

Motions and Forces Propeller

Discovery Question

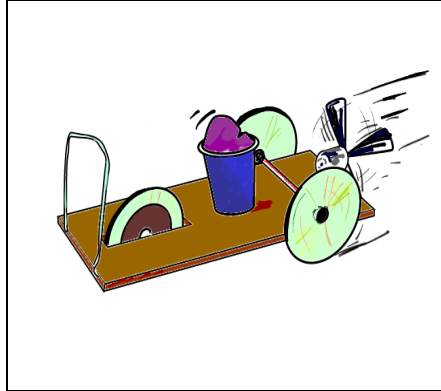
What are the effects of friction on the motion of the propeller-driven cart?

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Discovery Question

What are the effects of friction on the motion of the propeller-driven cart?

Introduction



In this activity you will investigate how friction and the driving force of a propeller mounted on an air cart oppose one another.

Thinking About The Question

What are the effects of friction on the motion of the propeller-driven cart?

If you sneeze in a weightless environment, as some of the astronauts have done, your body would move backwards and upwards. In order for a motion to happen, a force is needed. So, why does an astronaut's body move when they sneeze? What are the forces that occur during the sneeze? Write (or draw) your thoughts in Notes on your handheld computer.

Picture a propeller or fan blowing air. Think about how the accelerating air from the propeller relates to your description of the forces found during a sneeze in space. What is accelerating the air? Will your almost frictionless cart move when the propeller is turned on? Will it still move when you add more friction? Use arrows to draw the forces that will make the cart move? Write (or draw) your ideas in Notes on your handheld computer.

Materials

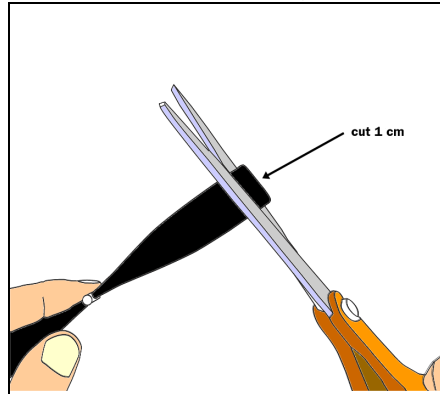
- CC SmartWheel probe installed on air cart
- handheld computer
- CC LabBook software
- constructed air cart (see Investigation: Air Cart)
- paper clip
- string or small, thin rubber band
- 2 - new 1.5V AA batteries
- scissors
- file card
- tape
- clay

Safety

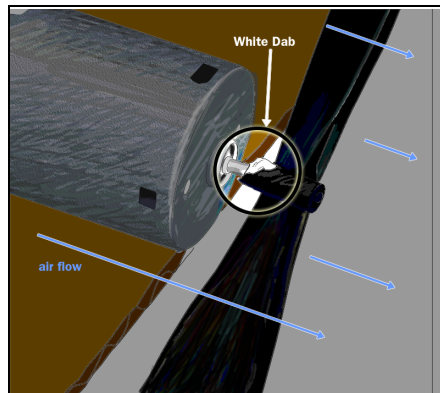
- The fan that is mounted on the air cart can hurt fingers when it is powered by the battery, so watch out for your fingers!

Trial I: Adding a propeller to a cart

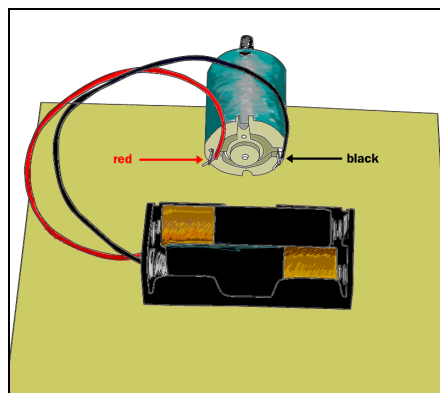
1. Use scissors to trim the ends of the plastic propeller (approximately 1cm) so that the ends of the propeller won't hit the ground.



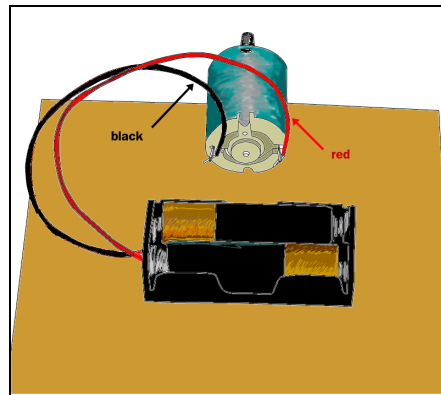
2. Press the propeller onto the shaft of the motor. The white dab of paint should face toward the motor.



