Transfer of Energy
Forms of Energy: Single Transformations

Discovery Question

Can all forms of energy be transformed from one form to another?

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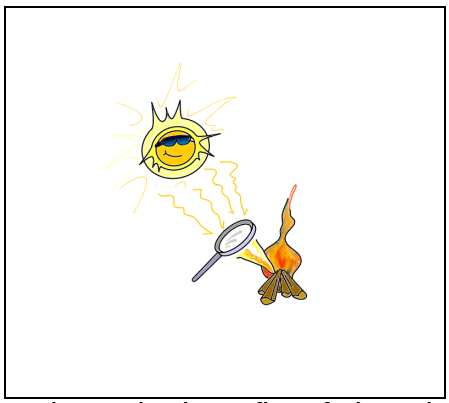
Introduction



In this activity you will investigate the benefits of changing one form of energy into another form of energy.

Thinking About The Question

Can all forms of energy be transformed from one form to another?

Energy comes in many forms - electrical, mechanical, chemical, light, nuclear - and it can be stored in many ways - batteries, springs, water towers, gasoline, radioactive materials. To make use of energy, we often want to change it from one form to another, then store it, then transform it again and use it later on.

Think of two kinds of energy that you make use of in and around your house. Where does each kind come from? How is it stored before you use it? What do you do with the energy? Answer these questions in Notes on your handheld computer.

Materials

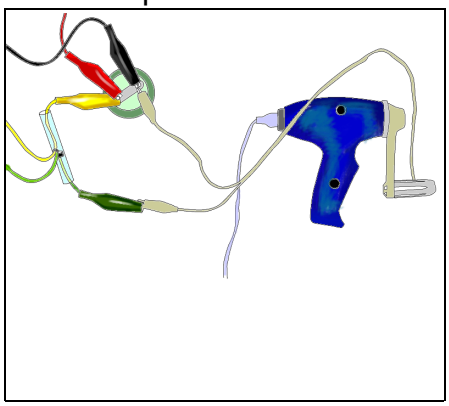
- CC Voltage/Current probe
- CC Fast Response Temperature probe
- handheld computer
- CC LabBook software
- handheld generator (Genecon)
- capacitor (1 farad)
- constructed air cart (see Investigation: Air Cart) wire clip leads
- wire clip leads
- heat cell
- Fresnel plastic lens (5cm x 8 cm)
- black marker or carbon from a burnt candle wick
- sunlight or incandescent light bulb in a lamp with no shade

Safety

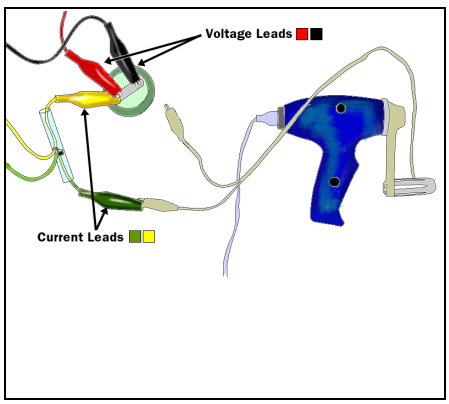
- When the Fresnel lens focuses sunlight, it produces a concentrated beam of light. Be very careful and never focus the beam on yourself or anyone else!
- Never look directly at the sun. Damage to your eyes will result.

Trial I: Storing electrical energy

1. You already know that electrical energy can be stored in a battery. There is an even more direct way with a capacitor. A capacitor stores electrical charges and can release them again as electrical current. Attach the Genecon and Voltage/Current probe to the capacitor. Follow the diagram carefully.



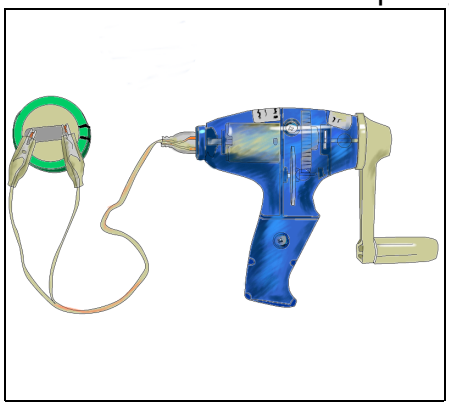
2. Connect the Voltage/Current probe to your handheld computer. Refer to Technical Hints to connect the Voltage/Current probe.
3. Start the software to record energy.
4. Crank until you have charged the capacitor.
5. Quickly disconnect one lead of the Genecon as shown, leaving the Voltage/Current probe attached. Wait for about 20 seconds.



