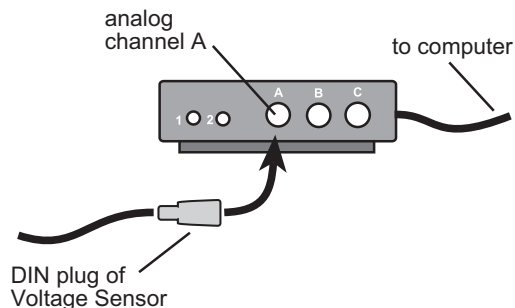
Procedure

1 Turn on the interface box and the computer. Plug a Voltage Sensor into analog channel A of the interface box.

2 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS12	MSS12 Power Foods.ds

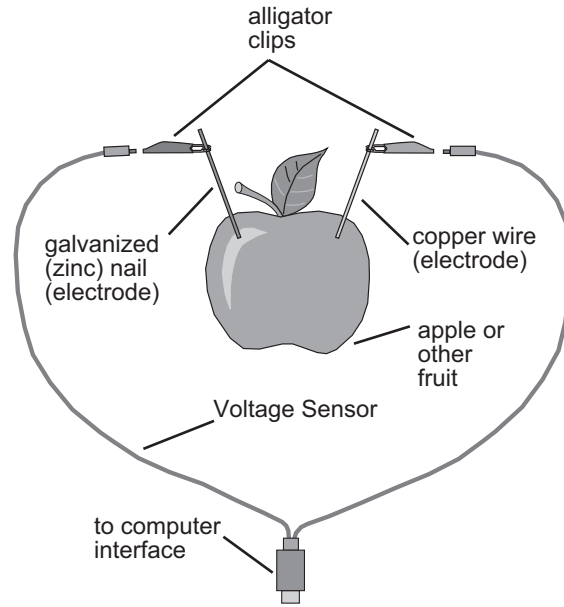
3 Make certain that the Voltage Sensor has alligator clips that can pinch hold of the copper wire and the nail.



4 Push the piece of copper wire into the apple or orange to form one of the two *electrodes*. Push the zinc nail into the fruit about 2 inches away from the copper wire.

5 When the fruit has both electrodes in place, connect the alligator clip of the *red wire of the Voltage Sensor to the copper wire*.

6 Connect the alligator clip of the *black wire of the Voltage Sensor to the zinc nail*.



A D-cell battery has about 1.5 volts. Write down in your notebook your predictions about each piece of fruit you will test. Do you think a piece of fruit can produce as much voltage as a real battery? Do you think a particular type of fruit, such as citrus, will produce more voltage than another type?

7 Start recording data on the fruit's voltage. Record for about 10 seconds, and then stop recording data .

8 Click the **Statistics** (Σ) button in the Table display to analyze the data you have recorded.



The Statistics area shows the minimum (Min) and maximum (Max) values for the voltage. Write in your notebook the type of fruit, and the maximum voltage it produced.

9 Try different ways of changing the voltage, such as pushing the electrodes in to different depths, putting the electrodes closer together or farther apart, or using different types or sizes of fruit. In your notes, keep a list of the things you try. For each, write down your predictions about what will happen to the voltage.

10 Record data for each thing you try. If you record several trials, or “runs” of data, you may use the **Data** menu button in the Table display to select the run of data you want to see.



What types of things caused the voltage to go up?

What types of things resulted in a lower voltage?

Which of your predictions turned out as you expected? Which predictions gave unexpected results?

How does a piece of fruit compare to a D-cell battery? Which electric devices are powered with D-cell batteries?



Be sure to follow your teacher’s instructions for disposing of the fruit, putting away your equipment, and shutting down the computer. If you are saving your data on a disk, remember to give it a new file name.

Springy Oscillations

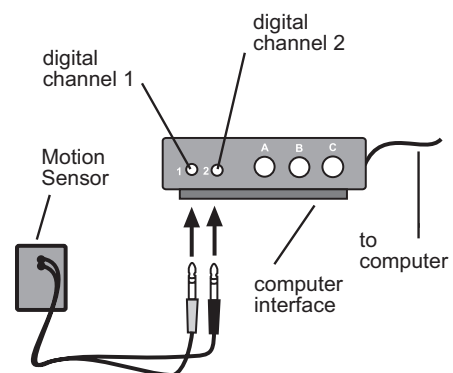
Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• empty soda can, with pull-tab intact
• Motion Sensor	• water
• one-third of a Slinky Jr.	
• support for Slinky Jr.	

Purpose

The purpose of this activity is to use the Motion Sensor to record and investigate the oscillations of a mass on the end of a spring.

Procedure

- 1 Turn on the interface box and the computer. Insert the yellow plug of the Motion Sensor into digital channel 1 of the interface box and the black plug into digital channel 2.



- 2 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS13	MSS13 Springy Oscillations.ds

- 3 Set up your work area to accomplish the following:
 - The Slinky Jr. hangs from a support (doorway, ceiling, ladder, ring stand, etc.) so that the bottom of the Slinky Jr. is approximately 1.5 meters above the floor.
 - The Coke can is attached by the pull-tab to the bottom of the Slinky Jr.

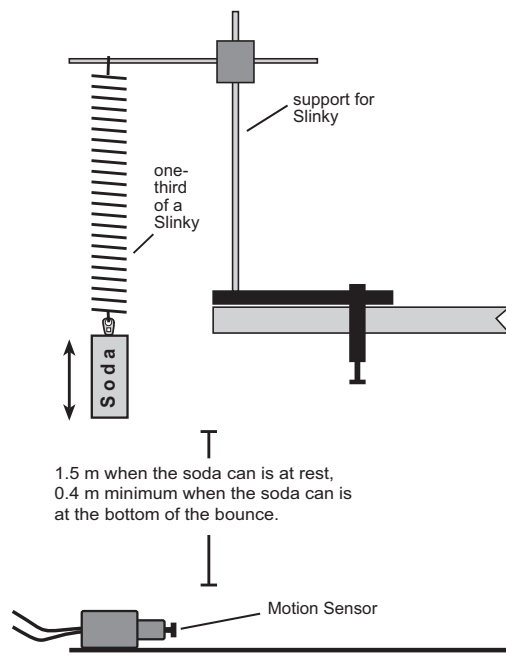
- The Motion Sensor is on the floor directly below the Coke can, so it is able to detect the can's motion.

4 Fill the Coke can with water so it is about half full.

5 Practice pulling the can down so that when it bounces, it does so without swaying from side to side.

6 When you are ready to record the motion of the Slinky's oscillations, start recording data and watch the graph for about 10 seconds.

7 Pull the Coke can to make it bounce, being careful to keep your hands OUT of the picture.



If the Motion Sensor has difficulty detecting your soda can, try these tips:

- Make the can a more visible "target" by adding a cardboard circle (a little larger diameter than the can) to the bottom.
- Make sure that your can comes no closer than 40 cm to the Motion Sensor.

8 After about 30 seconds, stop recording data.

9 Try different ways of changing the oscillations, such as changing the mass by changing the amount of water, or pulling on the can more lightly.



In your notes, keep a list of the things you try. For each, write down your predictions about what will happen to the motion *before* you do the experiment.

10

When you have finished collecting your temperature data, you are ready to analyze it. Re-scale your graph and point exact values for your oscillation motion data using the **Smart Cursor** or **Smart Tool**.



If you have recorded more than 3 different runs of data, you can clear your graph. To do this, click on the **Data** button and select **No Data**. You can also select which runs of data you want to display.

11

Find the oscillation with the biggest amplitude (bounce) you recorded (this is the difference between the y-coordinates of the lowest and highest points on your graph).

12

Find the fastest set of oscillations (bounces) you recorded.



What was the greatest number of oscillations you produced within a 20-second time period?

What was the longest-lasting oscillation? The shortest? What happens to the amplitude (bounce) from the first to the second oscillations? What happens to the amplitude after 4 oscillations?

What can you say about the amplitude (size) of the bounce, compared to the time it takes to complete the bounce?

Which of your predictions turned out as you expected? Which predictions did not match the results?



Be sure to follow your teacher's instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new file name.

Why Mittens Were Invented

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• None required
• Temperature Sensor	

Purpose

The purpose of this activity is to use the Temperature Sensor to record data on the temperature differences of the different parts of your hand.

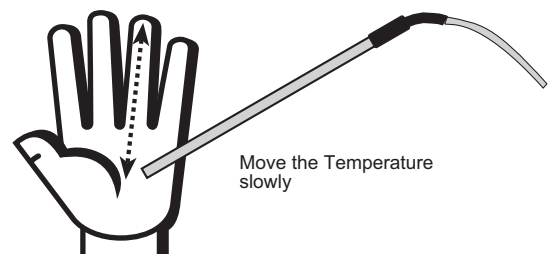
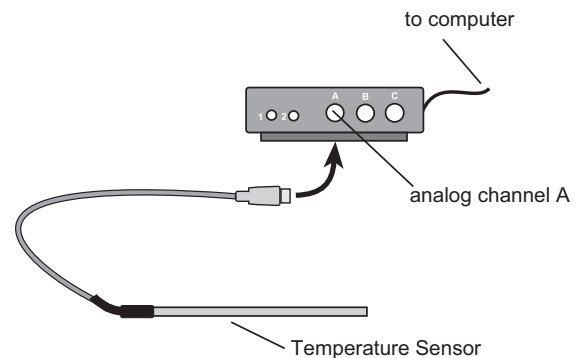
Procedure




1 Turn on the interface box and the computer. Plug a Temperature Sensor into analog channel A of the interface box.

2 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS14	MSS14 Mittens.ds

3 Place the tip of the Temperature Sensor on the middle of the palm of your hand. Start recording data. Watch the graph of the temperature for about 10 seconds.