3. Turn the propeller with your finger. Look at its shape. How can you tell which way the air will blow? Record your explanation in Notes on your handheld computer.
4. Now test your prediction. Choose the direction the propeller should turn to make the air blow away from the cart. While holding onto your cart, connect the battery wires to the motor. You can use the springiness of the wires to hold them lightly in place.



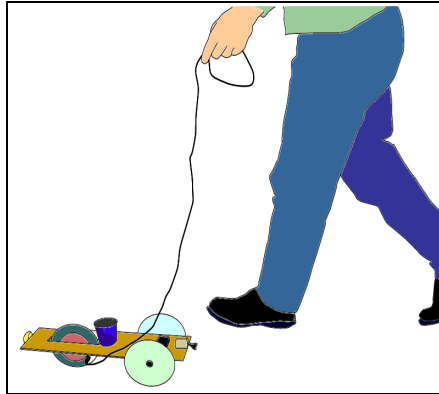
If the propeller doesn't blow away from the cart, reverse the wires.



5. Was your prediction correct? If not, write a better explanation. Write in Notes on your handheld computer.
6. While still holding onto your cart, carefully hold your other hand in front of and behind the propeller while it is on. Do you feel air moving in both locations or only in one? Is this the same as what you predicted? What is the difference you observe and why do you think it's that way? Record your answer in Notes on your handheld computer.

Trial II: Measuring the motion of a propeller-driven cart

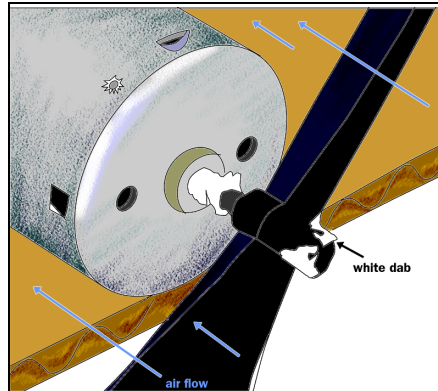
1. Connect the SmartWheel to your handheld computer. Refer to Technical Hints to see how to connect the SmartWheel.
2. Find a smooth surface, such as a tabletop or a linoleum floor, where the air cart will roll smoothly and easily. Drape the connecting wire loosely from above the cart so that it doesn't pull the cart one way or the other. If you run the cart a long way, one person will need to walk along with it, keeping the wire floppy.



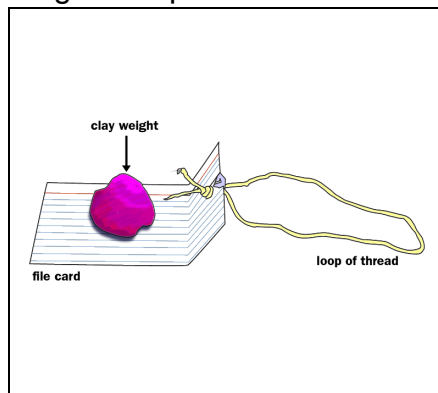
3. Start the software and observe the position versus time graph.
4. Start the propeller, holding on to the cart. Let the cart go and let it run for as far as you have space. Be sure to keep the wire floppy, so that it doesn't pull or push on the cart. Try several times until you get a really good graph, then save your data to the handheld computer.
5. What is the shape of the position graph? Is it a straight line? Why do you think it has this shape? What would it look like if your cart could keep going farther? Explain your reasoning in Notes on your handheld computer.

Trial III: Adding a friction sled to a propeller-driven cart

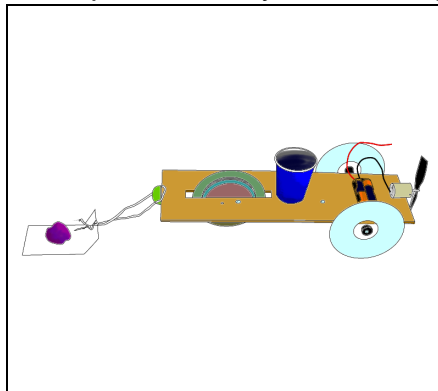
- Reverse the direction of the propeller and the motor so that it blows toward the cart. To do this, place the white dab of paint facing away from the motor, and reverse the red and black leads.



