Transfer of Energy
Forms of Energy: Multiple Transformations

Discovery Question

What energy transformations are used in everyday devices?

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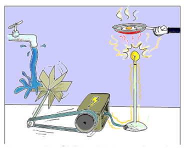
Introduction



In this activity you investigate energy being transformed through several steps to obtain a useful form.

Thinking About The Question

What energy transformations are used in everyday devices?

We use many devices that transform energy from one form to another. Sometimes a whole chain of transformations takes place. They often do it so smoothly that we don't even realize what's happening. Each step usually involves some loss of useful energy. An automobile engine, for instance, is only 30 per cent efficient. That is, only 30 percent of the available energy in gasoline is available to move the car.

Think of an example where energy is transformed several times before it is used. List each of the forms of energy in the chain. What do you think the efficiency is for each step? Where do you think the wasted energy goes?

Materials

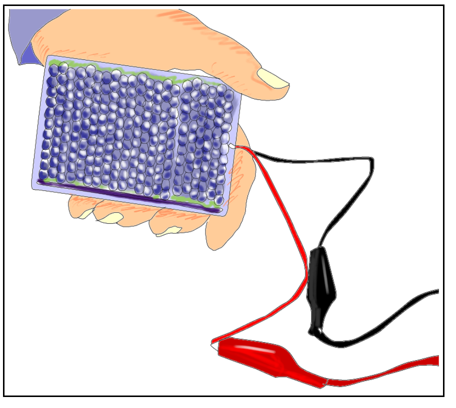
- CC Voltage/Current probe
- CC Light probe
- handheld computer
- CC LabBook software
- solar cell
- sunlight
- clip leads
- capacitor (1 Farad)
- mini light
- black film canister
- aluminum foil
- handheld generator (Genecon)
- pulley wheel and plastic bushing
- string
- 50g mass
- paper clip
- clay

Safety

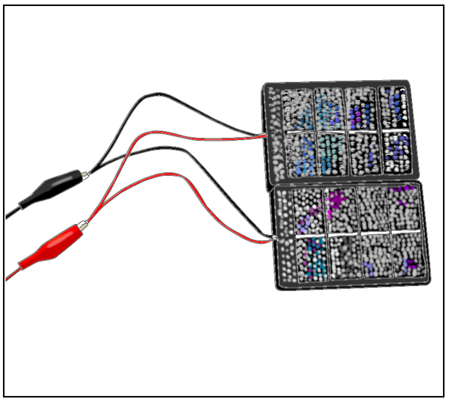
- Never look directly at the sun. Damage to your eyes will result.
- Although the hand-held generator is sturdily constructed, excessive speed in rotating the handle can result in stripped gears.
- While lighting the mini light with your Genecon, keep in mind that the mini light will become hot to the touch.

Trial I: Electricity from the sun

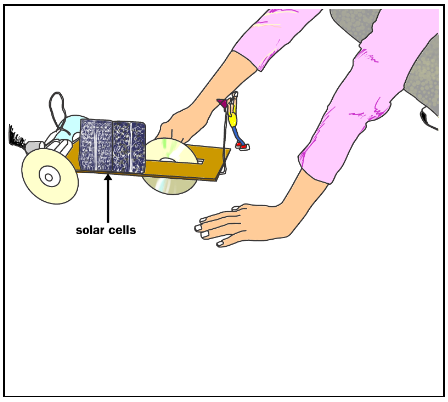
1. The solar cell changes sunlight directly into electrical energy, which can in turn be used for something else. It is not very efficient, but the source of energy is free! Connect the Voltage/Current probe to your handheld computer. Refer to Technical Hints to connect the Voltage/Current probe.
2. Start the software to read voltage.
3. Hook the solar cell to the voltage probe. Try it under different light conditions, such as a light bulb, direct sunlight, and indirect light from the sky. Stop the software and save your data.



4. What were the best and worst light sources? Record your observations in Notes on your handheld computer.
5. Team up with another group and connect two solar cells in parallel, using the clip leads.



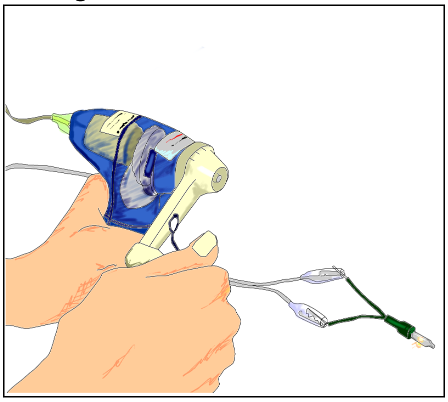
6. Mount them on a cart at an angle so that they face toward bright sunlight. Clip the leads to the motor.