-  4 Move the Temperature Sensor SLOWLY out from the palm of your hand to your fingertip. Leave the sensor on your fingertip for about 5 seconds, then move the sensor SLOWLY back up to the palm of your hand.
-  5 Stop recording data. Record a new run of temperature data from the palm of your hand out to a different fingertip and back to your palm. If you are able, record a run of data for each of the five fingers on one of your hands.
-  6 You are now ready to analyze your hand and finger temperature data. Re-scale the graph, and pinpoint exact values for your temperature data using the **Smart Cursor** or **Smart Tool**. Use the **Magnifier** or **Zoom Select** tool and **Statistics** menu to examine areas of your graph that seem interesting.



What happens to the temperature of your skin as you move away from the palm of your hand?

What is the difference between normal body temperature and your average fingertip temperature?

What might be a reason for the difference in temperatures?

Do you think gloves would be more efficient than mittens at keeping fingers warm in cold weather?



Be sure to follow your teacher's instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new file name.

Heart Beat

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] 500 Interface	• None required
• Heart Rate Sensor	

Purpose

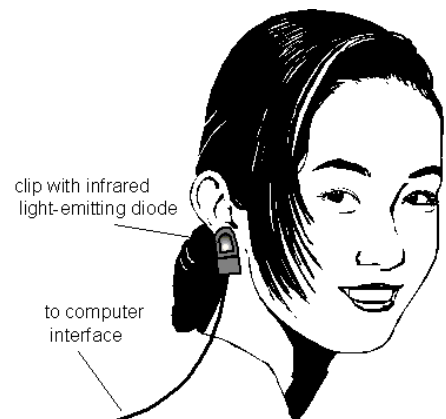
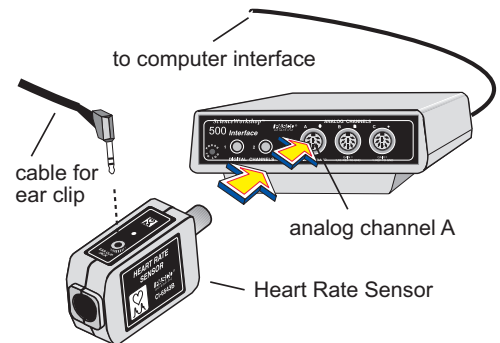
The purpose of this activity is to use the Heart Rate Sensor to record your heart rate—as beats per minute—during rest and after physical activity.

Procedure

- 1 Turn on the interface box and the computer.
- 2 Plug a Heart Rate Sensor into analog channel A of the interface box.
- 3 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS15	MSS15 Heart Beat.ds

- 4 Attach the Heart Rate Sensor clip to your ear lobe. Check to see if it is properly positioned. To do this, start recording data, and observe the Graph display for about 20 seconds. Then stop recording.





If a smooth curve or line appears, the clip is placed properly. If a “jumpy” pattern appears, move the clip on your earlobe until you see the smooth line on the graph. You may also try putting the clip on your finger tip..

5

Begin recording data on your heart rate. Sit very still, relaxed, and quiet while you record for 60 seconds. Stop recording data after 60 seconds.

6

Remove the sensor clip from your earlobe. Prepare to do some physical activity.



In your notes, write down your predictions about how the physical activity will affect your heart rate.

7

Go run a lap or jump rope, or whatever your teacher directs you to do.

8

After you have completed your running, re-attach the sensor clip to your ear lobe. You may monitor your heart rate again to check the position of the clip, as in *Step 4*, if you want. Record your heart rate data for another 60 seconds.

9

You are now ready to analyze your heart rate data. Re-scale the graph. Pinpoint the maximum and minimum heart beat rates using the **Smart Cursor** or **Smart Tool**. Use the **Statistics** feature to display the mean heart rate for the whole time that you record data. (*Hint: Click the **Statistics** button and the **Statistics** menu button. Click **Mean** to display the *average* heart rate.*)



What is your resting heart beat rate?

What happened to your heart beat rate after you exercised your heart?

Did your heart beat begin to return to its original rate within the 60 seconds you were recording?

How do your predictions compare to the data?

Lungs at Rest, Work, and Play

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> ® 500 Interface	• None required
• Respiration Sensor	

Purpose

The purpose of this activity is to use the Respiration Sensor to record the rate of your breathing, as respirations per minute, during rest and physical activity.

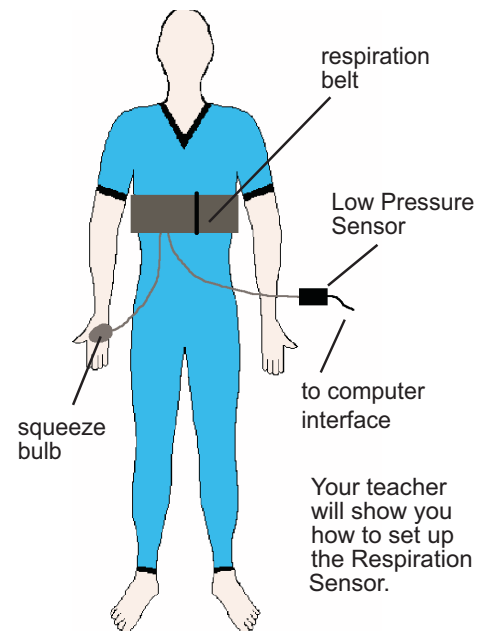
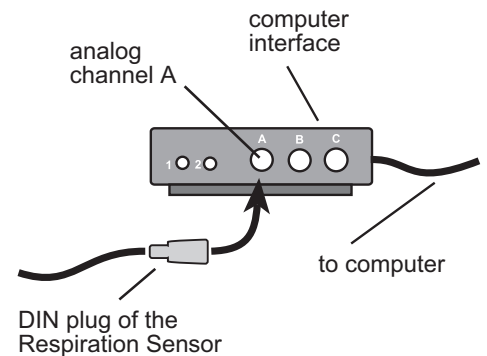
Procedure

1 Turn on the interface and the computer. Plug a Respiration Sensor into analog channel A of the interface box.

2 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS16	MSS16 Lungs.ds

3 Attach the respiration sensor belt around your rib cage. Make sure the rubber bladder is in front. Use the squeeze bulb to inflate the rubber bladder (between twenty and thirty squeezes). The belt should be tight but not uncomfortable. Check to see if it is properly positioned. To do this, begin recording data, and watch the graph for about 20 seconds. If a smooth curve or line appears, the belt is on properly. If a “jump” pattern appears, adjust the belt until you see the smooth line on the graph.



4 Begin recording data on your respiration rate. Sit very still, breathing normally, while you record for 60 seconds. Stop recording after 60 seconds.

5 Remove the sensor belt from your rib cage. Prepare to do some physical activity.



In your notes, write down your predictions about how the physical activity will affect your own respiration rate. Do as much strenuous activity as possible to increase your respiration rate. If you are an athlete, do some warm-up exercises from your favorite sport.

6 After you have completed your strenuous activity, reattach the sensor belt to your rib cage. You may check your respiration rate again to be sure of the position of the belt, as in Step 5, if you want to. Record your respiration data for another 60 seconds.

7 You are now ready to analyze your respiration rate data. Re-scale the graph. Pinpoint the maximum and minimum respiration rates. (*Hint:* Use the **Smart Cursor** or **Smart Tool**). From the Statistics Menu choose **Mean**, which will display the average respiration rate for the whole time. (*Hint:* Click the Statistics menu button to open the Statistics Menu.) Use the **Data** menu button to show or hide the runs of data you want on each graph.



What is your resting respiration rate?

What happened to that rate after you exercised strenuously?

Did your respiration rate begin to return to its original value within the 60 seconds you were recording?

How do your predictions compare to the data?

How might the resting and working respiration rates be different for an athlete and a person who does not exercise regularly?

How Loud Is That Bubble?

Equipment Needed	Consumables
<ul style="list-style-type: none"> • <i>ScienceWorkshop</i>[®] Interface 	<ul style="list-style-type: none"> • bubble gum (several kinds)
<ul style="list-style-type: none"> • Sound Sensor 	

Purpose

The purpose of this activity is to use the Sound Sensor to record the sound intensity of one bubble gum bubble compared to another.

Procedure

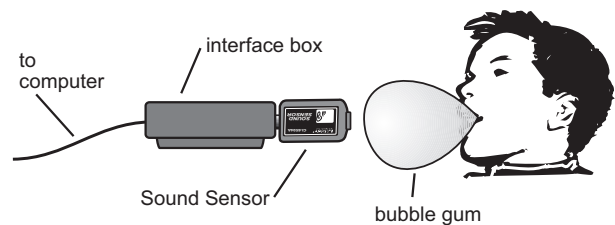
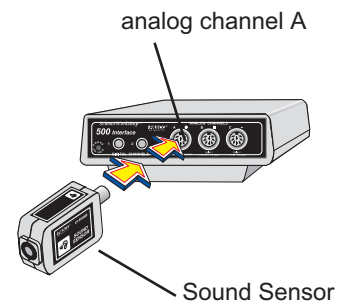
1 Turn on the interface box and the computer. Plug a Sound Sensor into analog channel A of the interface box.