- Build a sled to drag behind the cart. Fold up one end of a file card. Make a loop of thread about 20cm long and tape one end of it to the file card.



- Hook the loop over the bumper. Use clay to add weight to the sled.

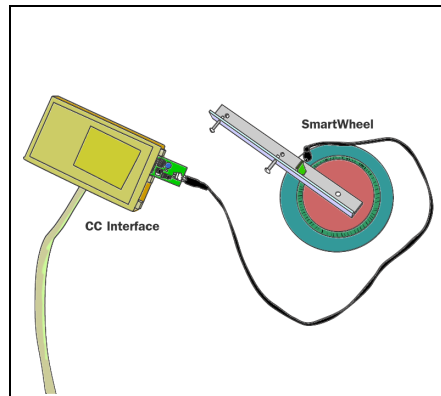


- Connect the SmartWheel to your handheld computer. Refer to Technical Hints to see how to connect the SmartWheel.
- Start the software to measure velocity. Make the following three measurements one after another with the graph running. You will then have all of your data on one graph, and you can analyze it. Note: because the cart is going backwards, the velocity graph will be upside down.

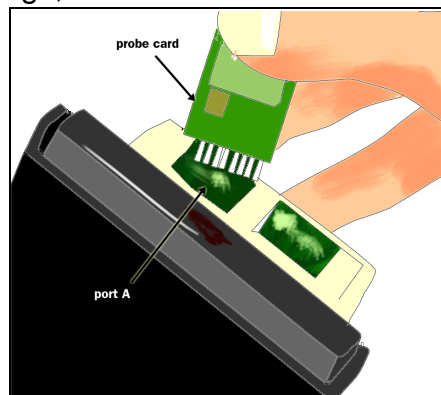
- a. With no weight on the sled, start the motor and let the cart go for about 3m.
 - b. Put some clay on the sled and hook it onto the bumper. Give the cart a push so that it rolls to a stop after about 3m.
 - c. With the clay still on the sled, start the motor and let the cart go for about 3m.
6. Save the data to your handheld computer.

Technical Hints

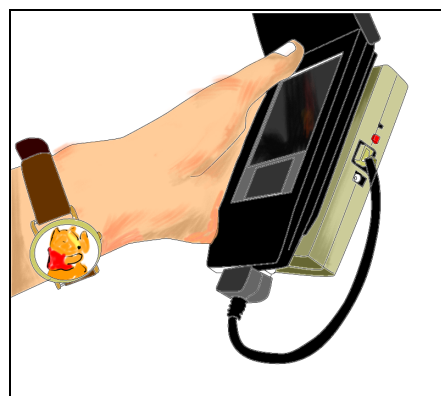
Connecting the SmartWheel



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



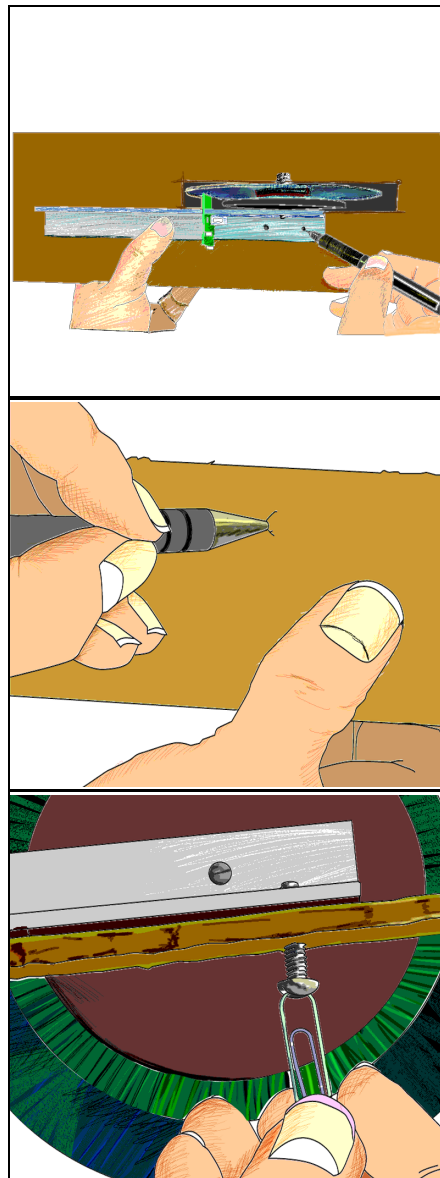
2. Attach the CCProbe Interface Box to your handheld with the Velcro square. Connect the CCProbe Interface Box to your handheld with the provided connector cable.