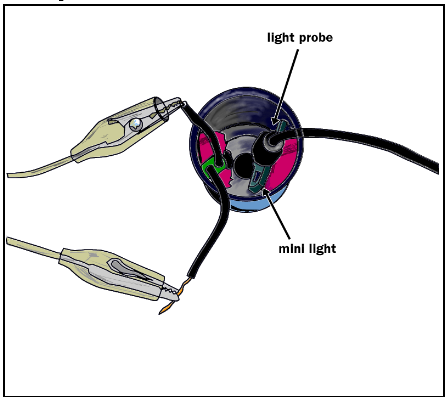
7. Is there enough power to drive the air cart? What energy transformations are happening there? How efficient do you think each step is? Record your thoughts in Notes on your handheld computer.

Trial II: Cranking up the lights

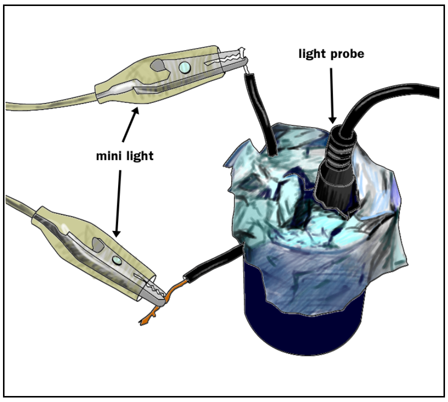
1. Attach the Genecon to a mini light. Crank it, but not too fast. If excessive cranking takes place, the light will burn out!



2. Connect the Light probe to your handheld computer. Refer to Technical Hints to connect the Light probe.
3. Start the software to read light intensity (lux).
4. Measure the light level from light bulbs, direct sunlight, and light from the sky. Stop recording. Write down, in lux, how the three compare.
5. Place the light bulb in a black film canister along with the Light probe. Make sure the Light probe faces the light bulb. Hold the Light probe and the mini light in place with pieces of clay.



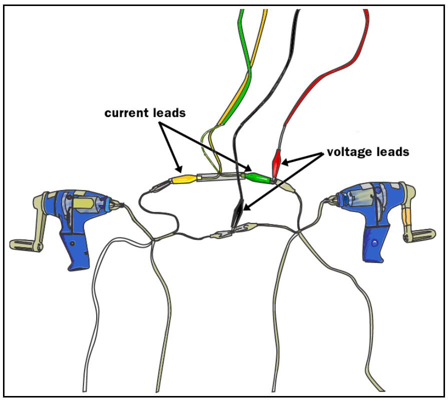
6. Cover the opening with aluminum foil to block as much outside light as you can.



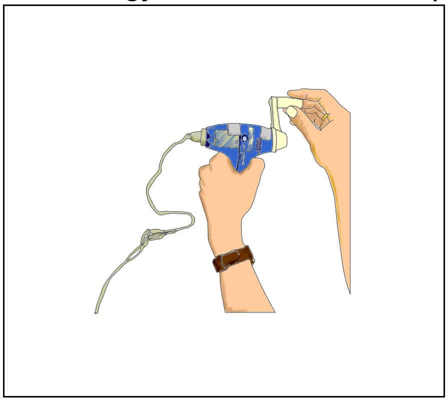
7. Restart the software to read light. Gradually increase the rate of cranking the Genecon. Do not crank too fast, or the light will burn out! See if you can establish a relationship between how fast you crank and how much light is produced. See if you can crank so slowly that no light is produced.
8. Save the data to your handheld computer.
9. What are the energy transformations happening here? What is the efficiency of each one? Do you think the mini light is producing only light energy? Record your answers in Notes on your handheld computer.

