Transfer of Energy
Potential and Kinetic Energy

Discovery Question

When you roll a cart up and down a ramp, how does the velocity change as the height of the cart changes?

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Discovery Question

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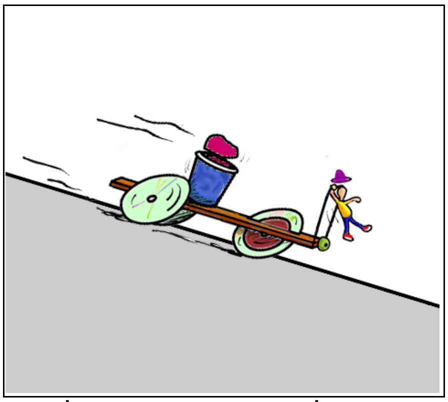
Introduction



In this activity you will relate the movement and energy of a cart as it rolls up and down a ramp.

Thinking About The Question

When you roll a cart up and down a ramp, how does the velocity change as the height of the cart changes?

A basketball player going for a lay up is a good example of an object in motion. Just as the player is ready to release the ball, the player exhibits both gravitational potential energy (how high the player jumps) and the kinetic energy of motion (how fast the player is going). How do these two energies relate?

Think about what happens when you are swinging on a playground swing. When you are near the ground, you are going fast. At the top of your swing you are stopped for a split second. Draw the motion of the swing. Where do you have the most energy? Where is the (gravitational) potential energy the greatest? Where is the kinetic energy the greatest? Use Notes on your handheld computer.

Materials

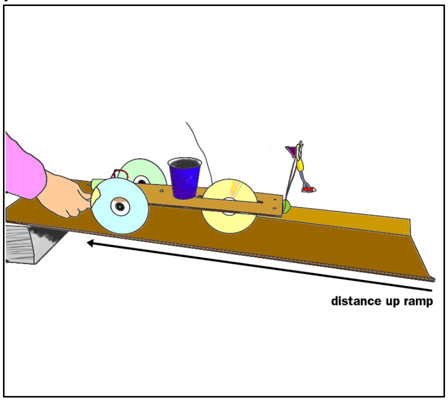
- CC SmartWheel probe
- handheld computer
- CC LabBook software
- constructed air cart (see Investigation: Air Cart)
- cardboard ramp (see Investigation: Air Cart)
- books to prop up ramp
- measuring tape or meter stick
- rubber bands

Safety

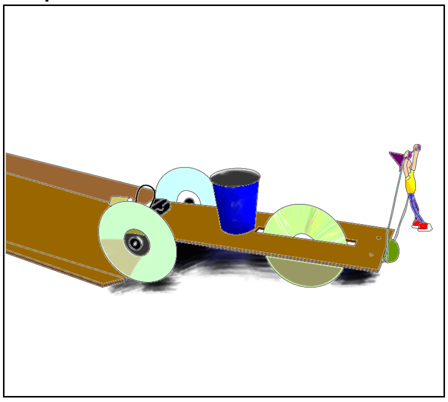
- Be careful with stretched rubber bands. They can hurt if you let them go and they hit someone!

Trial I: Rolling a cart down a hill

1. Set the ramp with a height of 10cm at the higher end. Place the cart on the ramp with the back wheels near the top. Mark where the back wheels are so you can repeat the experiment several times.



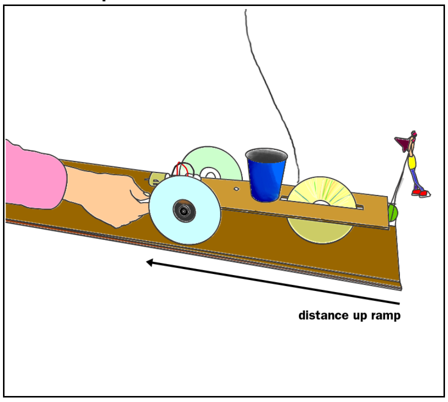
2. Connect the SmartWheel to your handheld computer. Refer to Technical Hints to see how to connect the SmartWheel.
3. Start the software to read a velocity versus time graph.
4. Let the cart roll down the ramp and continue along the floor or desk. If you have room, let it coast to a stop.