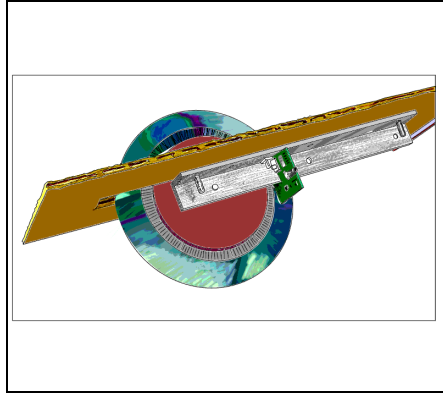


3. Tap on the CCProbe icon to open the software. Open or create a SmartWheel data collector. Choose either the linear position or the linear velocity mode.

Attaching the SmartWheel to the air cart

1. Center the SmartWheel in the slot so that it doesn't rub against the cardboard. Make it exactly parallel to the long edge of the cart. This will make the cart go straight. The aluminum arm goes against the underside of the cardboard, the same as the straw. Mark two screw holes with a pencil or pen, one at each end.
2. Make holes where the marks are, using a pencil or pen point. Enlarge the holes from both sides, until the screws fit snugly into them. The screws are provided with the SmartWheel.
3. Put the screws first through the cardboard from the other side, and then screw them into the arm of the SmartWheel. Tighten them until the heads squeeze the cardboard a little bit. A paper clip will work as a screwdriver.
4. The SmartWheel is now ready to use.





Using the CC LabBook software

To use CC LabBook just follow these easy steps!

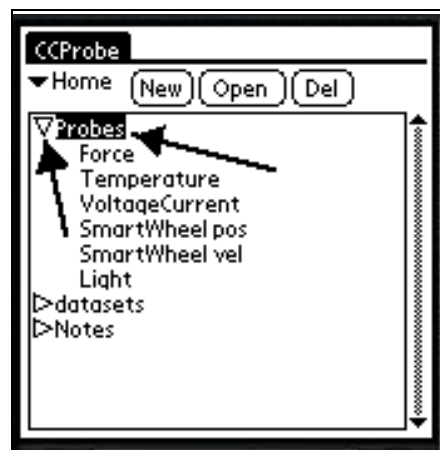
1. Opening the software

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



- b. The first screen you see is the LabBook.

2. Opening folders and subfolders



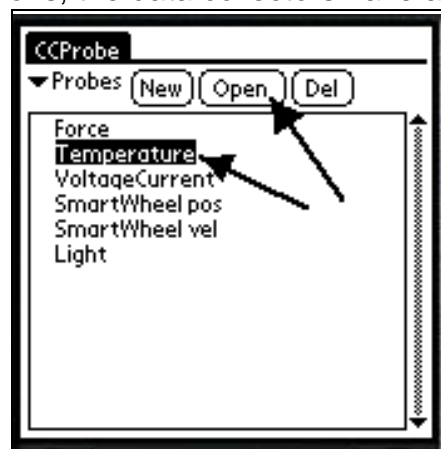
- a. The LabBook lists all of the folders, data collectors, notes, saved datasets, and other objects in the LabBook. To open folders and subfolders, tap the triangles or double-tap the folder name.



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

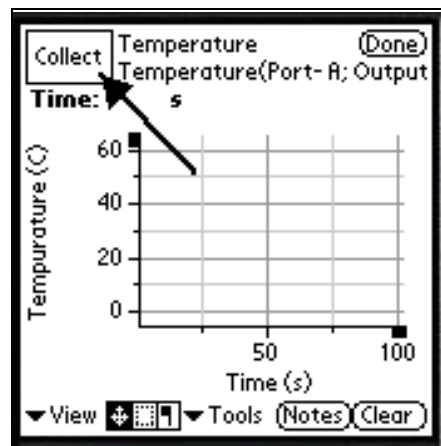
3. Opening a data collector

- 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.