2 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS17	MSS17 Bubble.ds

3 Chew a piece of gum to get it perfectly prepared to blow and pop LOUD bubbles.

4 When you are ready to record the popping of a bubble, **point the Sound Sensor directly at the bubble** while a partner uses the mouse. Signal for your “mouse driver” to begin recording data.



- 5** Stop recording once you have popped your bubble. Record several bubble pops.



For each bubble pop, keep the distance between the bubble and the Sound Sensor as constant as possible, and keep the Sound Sensor pointed directly at the bubble.



Write down in your notebook your predictions about which pops seem the loudest.

- 6** When you have collected enough data, you are ready to analyze it. Your data about the **sound intensity** is recorded as numbers in a table. The numbers can be compared to each other by their place value. For example, a number of 30.43 represents a greater intensity than does a number of 30.29.



Does the bubble with the highest number agree with the bubble that seemed loudest to you?

How do your predictions about each bubble compare to the data you recorded?

Which bubble pop was the most surprising?

Does the pitch (how low or high) of the sound seem to have any effect on the intensity?



Be sure to follow your teacher's instructions for disposing of the gum, putting away your equipment, and shutting down the computer. If you are saving your data on a disk, remember to give it a new file name.

Refrigerator Spies!

Equipment Needed	Consumables
<ul style="list-style-type: none"> • <i>ScienceWorkshop</i>[®] 500 Interface 	<ul style="list-style-type: none"> • None required
<ul style="list-style-type: none"> • Light Sensor 	

Purpose

The purpose of this activity is to use the Light Sensor to record the number of times the light goes on in the refrigerator.

Procedure

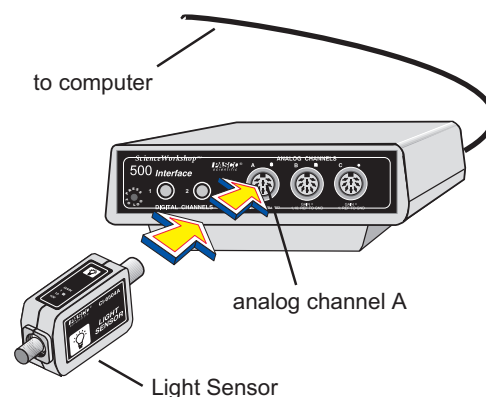
1 Before setting up the remote data logging equipment, design and create a realistic disguise for the equipment. You should be able to place the disguised equipment in your school's refrigerator in such a way that no one realizes it is in there.

2 Turn on the interface box and the computer. Plug a Light Sensor into analog channel A of the interface box.

3 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS18	MSS18 Refrigerator Spies.ds

4 You are now ready to disconnect the interface box and very stealthily move it and the Light Sensor to the refrigerator. To do so, select **Disconnect for Data Logging** on the Experiment menu (*ScienceWorkshop*) or click the **Logging** button on the Setup toolbar (DataStudio).





Printing the checklist is an option. Follow your teacher's instructions about whether or not to print the checklist.

- 5** Disconnect the computer cable and the power cord from the back of the interface box. **Leave the interface box turned on and the Light Sensor plugged in.** Place the equipment in its disguise, but make certain that the opening of the Light Sensor is not covered. Make a small hole for it to “see” through, if necessary.
- 6** The *ScienceWorkshop 500* Interface will let you know when it is ready to begin recording data remotely. When it is ready, a green light on the front will flash once every 5 seconds. This means it is in a “Sleep Mode” to save the batteries for actual data logging.
- 7** Carry the disguised interface box and sensor to the refrigerator. Place it in a good spot, then begin logging data. To do so, “wake up” the interface box by pushing—and holding down for a second—the **LOG** button on the front of the box. The green light will flash 10 times and then begin to flash rapidly. It is now recording data.
- 8** When you have spied for as long as possible, retrieve the disguised equipment. Press the **LOG** button to end recording. Return the interface box to the computer and reconnect the computer and power cables.
- 9** Select **Connect to Interface** on the Experiment menu (*ScienceWorkshop*), or click the **Connect** button on the Setup toolbar (DataStudio). Your data will appear on the screen on a Time vs. Light Intensity graph. Re-scale the graph so the data fills the window.



Find the points in time when the Light Sensor detected light. What does the presence of light tell you about the door of the refrigerator?

Do you notice any period of time when the activity in the refrigerator increased?

Do you think it would be possible to tell when it is lunch time?



Be sure to follow your teacher's instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new filename.

Feynman's* Magical Sugar Cube

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> ® 500 Interface	• sugar cubes (several)
• Light Sensor	
• pair of pliers	
• lightproof room (closet, etc.)	

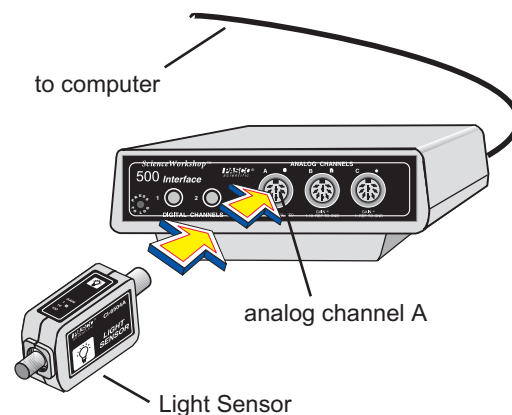
Purpose

The purpose of this activity is to use the Light Sensor to detect and record the faint burst of light (known as *triboluminescence*), which is emitted by the crystals in a sugar cube when friction is applied to them.

Procedure

- 1 Turn on the interface box and the computer. Plug a Light Sensor into analog channel A of the interface box.
- 2 Turn on the interface box and the computer. Plug a Light Sensor into analog channel A of the interface box.
- 3 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS19	MSS19 Sugar Cube.ds



* See page MSS19 - 4 for a note about Richard Feynman.

4 You are now ready to disconnect the interface box and move the Light Sensor to the lightproof area. To do so, select **Disconnect for Data Logging** on the Experiment menu (*ScienceWorkshop*) or click the **Logging** button on the Setup toolbar (DataStudio). (Printing the checklist is an option. Follow your teacher’s instructions about whether or not to print the checklist.)

5 Disconnect the computer cable and the power cord from the back of the interface box. ***Leave the interface box turned on and the Light Sensor plugged in.***

6 The *ScienceWorkshop 500* Interface will let you know when it is ready to begin recording data remotely. When it is ready, a green light on the front will flash once every 5 seconds. This means it is in a “Sleep Mode” to save the batteries for actual data logging.

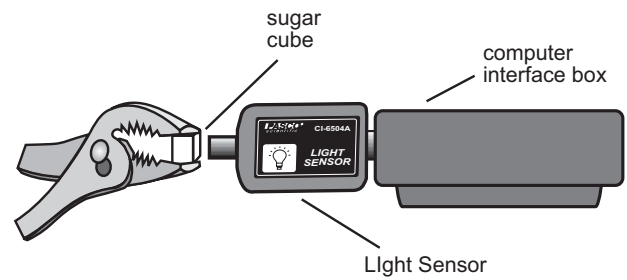
7 Carry the interface box and sensor to the light proof area. Before turning out the light, set up the area so that you can crush a sugar cube with the pair of pliers, directly in front of the Light Sensor.



Make some predictions about the best way to crush sugar cubes to produce friction. Write your predictions in your notebook.

8 Begin logging data. To do so, “wake up” the interface box by pushing—and holding down for a second—the **LOG** button on the front of the box. (The green light will flash 10 times and then begin to flash rapidly. It is now recording data.)

- 9** Turn out the light so there is complete darkness. Hold the Light Sensor near the pliers and sugar cube. Crush the sugar cube, watching for it to emit a tiny burst of light. If possible, repeat the crush with several sugar cubes.



- 10** Press the **LOG** button to end recording. Return the 500 Interface box to the computer and reconnect the computer and power cables.

- 11** On the Experiment menu of the Experiment Setup window, click **Connect to Interface** (*ScienceWorkshop*), or click the **Connect** button (*DataStudio*).

- 12** Your data will appear on the screen on a Light Intensity vs. Time graph. Re-scale the graph so the data fills the window.



Can you determine when the light was turned out?

- 13** Pinpoint exact values for your triboluminescence light data with the **Smart Cursor** (*ScienceWorkshop*) or **Smart Tool** (*DataStudio*).



Find the lowest light intensity you recorded (this is the y-coordinate of the lowest point on your graph). Write down this intensity in your notes.

Find the points in time when the Light Sensor detected light. What is the intensity of this light?



What was the highest intensity of light you were able to produce with triboluminescence?

What was the best method for applying the friction to the sugar cube?

Did slowly crushing it produce more light than crushing it as fast as possible?

Which of your predictions turned out as you expected? Which predictions did not match the results?



Be sure to follow your teacher's instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new filename.



Richard Feynman was a physicist famous not least of all for his sense of humor. He is popularly remembered for demonstrating how the O-ring failed to hold its shape when frozen, thereby explaining the mystery of the Challenger Shuttle disaster. Feynman was amazed at the ability of his Brazilian graduate students in physics to memorize information without really learning it. He didn't care that they could recite the definition of "triboluminescence" if they had never been in a dark closet with a sugar cube and a pair of pliers.

For a humorous account of Feynman's life, try *Surely You're Joking, Mr. Feynman!* by Richard Feynman.