Trial III: Remote lifting

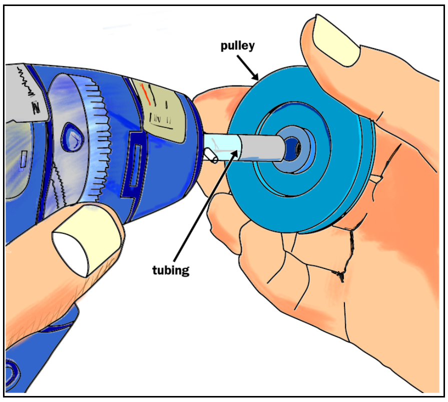
1. Team up with another group so that you can monitor two Genecons on one handheld computer.
2. Connect the VoltageCurrent probe to your handheld computer. Refer to Technical Hints to connect the VoltageCurrent probe.
3. Connect the VoltageCurrent probe leads to the Genecon leads as shown in the diagram.



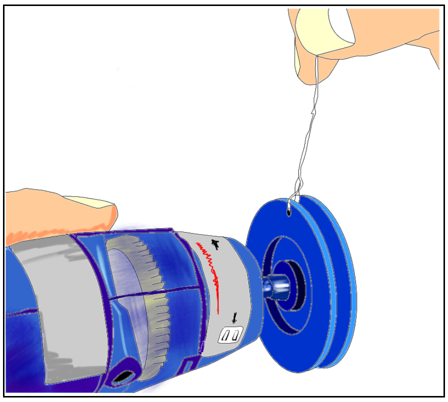
4. Start the software to read energy.
5. Sketch your graph. How did the graph relate to what you were doing with the Genecons? What are the energy transformations happening here?



6. Now attach a pulley to one of the Genecons. Leave the wires hooked up. Remove one handle. The pulley comes with a piece of plastic tubing (bushing). Fit the tubing on the Genecon shaft and slide the pulley tightly over the shaft.



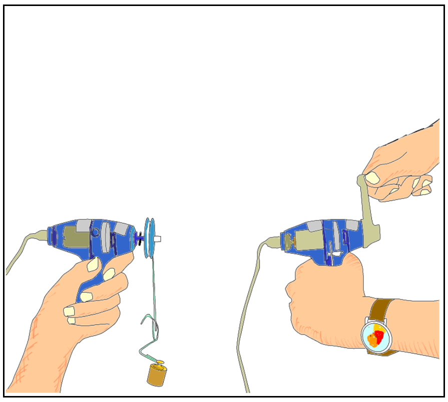
7. Cut about 2m of thread or string. Tie one end through the hole in the side of the pulley.



8. Wind up the string onto the pulley. Attach a hanging weight. You can use a 50g mass from your kit or a heavier one of your own. A paper clip works as a hook. It has a mass of about 0.3g.

9. Hold the Genecon with its shaft horizontal and the string hanging down from the pulley. Its leads should still be hooked to the other Genecon, with the Voltage/Current leads in place.

10. Restart the software to read energy.

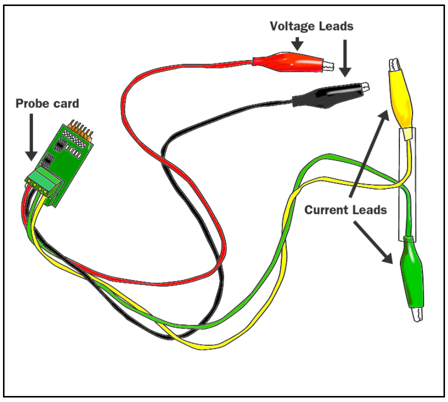


11. Crank the other Genecon to lift the weight. Also try to lower the weight. If the weight is heavy enough, will it fall by itself? Try different things, like raising and lowering slowly and quickly.

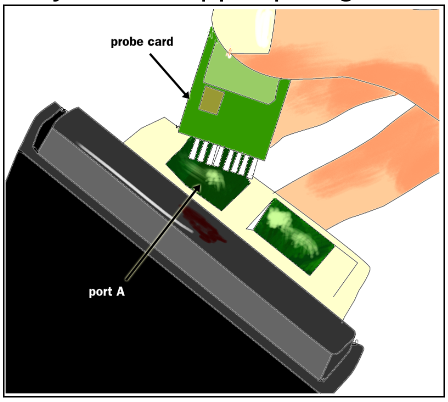
12. Save your data to your handheld computer. Sketch the graph and record the order in which you did things. Use Notes on your handheld computer.

Technical Hints

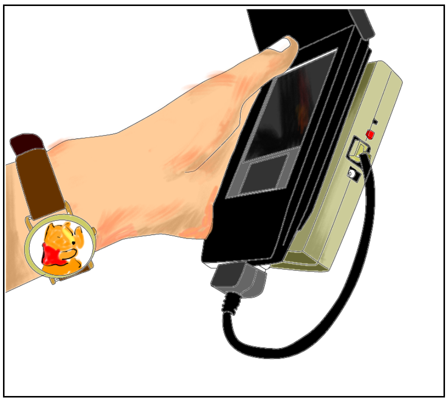
Connecting the VoltageCurrent probe



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.