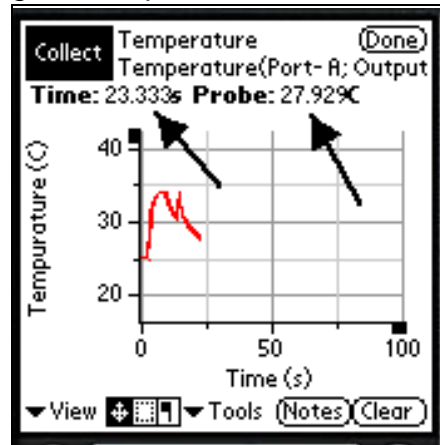


- b. To open an existing data collector, highlight its name, then tap it twice or tap Open. It may take a few seconds for the graph to appear.

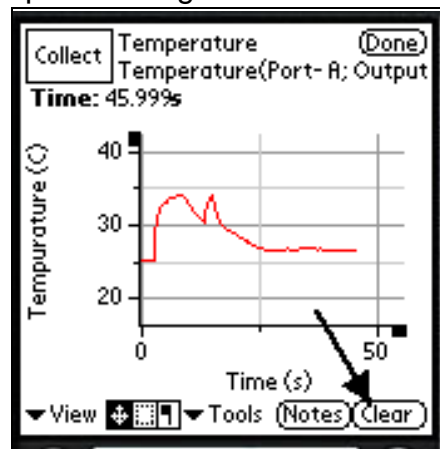
4. Collecting and clearing data



- a. To start collecting data, tap Collect.



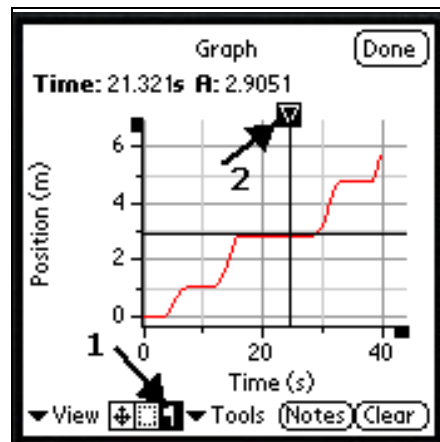
- b. As data is collected, the current values appear at the top of the graph. To stop collecting, tap Collect again.



- 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

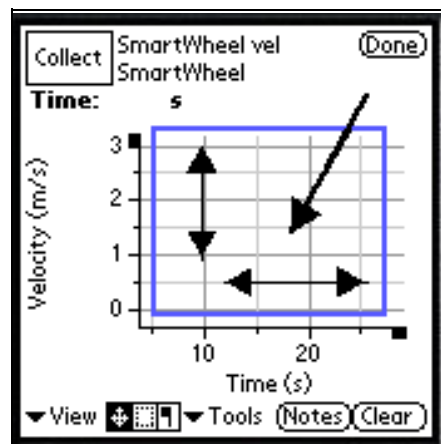
Force probe, 200/sec = about 15 seconds

SmartWheel = about 40 seconds

All others 3/sec = several minutes

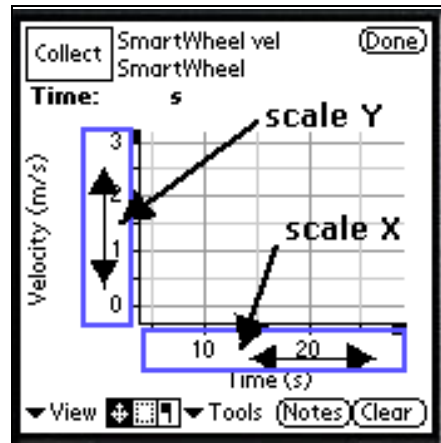
7. Scrolling around the graph

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

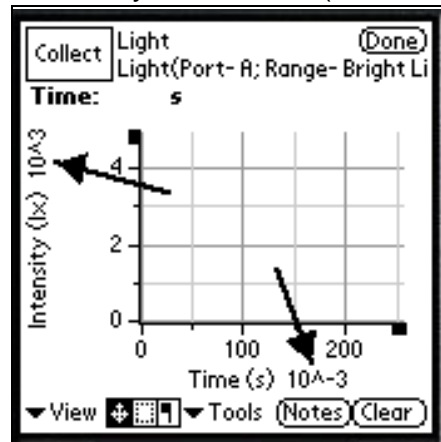


8. Changing the scale of an axis

- 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.