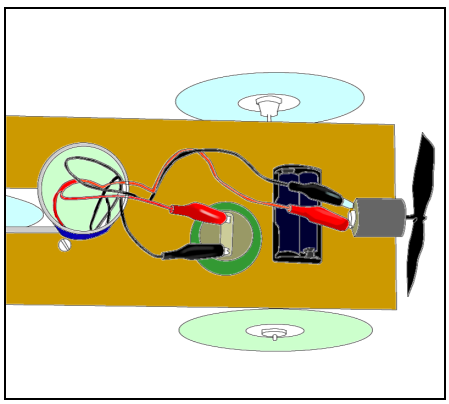
6. Re-attach the capacitor to the Genecon without cranking it. Obseve what happens.
7. When the Genecon stops, stop recording data and save to the handheld computer.
8. Look at the graph. Sketch the shape of the graph. Did the amount of cranking effort change as the capacitor "filled up"? Could you tell when it was fully charged? What did the graph do when the capacitor "drained out"? Record your thoughts in Notes on your handheld computer.

Trial II: Using stored electrical energy

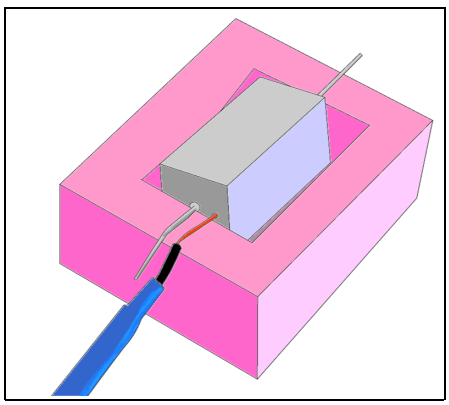
1. Charge up the capacitor with the Genecon and quickly disconnect it.



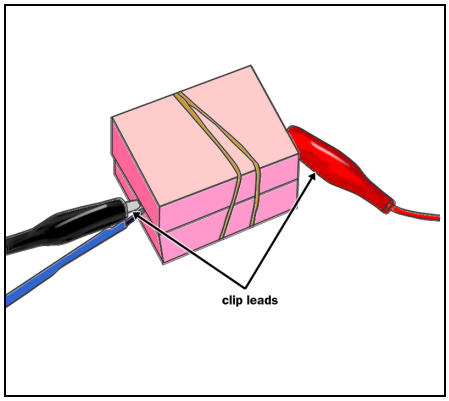
2. Connect the charged-up capacitor to power your air cart. Coil up the extra wire so that it doesn't rub against the wheels. Try it several times. How far will it go?



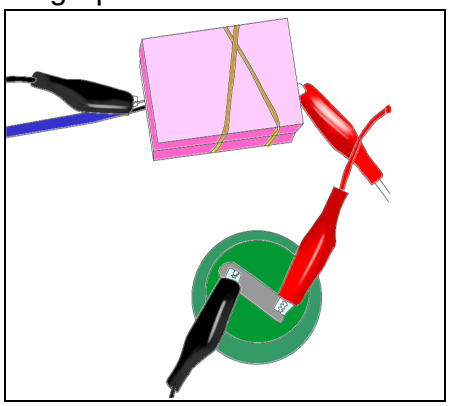
3. Another possible way to use the energy from the capacitor is to warm up the heat cell. Place the tip of the Temperature probe in the small hole in one end of the heat cell.



4. Close the heat cell in its insulating box by wrapping it with a rubber band and connecting the two clip leads to the metal wires that are sticking out.



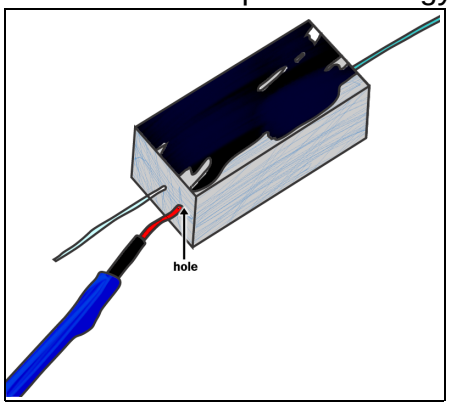
5. Connect the Temperature probe to your handheld computer. Refer to Technical Hints to connect the Temperature probe.
6. Start the software for the Temperature probe.
7. Charge up the capacitor again with the Genecon and quickly disconnect it.
8. Connect the capacitor to the heat cell with two clip leads and observe the temperature versus time graph.