5. Stop the software immediately after a good roll and save your data.
6. When the cart is rolling, it has what's called kinetic energy, or energy of motion. Yet when the cart started, it had no kinetic energy because it was not moving. So where did the energy come from? What is the greatest velocity of the cart? Where does this occur? Explain your reasoning in Notes on your handheld computer.

Trial II: Changing the starting height of the cart

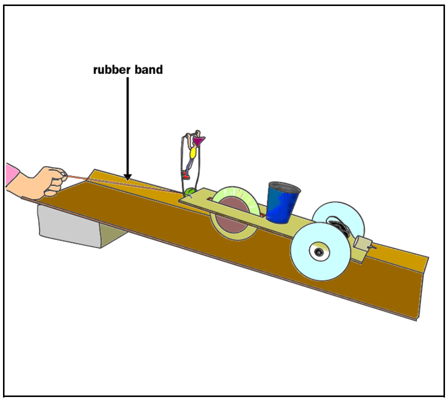
1. Connect the SmartWheel to your handheld computer. Refer to Technical Hints to see how to connect the cables.
2. Set the ramp with a height of 10cm at the higher end. Place the cart on the ramp with the back wheels halfway up the ramp. Mark where the back wheels are so you can repeat the experiment several times.



3. Start the software to read a velocity versus time graph.
4. Let the cart roll down the ramp and continue along the floor or desk. If you have room, let it coast to a stop.
5. Stop the software immediately after a good roll and save your data.
6. When the cart is rolling, it has what's called kinetic energy, or energy of motion. Yet when the cart started, it had no kinetic energy because it was not moving. So where did the energy come from? What is the greatest velocity of the cart? Where does this occur? Explain your reasoning in Notes on your handheld computer.

Trial III: Bouncing a cart down and up a hill Bouncing a cart down and up a hill Bouncing a cart down and up a hill

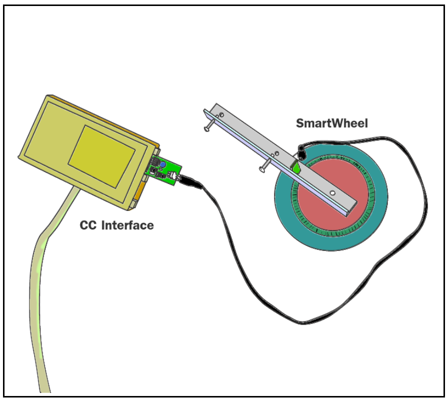
1. Connect the SmartWheel to your handheld computer. Refer to Technical Hints to see how to connect the cables.
2. Rubber bands can also store energy by being stretched. Attach one or several rubber bands (connected in line) to one end of the cart. Attach the other end to a table leg or stand so that the cart is held halfway up the ramp and is free to move up and down. It's something like a bungee cord but at an angle. You may need some string as well as the rubber bands.



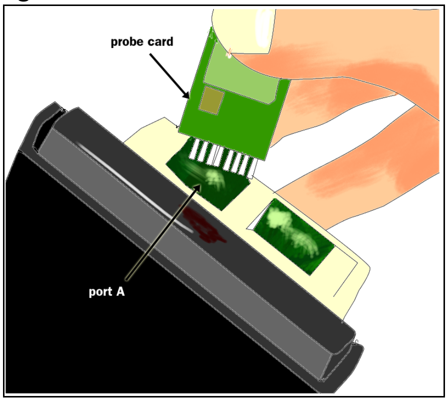
3. Start the software to read a velocity versus time graph.
4. Raise the cart to the top of the ramp and let it go.
5. Stop recording after it bounces up and down the ramp and comes to rest. Save your data to the handheld.
6. At what points in the cart's travels did it have the greatest speed? At what points did it have zero speed? How can you tell from the graph when the cart was going down and when it was going up? Explain your reasoning in Notes on your handheld computer.