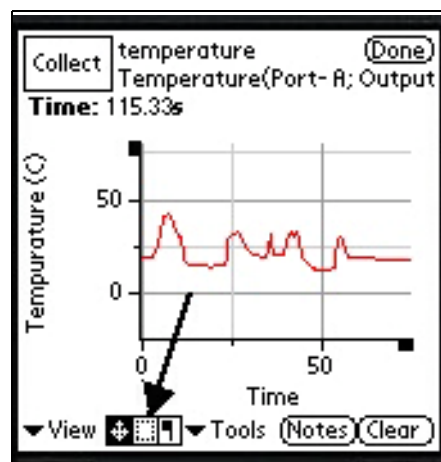


- b. If you stretch or shrink the scale a great deal, it will switch by a factor of 1000, shown as 10^3 (for large numbers) or 10^{-3} (for small numbers). For example, in the following screen, time is in milliseconds ($1/1000$ of a second) and light intensity is in kilolux (1000 lux).

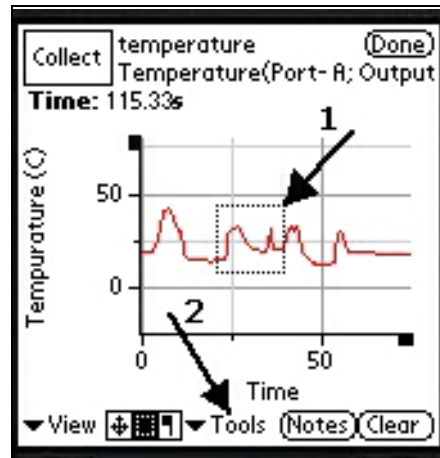


9. Zooming in on the graph

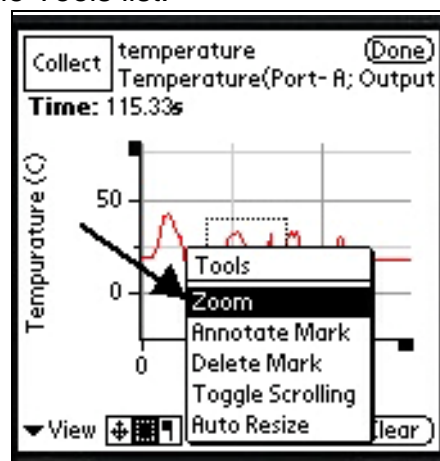
- a. To zoom in on part of a graph, tap on the area selector at the bottom of the screen.



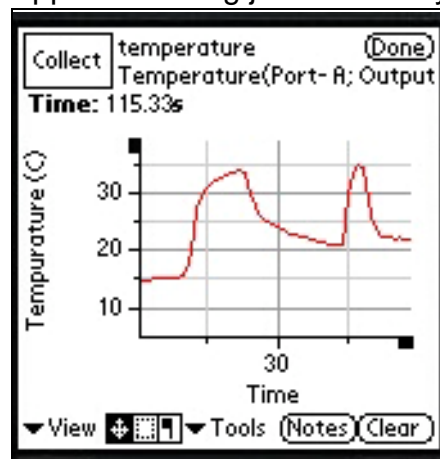
- b. Drag the outline around the area of the graph you want to zoom in on, then tap Tools.



- c. Click Zoom in the Tools list.

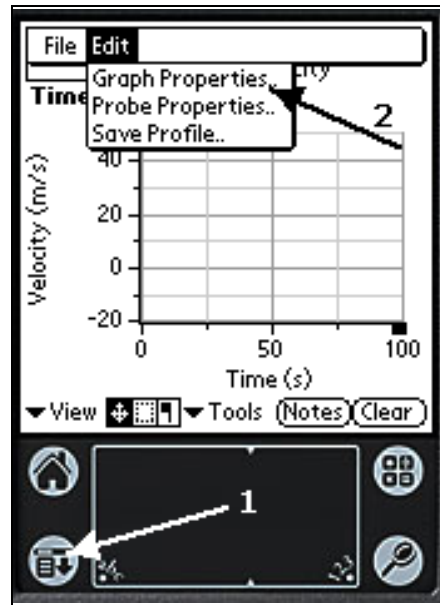


- d. The graph will reappear showing just the area you selected.