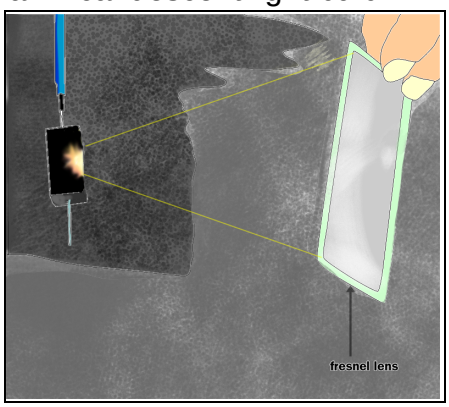
9. Zoom in on the graph until you can read the temperature change. Continue testing until you get a good temperature graph.
10. Save your data to the handheld computer.
11. Sketch the temperature graph. How long does it take for the energy from the capacitor to transfer into the heat cell? Record your thoughts in Notes on your handheld computer.
12. Calculate how much heat energy was stored in the capacitor. The heat cell contains 10 joules for each degree of temperature rise. How many joules of energy were obtained? Record your calculations in Notes on your handheld computer.

Trial III: Heating with sunlight

1. Set up the heat cell with the Temperature probe attached, but not in its insulating cover. Mark one face of the cell black with a marker or carbon from a burnt candlewick to increase the absorption of energy.



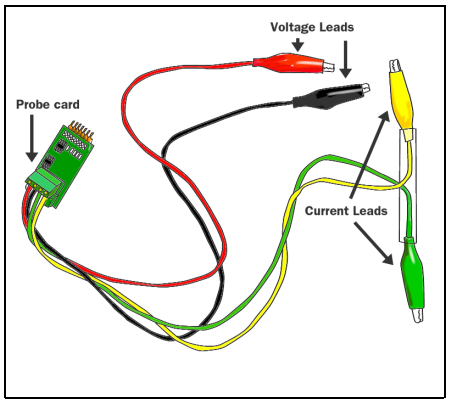
2. Connect the Temperature probe to your handheld computer. Refer to Technical Hints to connect the Temperature probe.
3. Start the software for the Temperature probe.
4. Try focusing sunlight on the heat cell with the Fresnel lens. If there's no sunlight, try focusing light from an incandescent light bulb.



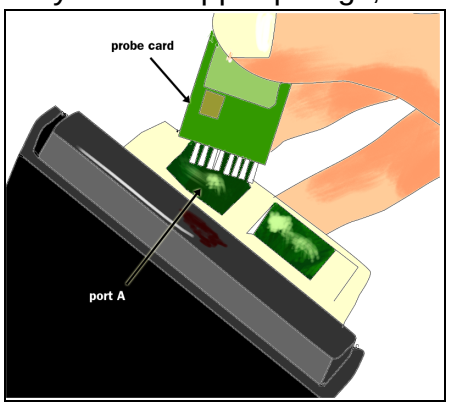
5. Monitor the temperature with the Temperature probe. Do not heat the cell above 50 degrees Celsius. The aluminum could be too hot to touch safely.
6. Save your data to the handheld computer.
7. How fast did the temperature rise? How does this compare to what a battery or a capacitor will do? How many square centimeters of sunlight does the Fresnel lens collect? Record your thoughts in Notes on your handheld computer.

Technical Hints

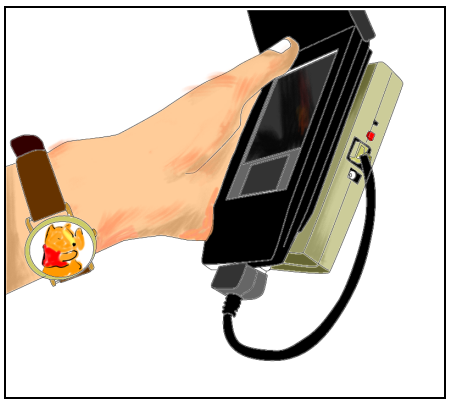
Connecting the VoltageCurrent probe



1. Connect the flexible cable from the VoltageCurrent probe to the VoltageCurrent probe card. Plug the VoltageCurrent probe card into Port A of the Interface Box. Be careful not to bend any of the copper prongs, or it won't work.



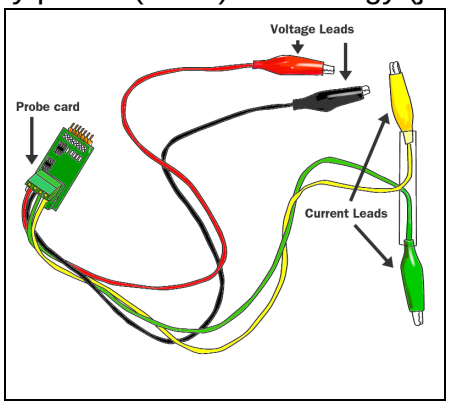
2. Attach the CCProbe Interface Box to your handheld with the Velcro square. Connect the CCProbe Interface Box to your handheld with the provided connector cable.