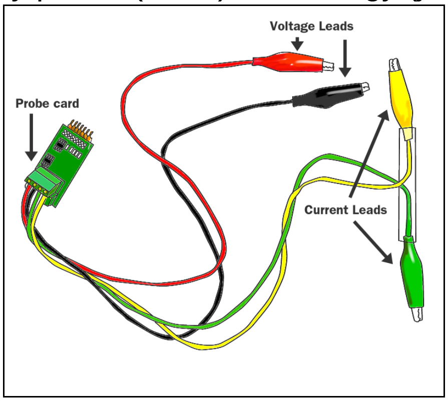
2. Attach the CCProbe Interface Box to your handheld with the Velcro square. Connect the CCProbe Interface Box to your handheld with the provided connector cable.



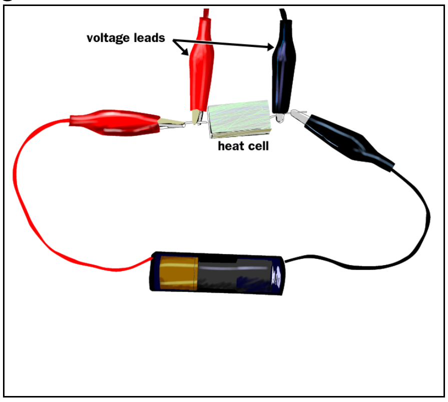
3. Tap on the the CCProbe icon to open the software. Open or create a VoltageCurrent probe data collector. Choose to read voltage, current, power, or energy.

Connecting the VoltageCurrent probe leads in a circuit

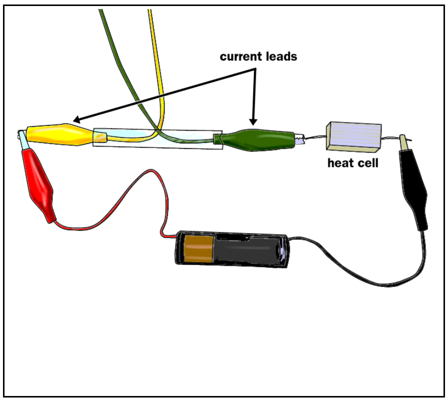
1. The Voltage/Current Probe measures either voltage or current. It can also measure both at the same time. The CCProbe software can use these readings to calculate and display power (watts) and energy (joules).



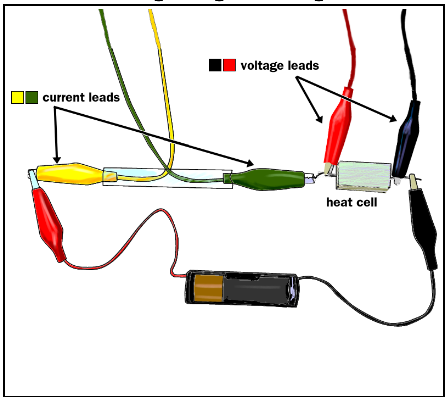
2. Voltage difference is measured in volts (V). The red clip lead goes to the positive (+) place, and the black clip lead goes to the negative (-) place. Here is how to measure voltage between two ends of a heat cell attached to a battery:



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).

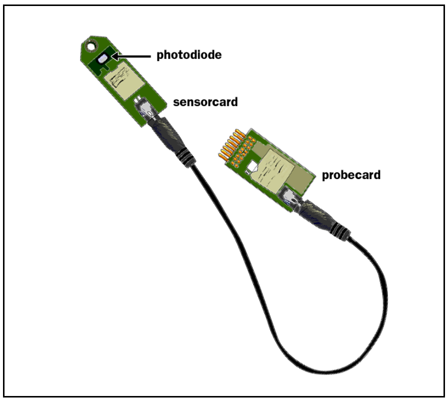


4. Electrical power, the rate of using energy, is voltage difference times current. It can be pictured as the number of electrons flowing per second, multiplied by the energy each one loses. Power is measured in watts (W).
5. Electrical energy is the power accumulated over time. It can be pictured as 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.