Boiling Points

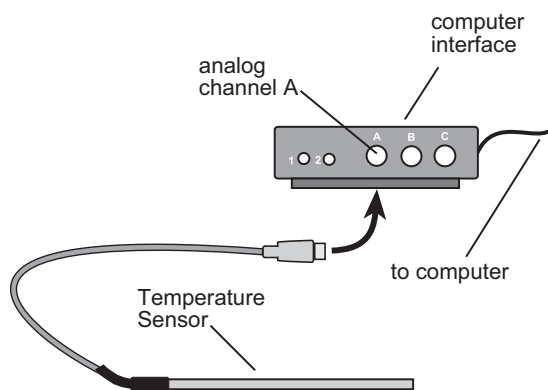
Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• isopropyl (rubbing) alcohol
• Temperature Sensor	• water
• glass container	• paper towels

Purpose

The purpose of this activity is to use the Temperature Sensor to record the boiling points of two different liquids.

Procedure

- 1 Turn on the interface box and the computer. Plug a Temperature Sensor into analog channel A of the interface box.



- 2 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS20	MSS20 Boiling Points.ds

- 3 Fill one of the test tubes half-full with water. Fill the other half-full with isopropyl alcohol.

4 Place the Temperature Sensor into the test tube of water, and position it so that the sensor's tip does not touch the test tube. Attach the tongs to the test tube to hold it safely during heating. ***Put on your safety goggles.*** Turn on your heat source. ***Be certain that long hair is tied back, and long sleeves are pulled up.***

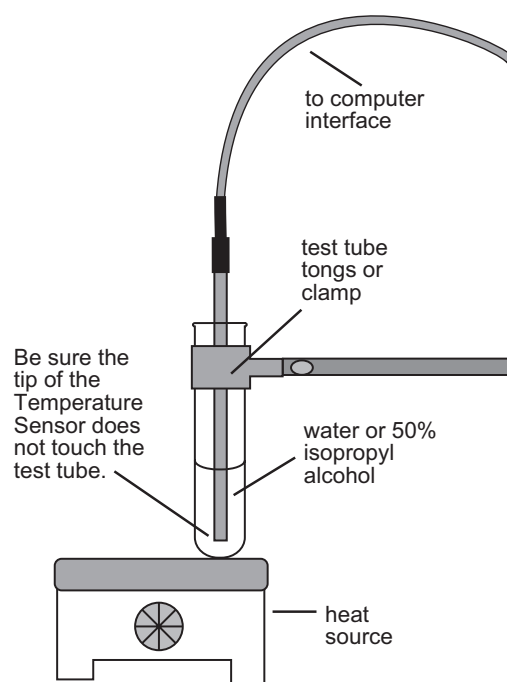
5 Hold the test tube of water, with the Temperature Sensor in it, over the heat source. Start recording data. You will heat the water until it boils.

6 When the water boils, first remove the test tube from the heat source and then stop recording temperature data. Stop recording data.

7 Place the Temperature Sensor in the test tube of alcohol. Attach the tongs to the test tube. Hold the tube of alcohol over the heat source. Begin recording data again. You will also heat the alcohol until it boils. When the alcohol boils, first remove the test tube from the heat source and then stop recording temperature data.

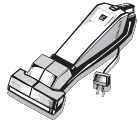
8 Turn off the heat source.

9 When you have finished collecting your temperature data, you are ready to analyze it. To do this, click the graph to make it active. Click the **Data** button to select both runs of your data. Re-scale the graph. Pinpoint exact values for your temperature data with the **Smart Cursor** or **Smart Tool**.





How does the rise in temperature for water compare to the rise in temperature of alcohol? At what temperature does each of these liquids boil?



Be sure to follow your teacher's instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new filename.

Cooling with Evaporation

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> ® 500 Interface	• isopropyl (rubbing) alcohol
• Temperature Sensor	• water
• glass container	• paper towels

Purpose

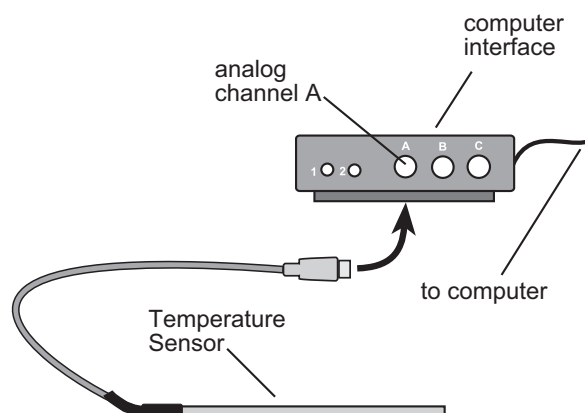
The purpose of this activity is to use the Temperature Sensor to record the temperature of two liquids before and during evaporation.

Procedure

- 1 Turn on the interface box and the computer. Plug a Temperature Sensor into analog channel A of the interface box.
- 2 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS21	MSS21 Cooling.ds

- 3 Fill one of the glass containers half-full with water.
Fill the other half-full with isopropyl alcohol.



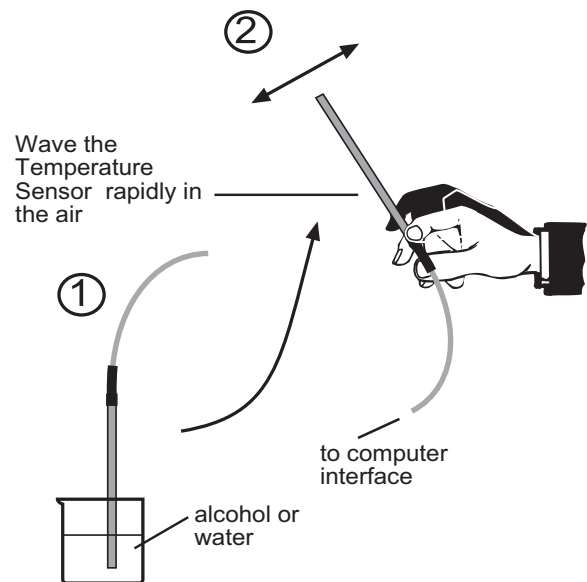
4 Place the Temperature Sensor into the container of water. Begin recording data. Watch the graph for about 10 seconds. Move the temperature Sensor to the other container and watch the graph for about 10 seconds or so. Stop recording data. Dry the tip of the Temperature Sensor by wiping it with a paper towel.

5 Begin recording data again. Place the Temperature Sensor in the container of water, then remove it and wave it in the air, vigorously, for 30 seconds. Stop recording data.

6 Begin recording data again. Place the Temperature Sensor in the container of alcohol, then remove it, and wave it in the air, vigorously, for 30 seconds. Stop recording data.

7 When you have finished collecting your temperature data, you are ready to analyze it. To do this, click the Graph display to make it active. Select Run #1 and Run #2 from the Data menu. (*Hint:* Click the **Data** button.)

8 Re-scale the graph. Pinpoint exact values for your temperature data with the **Smart Cursor** or **Smart Tool**.



What difference, if any, did you notice between the change in temperature using the water and the change in temperature using the alcohol?

How Our Ancestors Kept Their Milk Cold

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• paper towels
• Temperature Sensor	• water
• clay flower pot with a drain hole	• container of lunch milk (optional)
• plate or pie pan glass container	

Purpose

The purpose of this activity is to use the Temperature Sensor to record the temperature of air, which is cooled by evaporation, and to compare it to the temperature of the surrounding air.

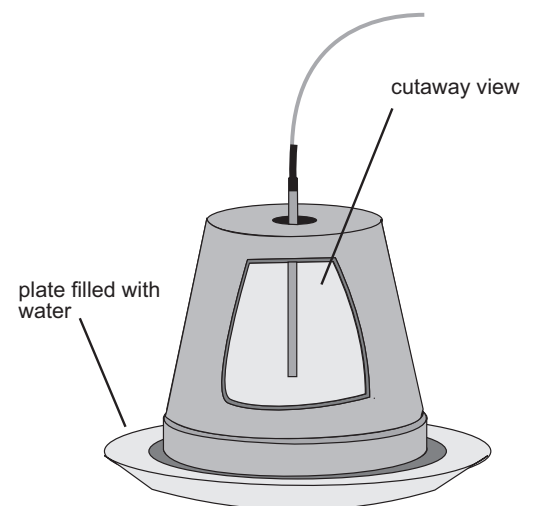
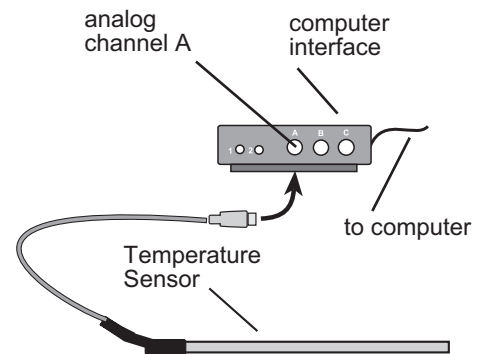
Procedure




1 Turn on the interface box and the computer. Plug a Temperature Sensor into analog channel A of the interface box.

2 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS22	MSS22 Cold Milk.ds

3 Wet the flower pot thoroughly with water, inside and out. Place the flower pot upside down in a plate of water. If you are using a carton of milk, put it on the plate inside the flower pot.