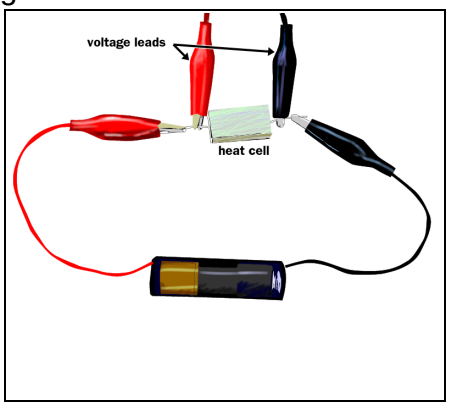
3. Tap on the the CCProbe icon to open the software. Open or create a VoltageCurrent probe data collector. Choose to read voltage, current, power, or energy.

Connecting the VoltageCurrent probe leads in a circuit

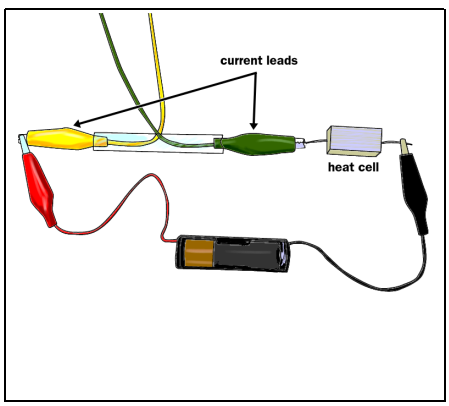
1. The Voltage/Current Probe measures either voltage or current. It can also measure both at the same time. The CCProbe software can use these readings to calculate and display power (watts) and energy (joules).



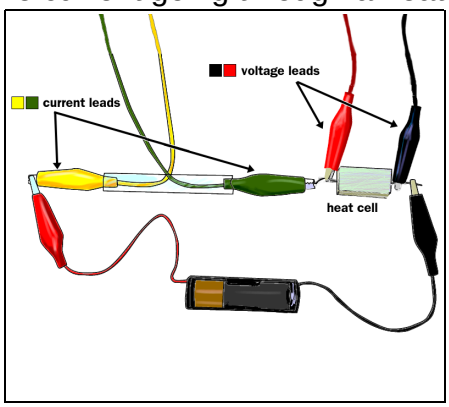
2. Voltage difference is measured in volts (V). The red clip lead goes to the positive (+) place, and the black clip lead goes to the negative (-) place. Here is how to measure voltage between two ends of a heat cell attached to a battery:



3. To measure the current in a wire, you have to break the wire and force the current to go through your current probe. The convention is that current is positive when it flows from a positive to a negative voltage, that is, from red to black. For the current through the probe to be positive, it should flow into the yellow clip lead and out of the green clip lead. Here is how to measure current going through a heat cell attached to a battery. Current is measured in amperes (A).

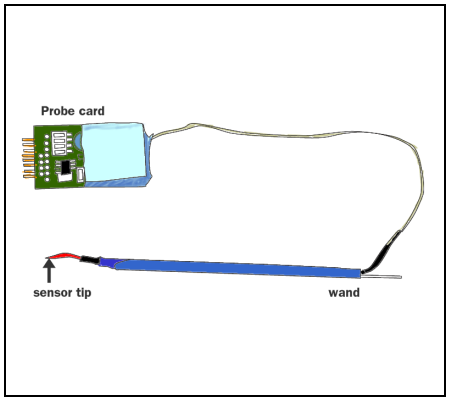


4. Electrical power, the rate of using energy, is voltage difference times current. It can be pictured as the number of electrons flowing per second, multiplied by the energy each one loses. Power is measured in watts (W).
5. Electrical energy is the power accumulated over time. It can be pictured as the total number of electrons that flow, multiplied by the energy that each one gains (or loses). Energy is measured in joules (J).
6. To measure the power or energy, you must measure both voltage and current. Here is how to measure current going through a heat cell attached to a battery.

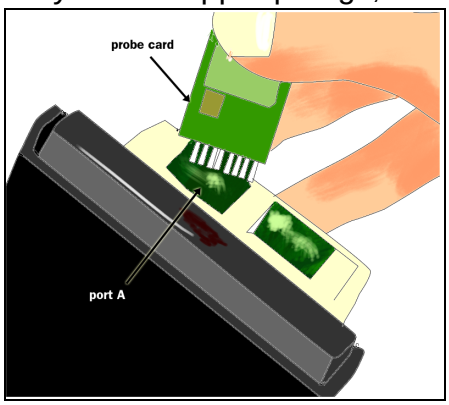


7. The CCProbeware will calculate and display the power or energy from these measurements.

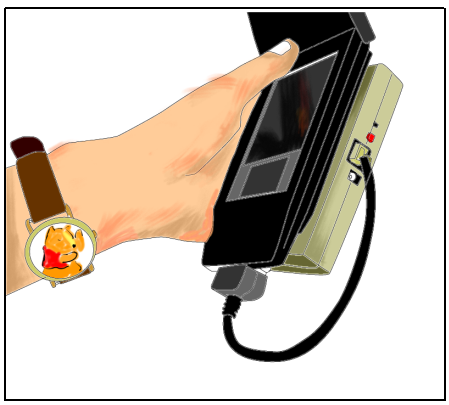
Connecting the Temperature probe



1. Connect the flexible cable from the Temperature probe to the Temperature probe card. Plug the Temperature probe card into Port A of the Interface Box. Be careful not to bend any of the copper prongs, or it won't work.