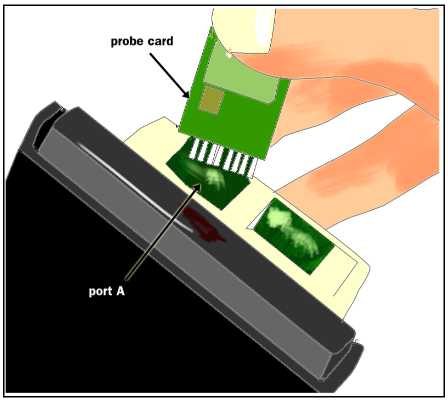


7. The CCProbeware will calculate and display the power or energy from these measurements.

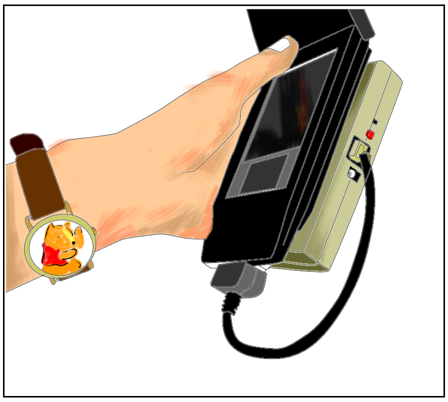
Connecting the Light probe



1. Connect the flexible cable from the Light probe to the Light probe card. Plug the Light 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 Light probe data collector.

Using the CC LabBook software

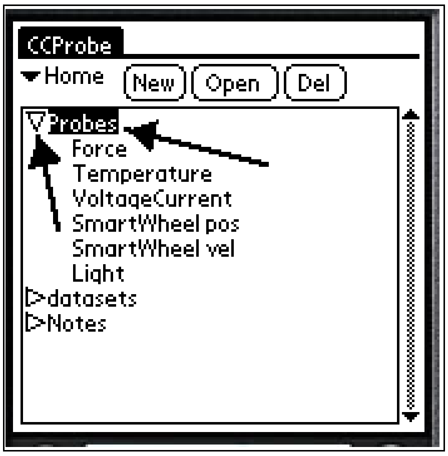
To use CC LabBook just follow these easy steps!

1. Opening the software

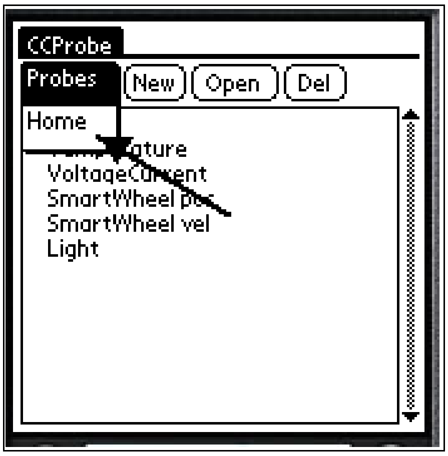
a. To open the software, tap the CCProbe icon.

b. The first screen you see is the LabBook.

2. Opening folders and subfolders



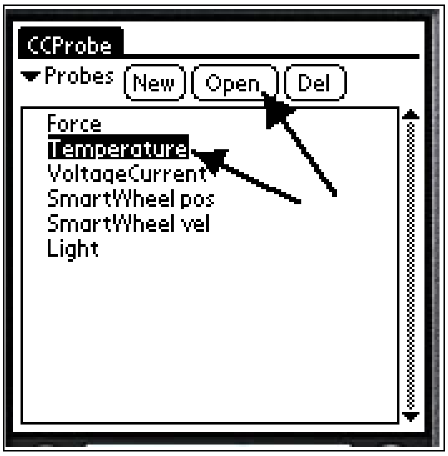
a. The LabBook lists all of the folders, data collectors, notes, saved datasets, and other objects in the LabBook. To open folders and subfolders, tap the triangles or double-tap the folder name.



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

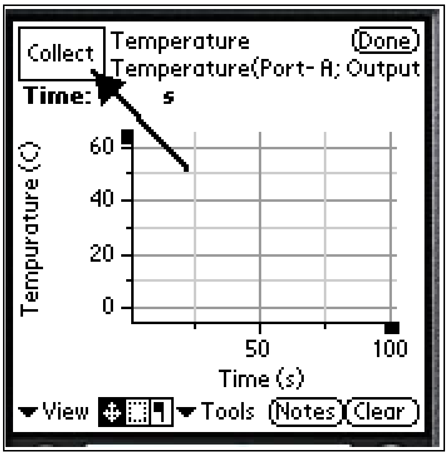
3. Opening a data collector

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.