-  Place the Temperature Sensor so it can detect the normal air temperature. Start recording data. Watch the graph for about 30 seconds. Place the Temperature Sensor inside the drain hole of the flower pot. Allow the computer to record temperature data for **at least** 30 minutes. If you are able to record for a longer time, do so.
-  After recording the temperature inside the flower pot, again move the sensor so it can detect the temperature of the surrounding, outside air. Record this temperature until the graph shows that the Temperature Sensor has reached a new and stable reading, then stop recording data.
-  When you have finished collecting your temperature data, you are ready to analyze it. Re-scale the graph. Pinpoint exact values for your temperature data using the **Smart Cursor** (*ScienceWorkshop*) or **Smart Tool** (*DataStudio*).



What was the difference between the highest and lowest temperatures? What is causing the change in temperature inside the flower pot?

How could you design a data collection experiment that would REALLY put this type of primitive refrigeration to the test?



Be sure to follow your teacher's instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new filename.

How Well Insulated is Your Room (House)?

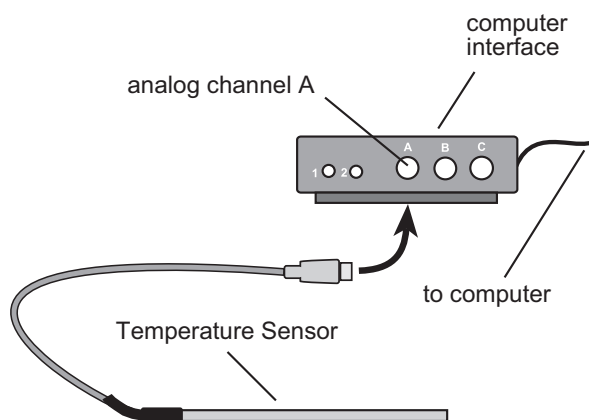
Equipment Needed	Consumables
<ul style="list-style-type: none"> • <i>ScienceWorkshop</i>[®] 500 Interface with fresh batteries and power adapter 	<ul style="list-style-type: none"> • None required
<ul style="list-style-type: none"> • Temperature Sensor 	

Purpose

The purpose of this activity is to use the Temperature Sensor to record the temperature inside a room or house.

Procedure

- 1 Turn on the interface box and the computer. Plug a Temperature Sensor into analog channel A of the interface box.
- 2 Open the Experiment Library template file:



<i>ScienceWorkshop</i>	DataStudio™
MSS23	MSS23 How Well Insulated.ds



ScienceWorkshop has been preset to record data once every 10 seconds, so data can be collected over a long period of time.

- 3 When you are ready to take the interface box and sensor home to begin logging remote data, select **Disconnect for Logging** (*ScienceWorkshop*) or click the **Logging** button on the Setup Toolbar (DataStudio).



Printing the checklist is an option. Follow your teacher's instructions about whether or not to print the checklist.

- 4** Disconnect the computer cable and the power cord from the back of the *ScienceWorkshop 500* Interface. ***Leave the interface box turned on and the Temperature Sensor plugged in.*** Be certain to take the AC power adaptor home with you also, since batteries only last for about 3 ½ hours.
- 5** Once at home, position the interface and sensor near a wall that faces the outside. Do not place the sensor near a heat or air conditioning vent. Do place the equipment where you can plug in the power adaptor. Keep the doors and windows the way they normally are in your house at this time of year. ***Be sure you plug the AC power adaptor into the wall outlet first before connecting it to the interface box.***
- 6** To begin recording the temperature, “wake up” the *Science Workshop 500* Interface by pushing — and holding down for a second — the **LOG** button on the front of the box. The green light will flash 10 times, and will then begin to flash rapidly. It is now recording.
- 7** Record the temperature from the moment you arrive home until you are ready to leave for school the next morning.
- 8** Press **LOG** button to end recording just before you leave for school.
- 9** When you arrive at school, plug the AC power adaptor into an electrical outlet, return the *500 Interface* box to the computer, and reconnect the computer and power cables. ***Be sure you plug the AC power adaptor into the wall outlet first before connecting it to the interface box.*** Start the *Science Workshop* program, and select **Connect to Interface** on the Experiment menu (*ScienceWorkshop*) or click the **Connect** button on the Setup toolbar (DataStudio).



Your data will appear on the screen on a Time vs. Temperature graph. If you are not able to analyze the data at this time, save it (according to your teacher's instructions) for later analysis.



When you are ready to analyze your home temperature data, re- scale the data. Use the **Smart Cursor** or **Smart Tool** and **Magnifier** tools to examine areas of interest. Activate the Statistics menu to see the Mean (or “average”) temperature for the entire time.



By how many degrees did the temperature vary in your room (or house) from the highest to the lowest temperature?

What was the average temperature for the whole time?

If heat or air conditioning was on, can you tell from your graph when it turned on and off?

By how many degrees can temperature vary and still remain comfortable to the people who live in the house?



Follow your teacher's instructions for finishing up this activity and putting away the equipment.

Electrolytes

Equipment Needed	Consumables
• <i>Science Workshop</i> ® 500 Interface	• table salt
• Voltage Sensor	• distilled water
• zinc (galvanized) nail	
• piece of copper wire (5 cm)	
• 2 beakers or glass jars (250 ml)	
• stirring rod	

Purpose

The purpose of this activity is to use the Voltage Sensor to measure the voltage of an electrolyte solution.

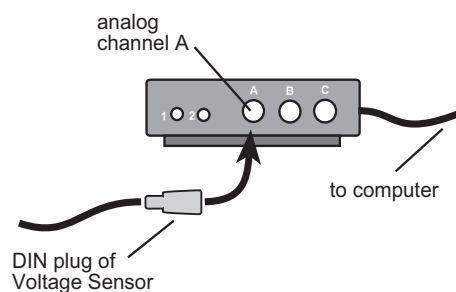
Procedure

1 Turn on the interface box and the computer. Plug a Voltage Sensor into analog channel A of the interface box.

2 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS24	MSS24 Electrolytes.ds

3 Fill two clean beakers or glass jars each with 200 ml of distilled water. In one of the beakers of water, dissolve about a tablespoon of salt.



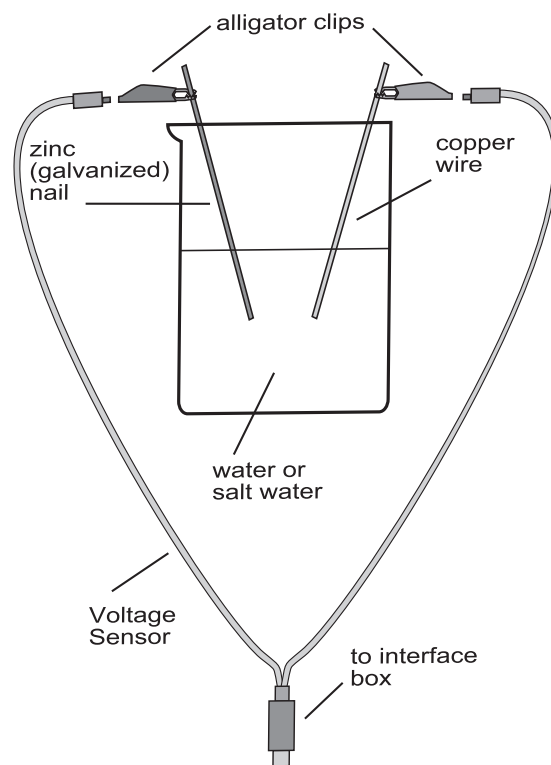
4 Connect the red alligator clip of the Voltage Sensor to the copper wire. Connect the black alligator clip of the Voltage Sensor to the zinc galvanized nail.

5 Position the nail and the copper wire in the plain distilled water, making certain that the two pieces of metal do not touch each other.

6 Begin recording data. After about 20 seconds of recording, stop recording data.

7 Move the pieces of metal to the beaker containing the electrolyte (dissolved salt) solution. Position the pieces of metal so that they are not touching. Begin recording data for the electrolyte solution. Record for about one minute.

8 When you have completed recording your data for the two beakers of liquid, you are ready to analyze the data. Re-scale your graph. Use the **Smart Cursor** or **Smart Tool** and **Magnifier** tools to investigate areas of the graph that seem interesting. You may select which runs of data to show or hide by clicking on the **DATA** menu button.



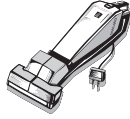
Can you describe the chemical and physical properties of the distilled water?

How are the properties of the saltwater solution different from the properties of distilled water?

What happens when you put one piece of metal in one of the fluids, and the

other piece in the other fluid?

What amount of voltage were you able to produce with your electrolyte solution?



Follow your teacher's instructions for finishing up this activity and putting away the equipment.

The Beam Team

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> ® 500 Interface	• None required
• Light Sensor	
• MagLight® flashlight or laser pointer	
• mirrors (two or more)	

Purpose

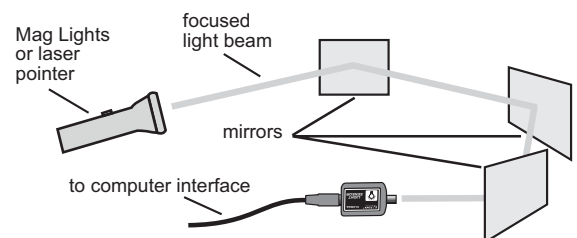
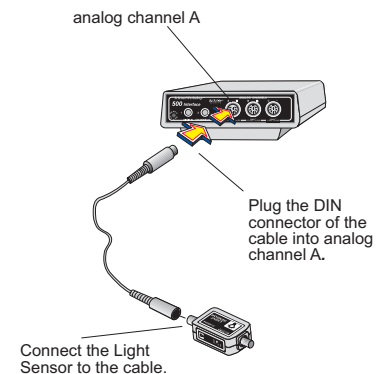
The purpose of this activity is to use the Light Sensor to record the intensity of a beam of reflected light.