2. Attach the CCProbe Interface Box to your handheld with the Velcro square. Connect the CCProbe Interface Box to your handheld with the provided connector cable.



3. Tap on the CCProbe icon to open the software. Open or create a Temperature probe data collector.

Using the CC LabBook software

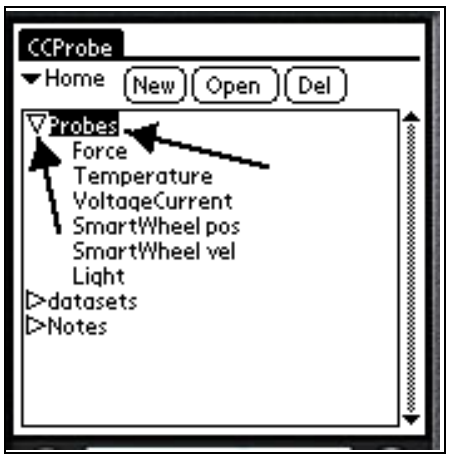
To use CC LabBook just follow these easy steps!

1. Opening the software

a. To open the software, tap the CCProbe icon.

b. The first screen you see is the LabBook.

2. Opening folders and subfolders

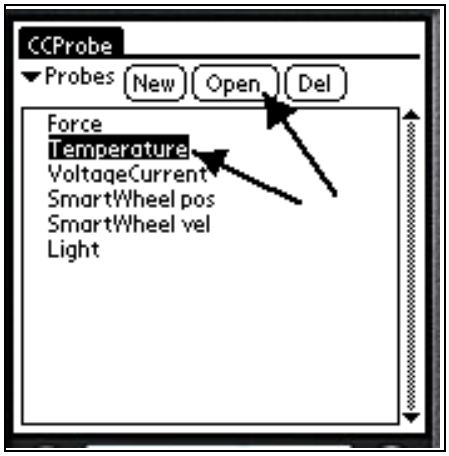


a. The LabBook lists all of the folders, data collectors, notes, saved datasets, and other objects in the LabBook. To open folders and subfolders, tap the triangles or double-tap the folder name.

b. Click Home (upper left) to go back to the top level folder.

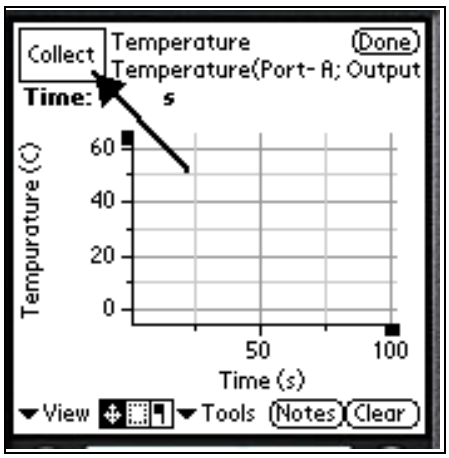
3. Opening a data collector

a. To take data with a CC probe, you must open or create a data collector. In these investigations, the data collectors have already been created.

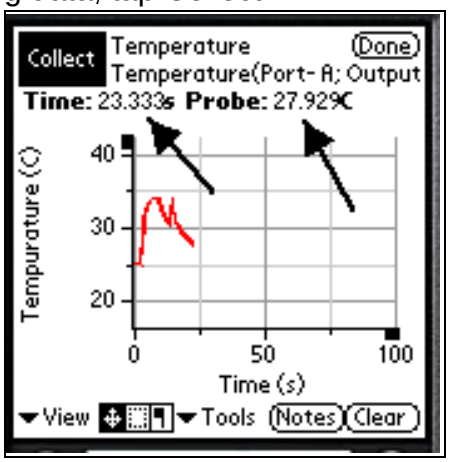


b. To open an existing data collector, highlight its name, then tap it twice or tap Open. It may take a few seconds for the graph to appear.