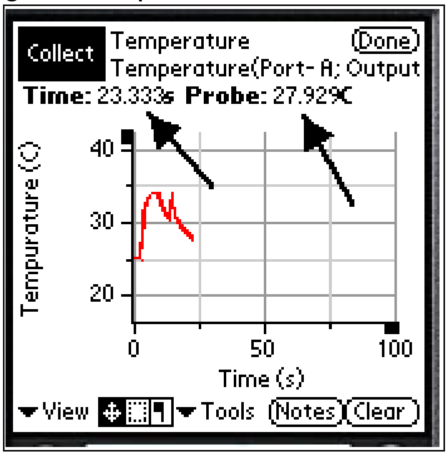


b. To open an existing data collector, highlight its name, then tap it twice or tap Open. It may take a few seconds for the graph to appear.

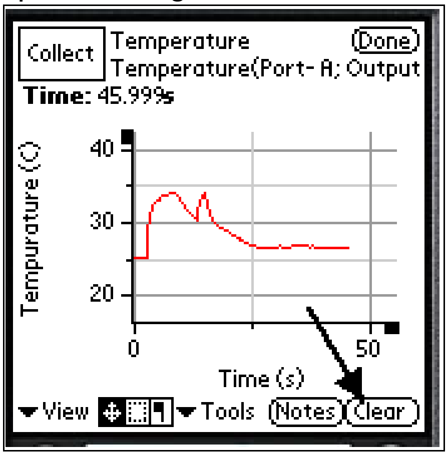
4. Collecting and clearing data



a. To start collecting data, tap Collect.



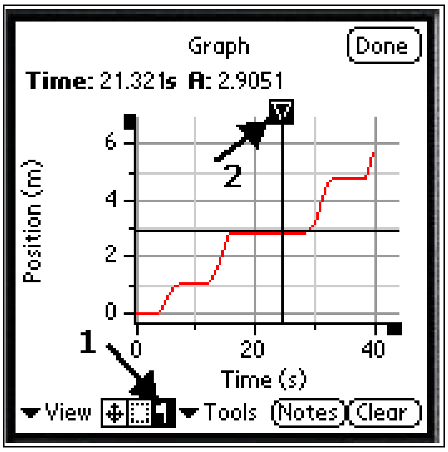
b. As data is collected, the current values appear at the top of the graph. To stop collecting, tap Collect again.



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

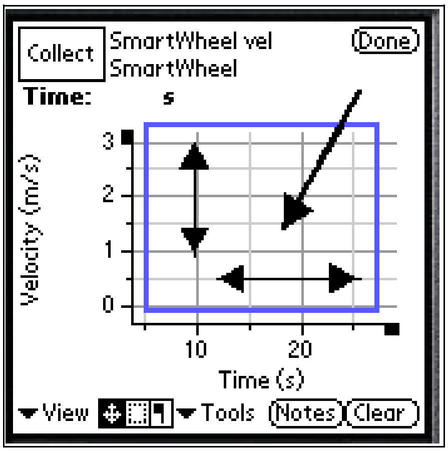
Force probe, 200/sec = about 15 seconds

SmartWheel = about 40 seconds

All others 3/sec = several minutes

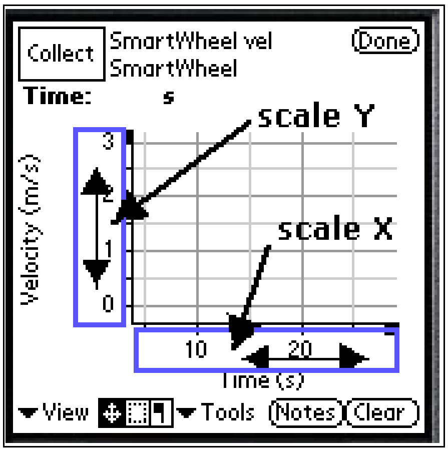
7. Scrolling around the graph

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

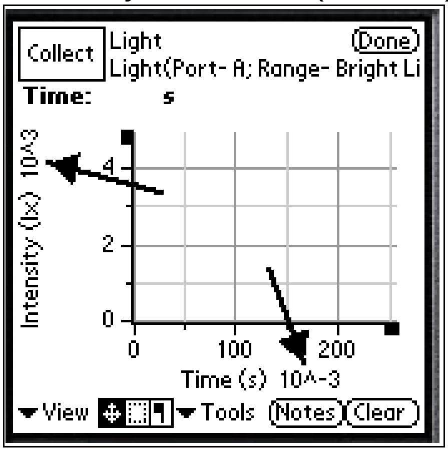


8. Changing the scale of an axis

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.