Technical Hints

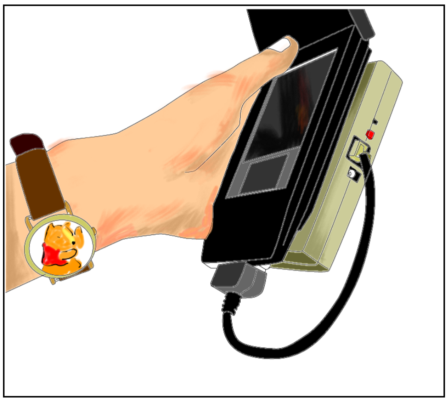
Connecting the SmartWheel



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.

Using the CC LabBook software

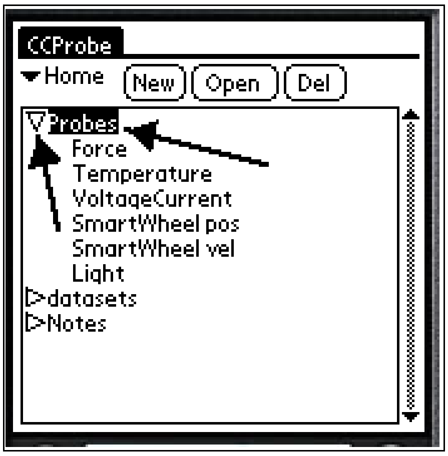
To use CC LabBook just follow these easy steps!

1. Opening the software

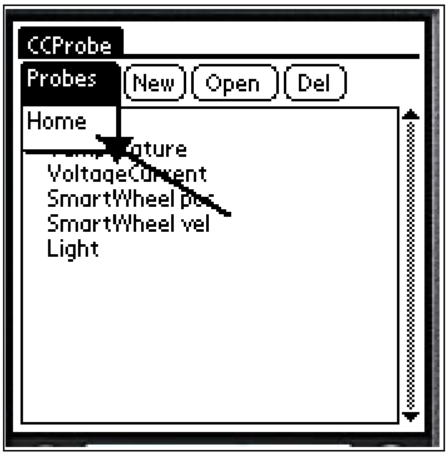
a. To open the software, tap the CCProbe icon.

b. The first screen you see is the LabBook.

2. Opening folders and subfolders



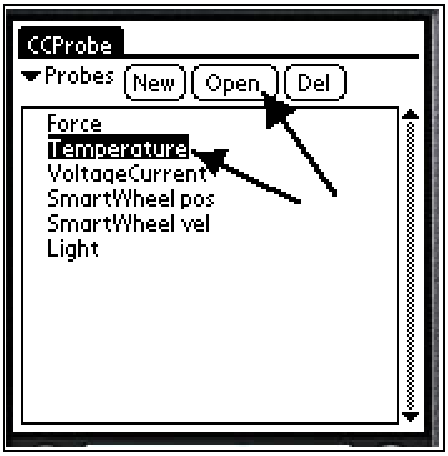
a. The LabBook lists all of the folders, data collectors, notes, saved datasets, and other objects in the LabBook. To open folders and subfolders, tap the triangles or double-tap the folder name.



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

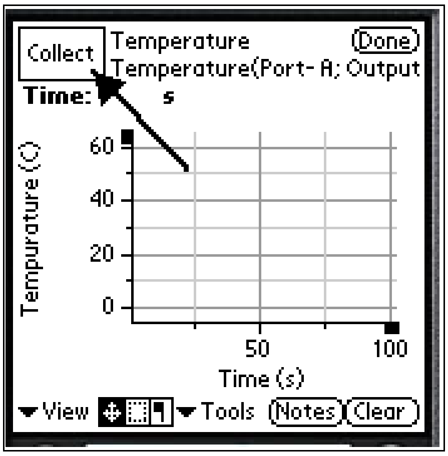
3. Opening a data collector

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.

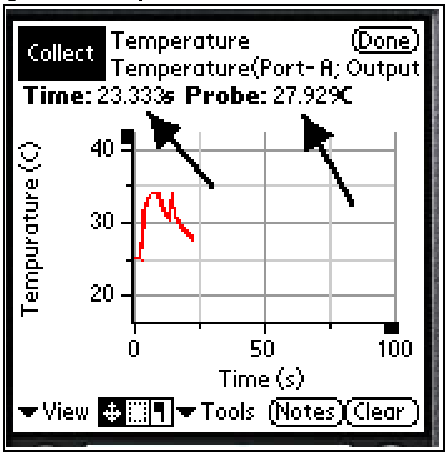


b. To open an existing data collector, highlight its name, then tap it twice or tap Open. It may take a few seconds for the graph to appear.