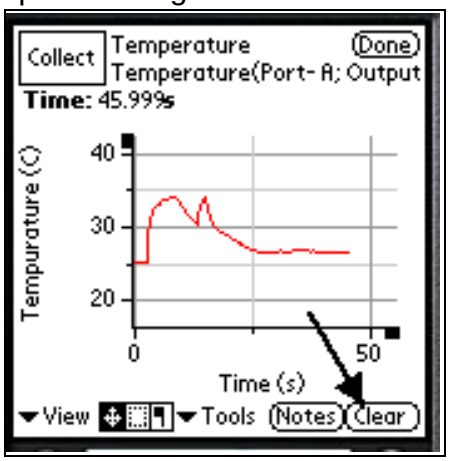
4. Collecting and clearing data



a. To start collecting data, tap Collect.



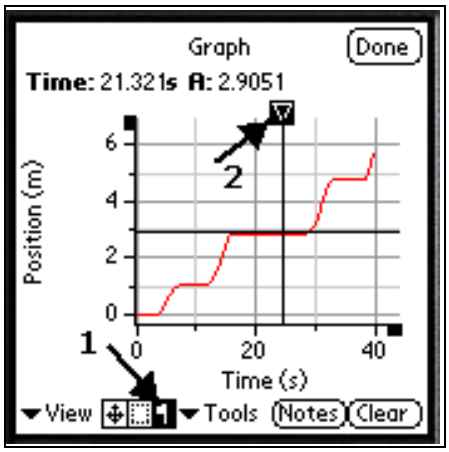
b. As data is collected, the current values appear at the top of the graph. To stop collecting, tap Collect again.



c. You can clear the data with Clear, and then continue collecting data with Collect.

5. Reading graph values

a. To read values of a graph once it has been collected, tap on the Mark flag and tap where you want to read the value.



b. A little triangle will appear, connected to crossed lines. The mark can be moved around with the cursor, and the x and y values of the graph will show at the top.

6. Recognizing collection limits

Currently there is a limit to how much data can be collected at once, about 4000 data points. The collecting will stop when this amount is reached, so plan your experiments with this in mind. In terms of time, the limits are as follows:

Force probe, 400/sec = about 7 seconds

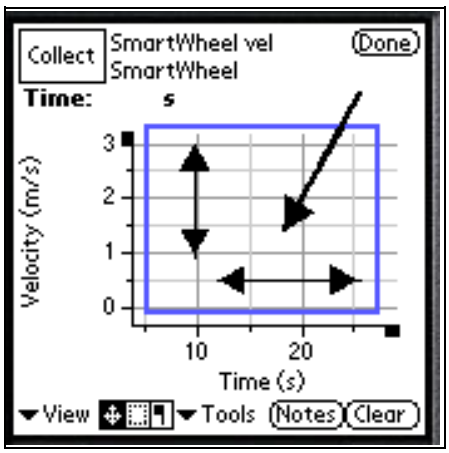
Force probe, 200/sec = about 15 seconds

SmartWheel = about 40 seconds

All others 3/sec = several minutes

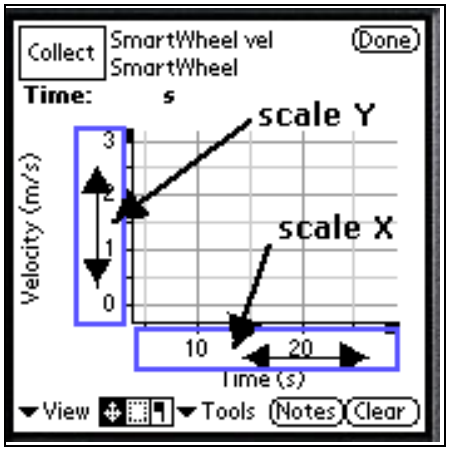
7. Scrolling around the graph

To scroll around the graph, tap and drag within the graph area itself. There may be a slight delay before the graph responds.

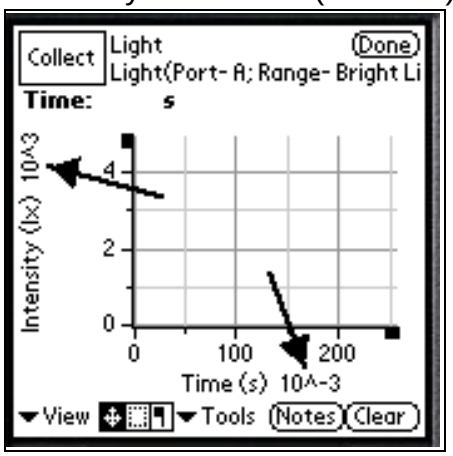


8. Changing the scale of an axis

a. To change the scale of an axis, tap and drag on the region along the axis. Drag away from zero to expand the scale and toward zero to shrink the scale. There may be a slight delay before the graph responds.