Procedure




- 1 Turn on the interface box and the computer. Plug a Voltage Sensor into analog channel A of the interface box.
- 2 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS25	MSS25 The Beam Team.ds

- 3 Arrange several students, holding mirrors, around the room. Turn on the flashlight and focus its beam as tightly as possible. One person shines the flashlight so its beam is reflected off a mirror. The person holding that mirror then bends the beam so it is reflected to the next mirror, and so on. Imagine that you are “playing catch” with a beam of light. Reflect the beam of light to the Light Sensor.



This requires a *great team effort!*

-  **4** Begin recording data on the intensity of this beam of light. After you have collected about 20 seconds of data from the beam of light, stop recording data.
-  **5** Re-scale the graph. Pinpoint exact values for your light intensity data using the **Smart Cursor** or **Smart Tool**.
-  **6** If possible, try other things, such as adding another mirror to reflect and bend the beam even more before it reaches the Light Sensor, or changing the distances between each mirror.



How does the distance between the mirrors affect the intensity of your beam of light?

How would you change the experiment so that you could increase the intensity of light?



Be sure to follow your teacher's instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new file name.

Michael Faraday's Discovery



Reminder: Always keep magnets away from computers!

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• clear tape
• Voltage Sensor	• one-half length of a toilet paper tube
• bar magnet	• 2.5 – 4 m of insulated copper wire

Purpose

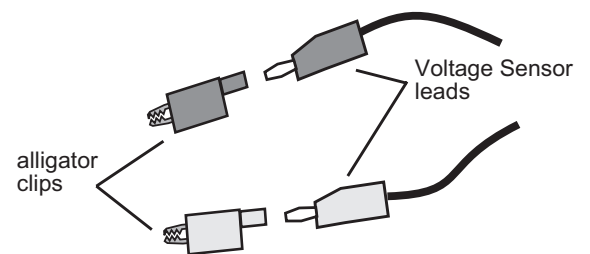
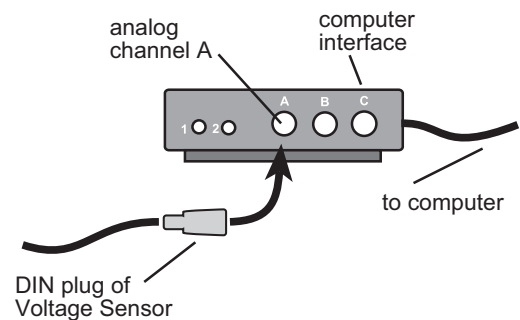
The purpose of this activity is to use the Voltage Sensor to measure the voltage created in a coil of wire when a magnet passes through the coil. This is called *magnetic induction of a current*, and was discovered in 1831 by an English scientist named Michael Faraday.

Procedure

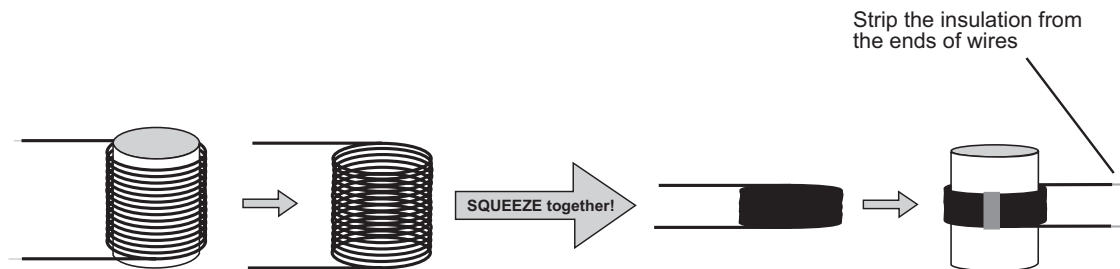
- 1 Turn on the interface box and the computer. Plug a Voltage Sensor into analog channel A of the interface box.
- 2 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS26	MSS06 Faradays Discovery.ds

- 3 Make sure you have the correct, color-coded alligator clips on the ends of the Voltage Sensor wire leads. These clips will connect to the free ends of the copper wire coil.



- 4 Make the coil by wrapping 20–30 turns of the copper wire around the toilet paper tube, leaving 10–15 cm free on each end of the coil. Do not wrap the wire too tightly.
- 5 Scrape off some insulation at each free end of the wire.
- 6 Slide the coil off the tube, *squeeze the wire together* like a slinky, and tape it to secure it. You should now have a wire ring.



- 7 Put the taped coil ring back onto the toilet paper tube. Make sure the alligator clips can attach to the free, non-insulated, ends of the wire. Attach an alligator clip to each end of the coil.
- 8 You should now prepare to drop the bar magnet through your coil. Since magnets can break easily, you will need to place the coil in such a way that the magnet can be dropped without hitting the floor. Practice a few drops to make sure the magnet can fall freely through the coil.
Remember to keep the magnet away from the computer.
- 9 Start recording data. Hold the magnet in the “ready” position, close to the tube so that one end is about 2 cm outside of the coil.
- 10 Allow the magnet to fall freely through the tube coil of wire so that it comes out the other end of the tube. Repeat this several times. After about 15 seconds, stop recording data, and re-scale the graph.

- 11** You are ready to investigate Michael Faraday’s discovery! What can you do to change the amount of voltage produced by your magnet and coil? Try different things, such as taping two bar magnets together so you have a longer magnet, or taping the magnets together so both south poles are forced to touch each other. You can change the number of turns of wire, or move the magnet through the coil more slowly or quickly.



Write down your ideas and predictions in your notebook, for each new thing you try.

Record data on the voltage produced by each of your variations of the magnet and/or the coil.

- 12** When you have finished recording data on the magnetic induction of electric current in your wire coil, you are ready to analyze your data. To do this, select a run of data by clicking on the run in the Data list. Re-scale the graph and pinpoint exact values using the **Smart Cursor** or **Smart Tool**.



About how much time does it take for the magnet to fall through the coil?

How would you describe the graph for one pass of the magnet through the coil?



Is there an “up” part and a “down” part on the graph for each magnet pass? If so, what do you think would cause this reversal?

Which magnet pass resulted in a voltage farthest from zero, either negative or positive?

Which magnet pass resulted in a voltage nearest to zero, either positive or negative?

What patterns do you notice in your up and down peaks? Look at each run of data as you consider this question.

Compare your data with the predictions you made. Which of your predictions

turned out as you expected? Which predictions did not match the experiment results?



Be sure to follow your teacher's instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new file name.

Ocean Floor Mapping

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• materials to build up terrain (boxes, books, chairs, etc.)
• Motion Sensor	
• area to use as ocean floor	

Purpose

The purpose of this activity is to use the Motion Sensor to record an image of the terrain on the ocean floor.

Procedure

1 Set up an area of the room to represent the ocean floor. Stack books, boxes, or other objects to give a random, uneven surface.

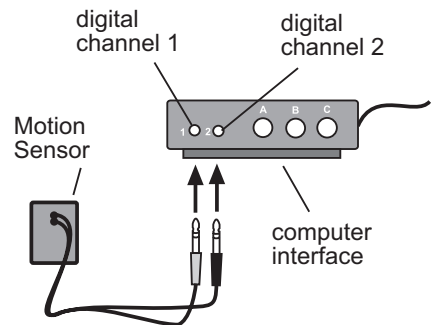
2 Turn on the interface box and the computer. Plug a Motion Sensor into digital channel 1 (yellow) and 2 (black) of the interface box.

3 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS27	MSS27 Ocean Floor Mapping.ds

4 You are now ready to disconnect the interface box. To do so, on Experiment menu, click **Disconnect for Data Logging** (*ScienceWorkshop*) or click the **Logging** button on the Setup toolbar (DataStudio).

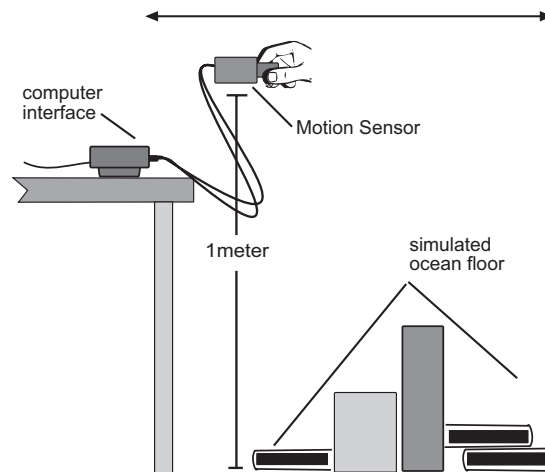
Note: Printing the checklist is an option. Follow your teacher's instructions about whether or not to print the checklist.



5 Disconnect the computer cable and the power cord from the back of the interface box. **Leave the interface box turned on and the Motion Sensor plugged in.** (The *ScienceWorkshop 500* Interface will let you know when it is ready to begin recording data remotely. When it is ready, a green light on the front will flash once every 5 seconds. This means it is in a “Sleep Mode” to save the batteries for actual data logging.)

6 Carry the interface box and sensor to the ocean floor area. Begin logging data. To do so, “wake up” the interface box by pushing—and holding down for a second—the **LOG** button on the front of the box. The green light will flash 10 times and then begin to flash rapidly. You will hear a clicking noise from the Motion Sensor. It is now recording data.