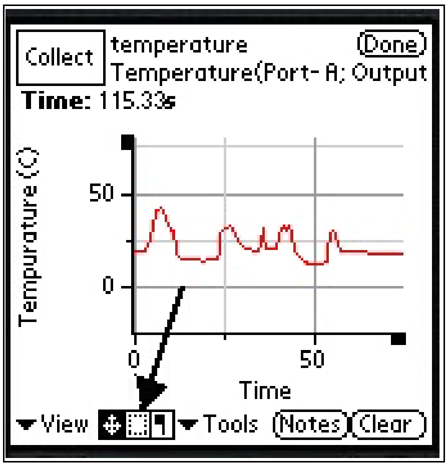


b. If you stretch or shrink the scale a great deal, it will switch by a factor of 1000, shown as 10^3 (for large numbers) or 10^-3 (for small numbers). For example, in the following screen, time is in milliseconds (1/1000 of a second) and light intensity is in kilolux (1000 lux).

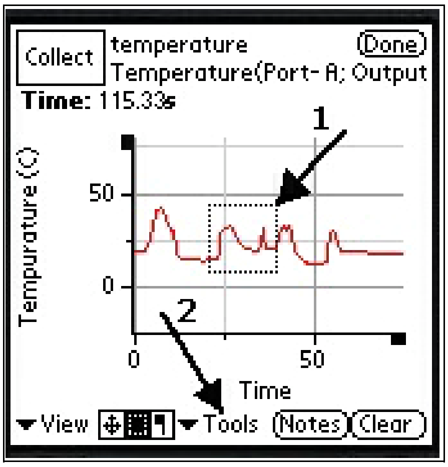


9. Zooming in on the graph

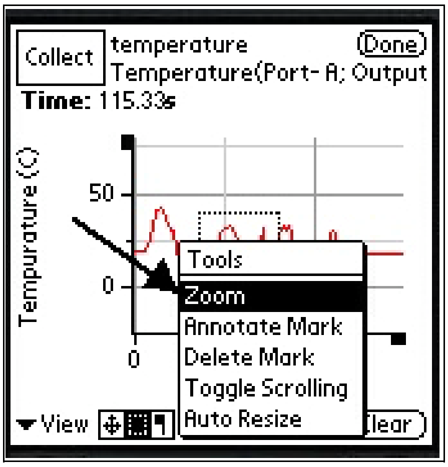
a. To zoom in on part of a graph, tap on the area selector at the bottom of the screen.



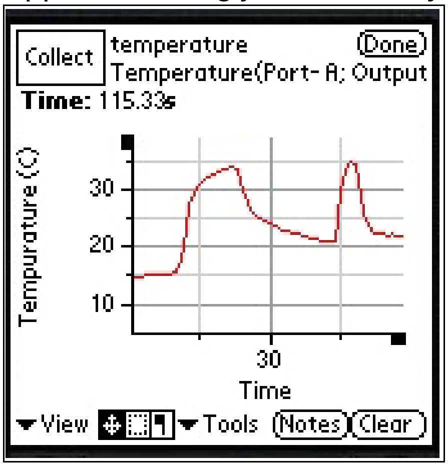
b. Drag the outline around the area of the graph you want to zoom in on, then tap Tools.



c. Click Zoom in the Tools list.

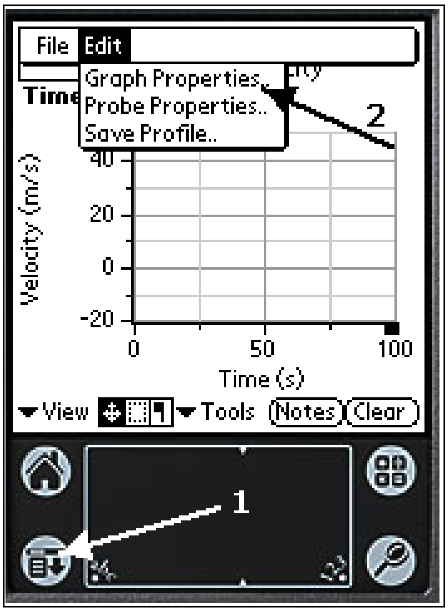


d. The graph will reappear showing just the area you selected.