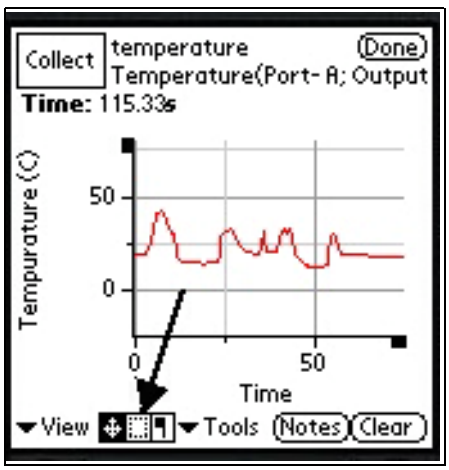


b. If you stretch or shrink the scale a great deal, it will switch by a factor of 1000, shown as 10^3 (for large numbers) or 10^-3 (for small numbers). For example, in the following screen, time is in milliseconds (1/1000 of a second) and light intensity is in kilolux (1000 lux).

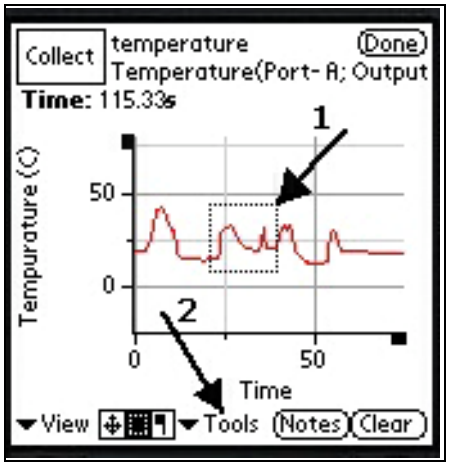


9. Zooming in on the graph

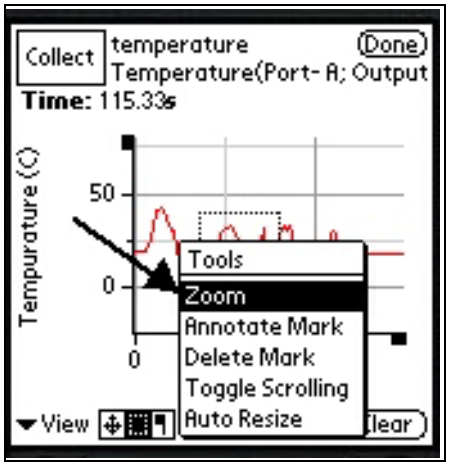
a. To zoom in on part of a graph, tap on the area selector at the bottom of the screen.



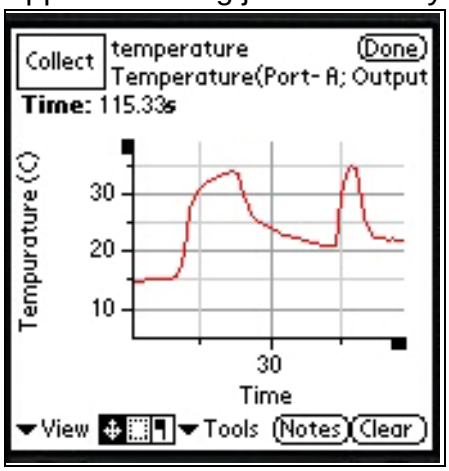
b. Drag the outline around the area of the graph you want to zoom in on, then tap Tools.



c. Click Zoom in the Tools list.

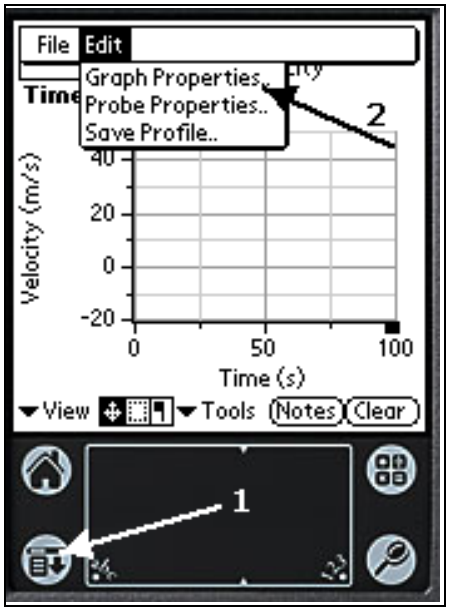


d. The graph will reappear showing just the area you selected.