7 Move the Motion Sensor *slowly and steadily* over the ocean floor, at a height of one meter above the floor. Make sure that the round metal screen on the sensor is facing the floor, and that your arms and body don’t get in between the ocean floor and the Motion Sensor.



8 Press the **LOG** button to end recording. Return the interface box to the computer and reconnect the computer and power cables. On the **Experiment** menu, click **Connect to Interface** (*ScienceWorkshop*) or click the **Connect** button (*DataStudio*).

9 Your data will appear on the screen on a Position vs. Time graph. Re-scale the graph.



Compare the shape of the graph on the screen to the height and shape of the objects that represent the ocean floor.

Can you identify specific features of the ocean floor terrain?

Tunnel Vision

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] 500 Interface	• tape
• Light Sensor	• cardboard or dark-colored construction paper
• kinetic cart or toy cart	
• ramp or inclined plane	

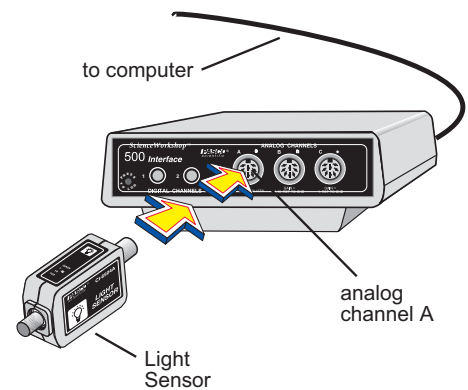
Purpose

The purpose of this activity is to use the Light Sensor to detect and record the change in light intensity that is experienced by a vehicle as it passes through a tunnel.

Procedure

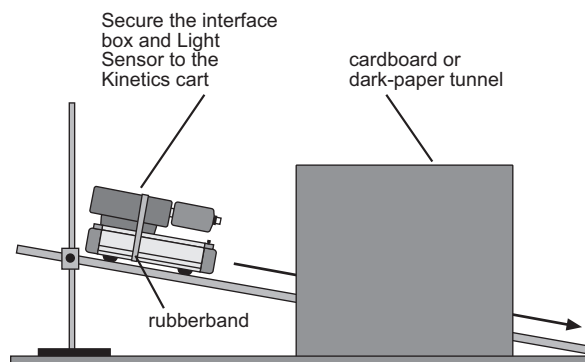
- 1 Design and construct a ramp with a tunnel. The *ScienceWorkshop* 500 Interface box and Light Sensor, attached to the car, will travel down the ramp and pass through the tunnel. You should experiment with the slope of the ramp to find the angle that works best for your car.
- 2 Turn on the interface box and the computer. Plug a Light Sensor into analog channel A of the interface box.
- 3 Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS28	MSS28 Tunnel Vision.ds



- 4 You are now ready to disconnect the interface box and move the Light Sensor to the tunnel and ramp. To do so, select **Disconnect for Data Logging** on Experiment menu (*ScienceWorkshop*) or click the **Logging** button on the Setup toolbar (DataStudio). (Printing the checklist is an option. Follow your teacher’s instructions about whether or not to print the checklist.).

- 5 Disconnect the computer cable and the power cord from the back of the interface box. **Leave the interface box turned on and the Light Sensor plugged in.** Attach the interface box and sensor securely to the car.



- 6 Carry the car with the interface box and sensor to the ramp and tunnel.

- 7 The *ScienceWorkshop 500* Interface will let you know when it is ready to begin recording data remotely. When it is ready, a green light on the front will flash once every 5 seconds. This means it is in a “Sleep Mode” to save the batteries for actual data logging.



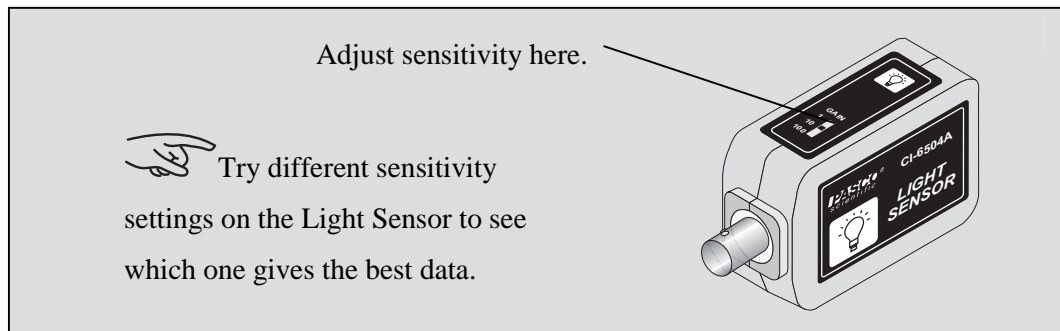
Make some predictions about how the light will vary as the car “drives” through the tunnel. Write your predictions in your science notebook.

- 8 Begin logging data. To do so, “wake up” the interface box by pushing—and holding down for a second—the **LOG** button on the front of the box. The green light will flash 10 times and then begin to flash rapidly. It is now recording data.

- 9 Let the car drive down the ramp and through the tunnel, making certain not to let it crash-land at the bottom. Press the **LOG** button to end recording.

- 10** Return the interface box to the computer and reconnect the computer and power cables. Select **Connect to Interface** on the Experiment menu (*ScienceWorkshop*). Click connect on the setup window toolbar (DataStudio). Your data will appear on the screen in a Time vs. Light Intensity graph.

- 11** Re-scale the graph, and pinpoint exact values for your light data.



Can you determine when the car was in the tunnel?

- 12** If possible, try different things with your car and tunnel, such as making your ramp steeper so the car travels faster, or shortening or lengthening the tunnel.



Be sure to follow your teacher's instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new file name.

Twenty-Two Cent Battery

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• copper wire (60 cm)
• Voltage Sensor	• sandpaper, fine grit table
	• heavy watercolor paper or thick paper towel
	• salt and water solution
	• 2 dimes and 2 pennies, with holes for wires

Purpose

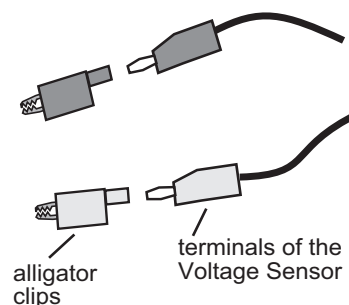
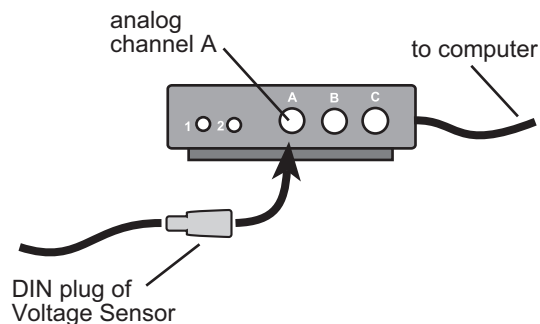
The purpose of this activity is to use the Voltage Sensor to measure the voltage produced by a coin battery,” and then compare this to the voltage of an actual D-cell battery.

Procedure

- 1 Turn on the interface box and the computer. Plug a Voltage Sensor into analog channel A of the interface box.
- 2 Open the Experiment Library template file:

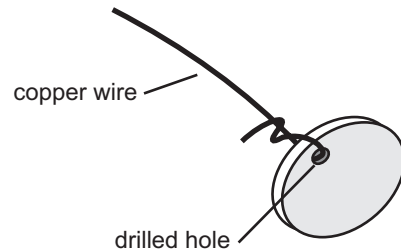
<i>ScienceWorkshop</i>	DataStudio™
MSS29	MSS29 Cent Battery.ds

- 3 Make sure you have the correct, color-coded alligator clips on the ends of the Voltage Sensor wire leads. These clips will connect to the free ends of the copper wire.



4 Clean each of the coins thoroughly by sanding them with fine sandpaper. They should be shiny on all surfaces. Wash them with soap and water, then rinse and dry them.

5 Attach a 5 cm piece of copper wire securely to each coin, as shown in the diagram.

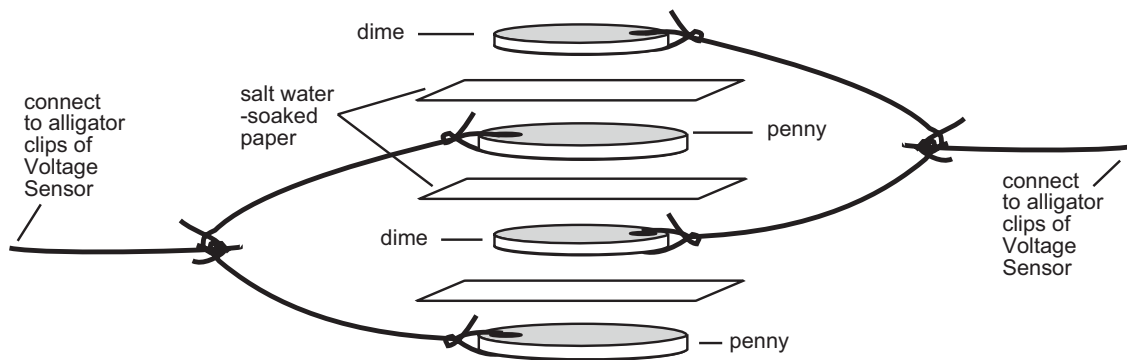


6 Cut watercolor paper (or heavy paper towel) into three round pieces, each slightly larger than a penny. Soak these pieces of paper in salt water.