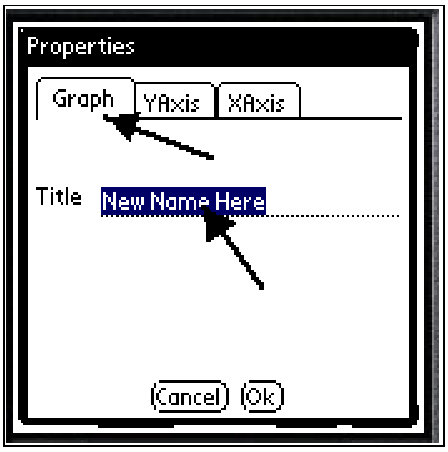


10. Changing graph properties

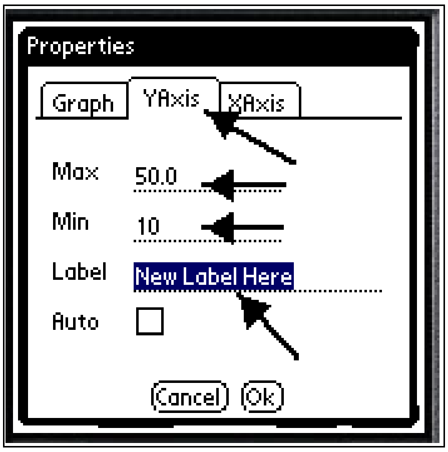
a. To change graph properties, tap the Palm menu icon at the bottom left corner, then the Edit menu item. Tap Graph Properties.



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



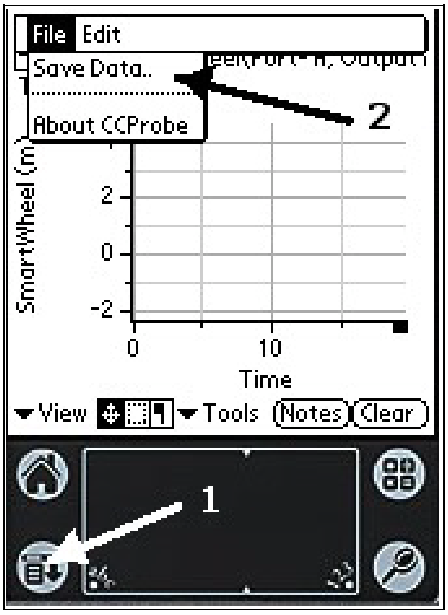
c. To change the range and the label of an axis, tap on the YAxis or XAxis tab. Write in the Max, the Min, and the Label, and then tap OK.



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

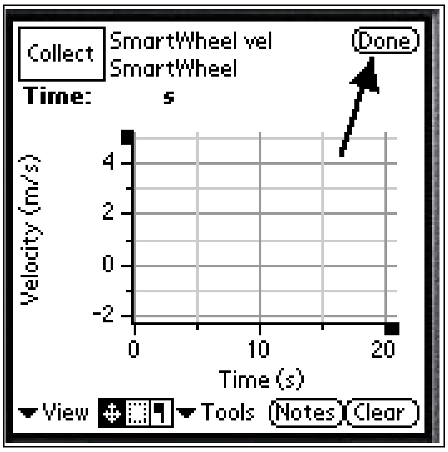
a. To save your data, tap the Palm menu icon at the bottom left corner. Then tap Save Data in the File menu. The menu will disappear when the data is saved. This may take several seconds.



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. You built a solar car in Trial I! What other features would it need to be a practical vehicle?

2. You were asked to rate the efficiency of each energy transformation. Low efficiency means that useful energy is lost. Where does the lost energy go, in the case of the solar cell, the light bulb, and the Genecon? How efficient do you think each transformation is?

3. What series of energy transformations is happening when one Genecon drives another? What do you think the efficiency of this system is?

4. Design an energy "Rube Goldberg" machine. This type of machine is a wacky series of devices that change energy through various forms and ends up serving a purpose. Please no live animals! Make a drawing of your Rube Goldberg on your handheld computer.

Further Investigations

- Measure the efficiency of the Genecon. Here are three ways:
- Build your own energy "Rube Goldberg" using the equipment in your kit or anything else you can find!