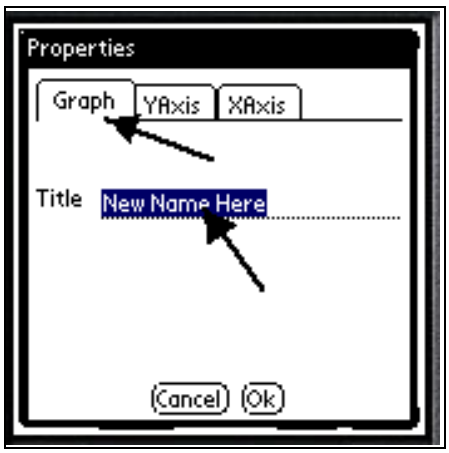


10. Changing graph properties

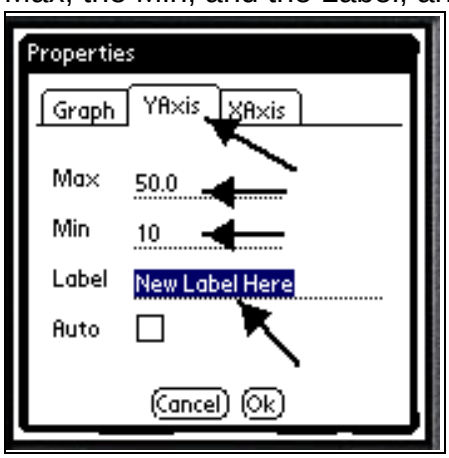
a. To change graph properties, tap the Palm menu icon at the bottom left corner, then the Edit menu item. Tap Graph Properties.



b. To change the title, go to the Graph tab. Write the new title, and then tap OK.



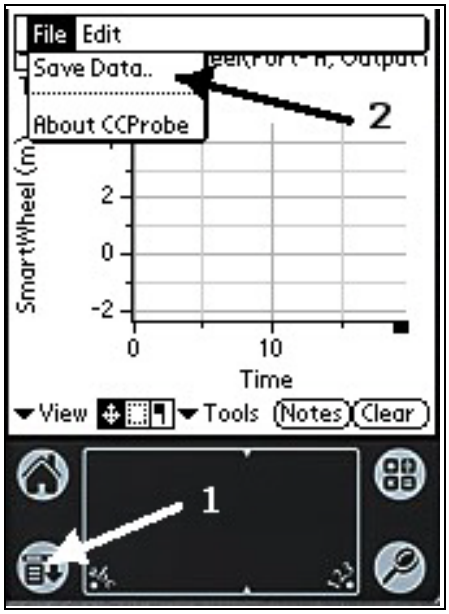
c. To change the range and the label of an axis, tap on the YAxis or XAxis tab. Write in the Max, the Min, and the Label, and then tap OK.



d. Another method of changing the range and the label of an axis is to tap on the ends of axes to open graph properties.

11. Saving data

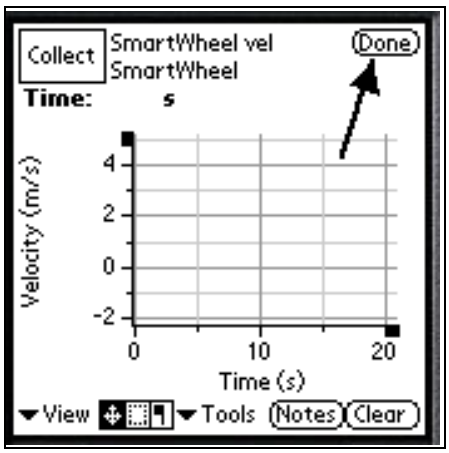
a. To save your data, tap the Palm menu icon at the bottom left corner. Then tap Save Data in the File menu. The menu will disappear when the data is saved. This may take several seconds.



b. When prompted, give your data set a name. It will be saved in your LabBook.

12. Closing the data collector

To close the data collector and go back to the LabBook screen, tap Done. Your data will NOT automatically be saved.



Analysis

1. In Trial I you charged the capacitor with the Genecon, then ran the Genecon with the capacitor. Do you think you obtained as much mechanical energy out of the capacitor as you put in it? How could you find out? If you didn't, where did the energy go?

2. Capacitors, with their ability to store electrical energy and release it very fast, have many uses. A familiar one is the flash on a camera. A very small amount of energy is released so fast that it makes a bright, but brief, light. This is just what a camera needs! But when you want a slow, steady supply of energy, as with the air cart motor, a capacitor is not the best source of energy. A battery is much better. What's another situation that uses batteries? What's another situation that might use capacitors?

3. The Fresnel lens concentrates light from a larger area to a smaller area, by bending the light that comes through it. This is called refraction. The Fresnel lens increased the amount of sunlight reaching the heat cell compared to being in the Sun without the lens. How much was it increased? Could you calculate it?

4. List some devices that use lenses to focus light?

5. How do you think sunlight is converted into heat? Do you think it matters if the heat cell is black instead of plain aluminum? conversion. What is an example of heat being converted into light?

Further Investigations

- Hook several capacitors in parallel and series, using clip leads. Charge them with the Genecon for both cases. See if either method works better than a single capacitor for both running the cart and warming the heat cell.
- How much brighter is the sun than a incandescent light bulb? Measure how fast the heat cell will be heated by sunlight compared to light from a bulb.