7 Arrange a “sandwich” of pennies, dimes, and wet paper, as shown in the diagram. Stack the layers on top of each other.

8 Attach the wires from the dimes to another 10-cm piece of copper wire. These wires will attach to the alligator clips of the Voltage Sensor.

9 Connect the alligator clips of the Voltage Sensor to the wires leading from the two pennies and the two dimes. Begin recording data on the voltage created by your 22-cent battery.



10 Record voltage data for 60 seconds, and then stop recording data.

11 Re-scale the graph, and use the **Smart Cursor** or **Smart Tool** to investigate interesting areas of your data.

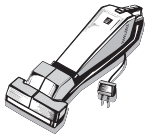


Compare the voltage produced by the battery you made from coins and salt water-soaked paper, to the voltage produced by an actual D-cell.



What changes could you make in your 22-cent battery that would affect the amount of voltage it produces?

Why is salt water used instead of tap water?



Be sure to follow your teacher's instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new file name.

Eleven Cent Battery

Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] Interface	• heavy watercolor paper or thick paper towel
• Voltage Sensor	• 1 dime and 1 penny
	• salt water
	• eraser

Purpose

The purpose of this activity is to use the Voltage Sensor to measure the voltage produced by a coin “battery” and then compare this to the voltage of an actual D-cell battery.

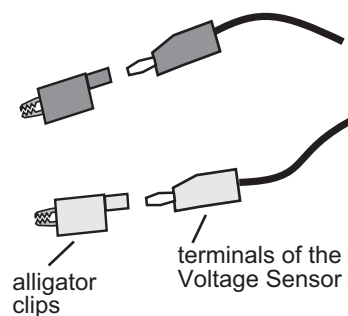
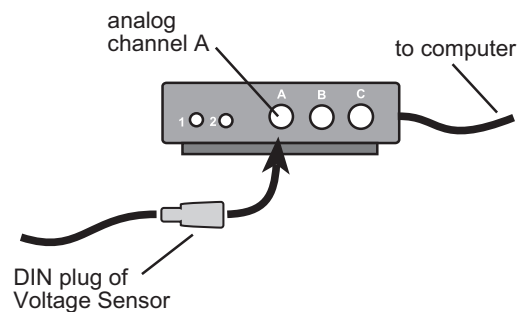
Procedure

1 Turn on the interface box and the computer. Plug a Voltage Sensor into analog channel A of the interface box.

2 Open the Experiment Library template file:

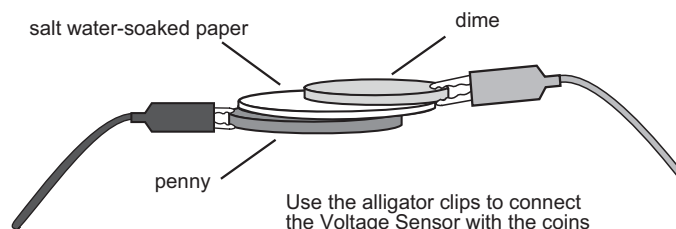
<i>ScienceWorkshop</i>	DataStudio™
MSS30	MSS30 Eleven Cent Battery.ds

3 Make sure you have the correct, color-coded alligator clips on the ends of the Voltage Sensor wire leads. These clips will connect to the free ends of the copper wire.



- 4 Clean each of the coins by rubbing them with an eraser. They should be shiny on all surfaces. Wash them with soap and water, then rinse and dry them.
- 5 Cut the watercolor paper (or heavy paper towel) into a round circle slightly larger than a penny. If your paper towel is thin, cut two circles. Soak these pieces in salt water.

- 6 Connect one of the alligator clips of the Voltage Sensor to the penny and the other to the dime. Place the paper towel circle(s) between the coins.



- 7 Begin recording data. Record for 60 seconds, and then stop recording data.



If you get very low voltage readings, re-soak the paper circles in the salt water solution.

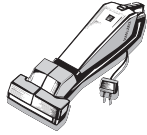
- 8 Re-scale the graph, and investigate interesting areas of your data with the **Smart Cursor** or **Smart Tool**.



Compare the voltage produced by the battery you made from coins and salt water-soaked paper to the voltage produced by an actual D-cell



What changes could you make in your 11-cent battery that would affect the amount of voltage it produces? Why is salt water used instead of tap water?



Be sure to follow your teacher's instructions for putting away your equipment and shutting down the computer. If you are saving your data on a disk, remember to give it a new file name.

Optional: While still connected to the Voltage Sensor, place the coins in the saltwater solution. Did the voltage increase, decrease or stay the same?

Parachute Contest

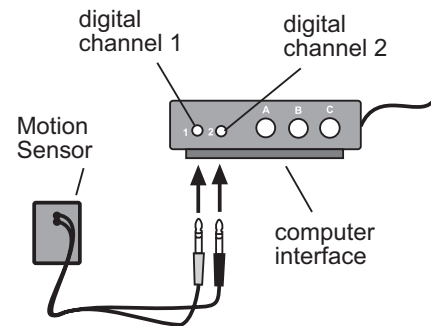
Equipment Needed	Consumables
• <i>ScienceWorkshop</i> [®] 500 Interface	• thin plastic film
• Motion Sensor	• thread or string
• staircase or area to use for dropping parachutes	• weight and cardboard

Purpose

The purpose of this activity is to use the Motion Sensor to record the position of a descending parachute and to use *ScienceWorkshop* to calculate its velocity.

Procedure

- Design and construct a parachute from the available materials. You may need to attach a cardboard “target” to the weight to increase the target size of the falling object.
- Set up an area to use as a drop zone for the parachute(s). Measure the height of the drop, in meters. This height will be represented by the “Distance (m)” on the y-axis of the graph.
- Turn on the interface box and the computer. Plug a Motion Sensor into digital channel 1 (yellow) and 2 (black) of the interface box.



- 4** Open the Experiment Library template file:

<i>ScienceWorkshop</i>	DataStudio™
MSS31	MSS31 Parachute Contest.ds

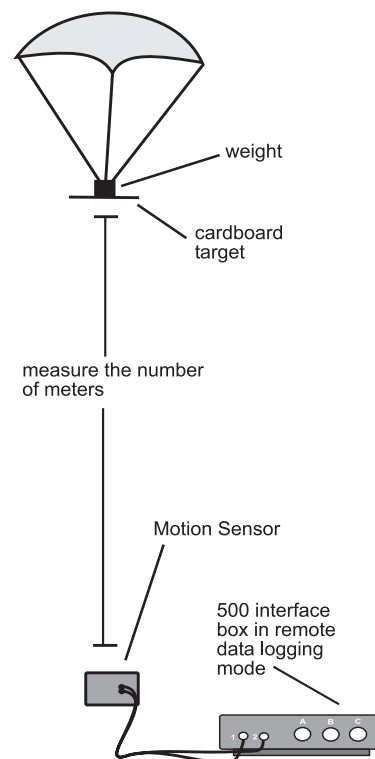
- 5** You are now ready to disconnect the interface box. To do so, on Experiment menu, click **Disconnect for Data Logging** (*ScienceWorkshop*) or click the **Logging** button on the Setup toolbar (DataStudio).

Note: Printing the checklist is an option. Follow your teacher’s instructions about whether or not to print the checklist.

- 6** Disconnect the computer cable and the power cord from the back of the interface box. **Leave the interface box turned on and the Motion Sensor plugged in.** (The *Science Workshop 500* Interface will let you know when it is ready to begin recording data remotely. When it is ready, a green light on the front will flash once every 5 seconds. This means it is in a “Sleep Mode” to save the batteries for actual data logging.)

- 7** Carry the interface box and sensor to the drop zone. Position the Motion Sensor on the ground *directly* under the parachute, which is in place to drop. Make certain that the round metal screen of the sensor is facing up at the parachute. Next, position the first parachute for dropping.

- 8** Begin logging data. To do so, “wake up” the interface box by pushing—and holding down for a second—the **LOG** button on the front of the box. The green light will flash 10 times and then begin to flash rapidly. It is now recording data.



- 9 Drop the parachute, directly over the Motion Sensor. When the parachute has reached the ground, push the **LOG** button on the front of the interface box to stop recording.
- 10 Position the next parachute, directly over the Motion Sensor. Push the **LOG** button again, to begin recording. When the green light is rapidly flashing, drop the parachute, then push the **LOG** button once it has landed. Repeat this step for each parachute.
- 11 Return the interface box to the computer and reconnect the computer and power cables. On the **Experiment** menu, click **Connect to Interface** (*ScienceWorkshop*) or click the **Connect** button (*DataStudio*).
- 12 Your data will appear on the screen on a Position vs Time graph. Re-scale the graph, and select a single data run for display from the **Data** menu.
- 13 Click the **Magnify** or **Zoom Select** button and drag a box around the section of graph that represents the parachute's falling motion. (The points in this box will be used to determine the rate at which the parachute fell.)
- 14 Click the **Statistics** button and the **Statistics menu** button to open the menu of statistics options. Select **Curve Fit, Linear Fit** to see the slope of the line suggested by your parachute. The slope of this line is the approximate speed (velocity) at which your parachute fell.



How do the *Linear Fit* lines for different parachutes compare?

What does a steep slope mean, compared to a flatter slope?

Which parachute took the longest to fall to the ground?

Which fell the fastest?