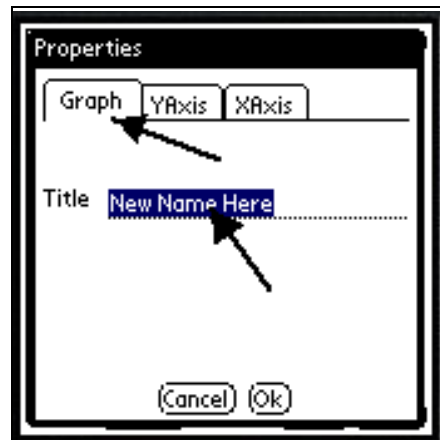


10. Changing graph properties

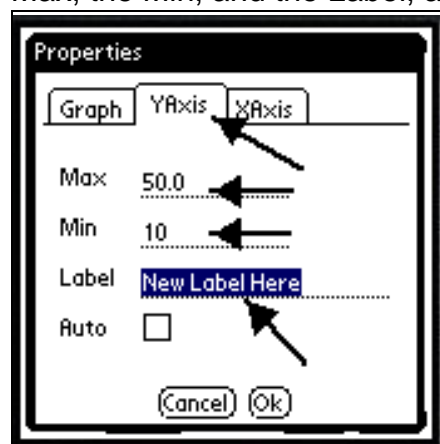
- a. To change graph properties, tap the Palm menu icon at the bottom left corner, then the Edit menu item. Tap Graph Properties.



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



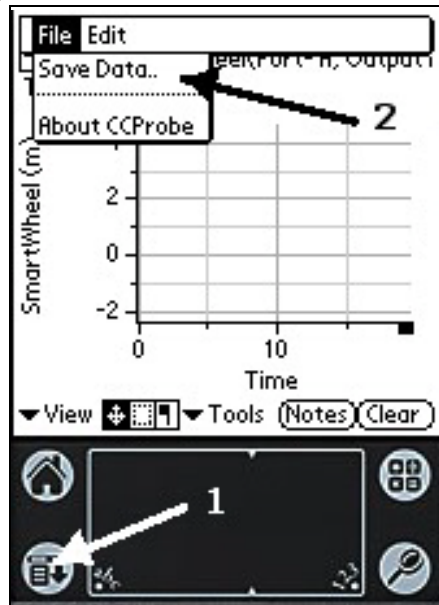
- c. To change the range and the label of an axis, tap on the YAxis or XAxis tab. Write in the Max, the Min, and the Label, and then tap OK.



- 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

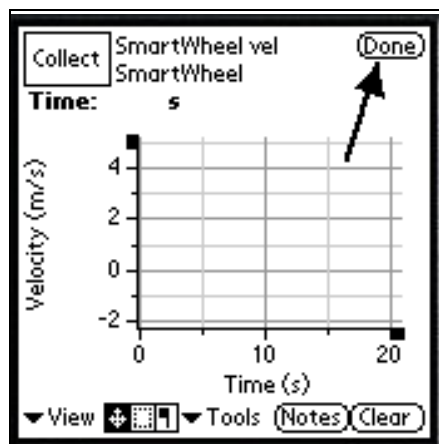
- a. To save your data, tap the Palm menu icon at the bottom left corner. Then tap Save Data in the File menu. The menu will disappear when the data is saved. This may take several seconds.



- 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. How does a propeller create a force that pushes on a cart?
2. Would a propeller work in outer space, where there's no air? If not, how could you make something move in outer space?
3. Look at your position versus time graph in Trial II. Is the velocity of the cart constant? How can you tell?
4. Look at your velocity versus time graph in Trial III. For each case, describe the graph and then write why you think it has that shape.
 - a. no friction, push cart
 - b. add friction, push cart
 - c. add friction, run propeller
5. Do you think the graphs are evidence that friction exerts a force like the propeller, but in the opposite direction?
6. The rate of change of velocity is the slope of the velocity versus time graph. What is happening to the cart when the slope of the velocity graph is not zero? What is done to the cart to increase or decrease its rate of change of velocity?

Further Investigations

- Can you add enough clay to the sled so that the propeller makes it reach a maximum velocity and then level off? What do the position and velocity graphs look like? This is called "terminal velocity". In what other situations is there a terminal velocity?
- Try placing a different designs of wind shields or sails on your cart to affect its motion.
- Add clay to the sled until it just won 't move. What 's the force on the cart at this moment?