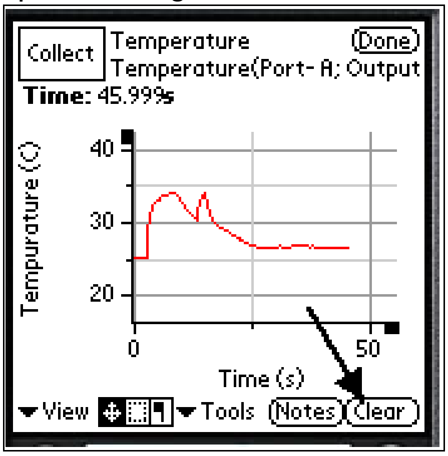
4. Collecting and clearing data



a. To start collecting data, tap Collect.



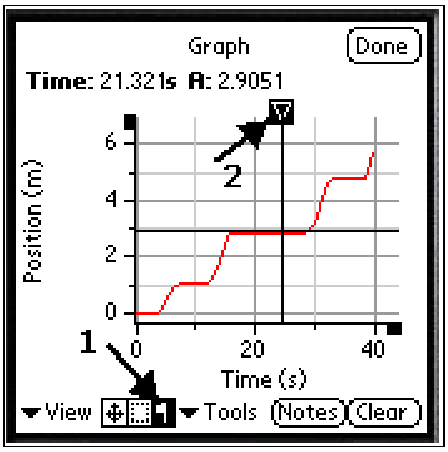
b. As data is collected, the current values appear at the top of the graph. To stop collecting, tap Collect again.



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

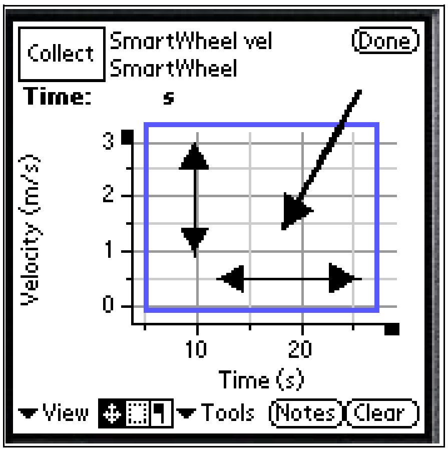
Force probe, 200/sec = about 15 seconds

SmartWheel = about 40 seconds

All others 3/sec = several minutes

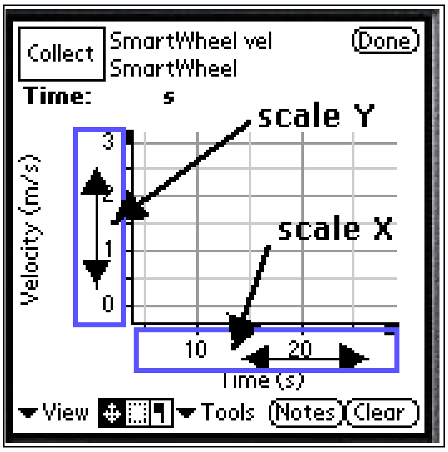
7. Scrolling around the graph

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

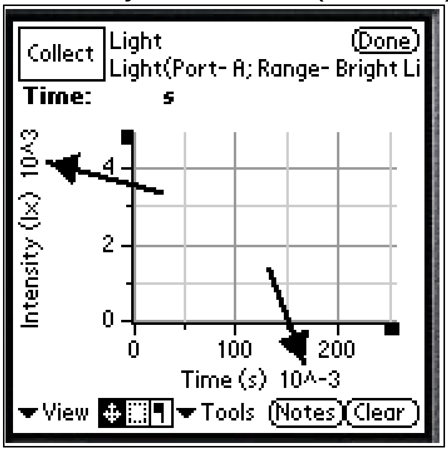


8. Changing the scale of an axis

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.

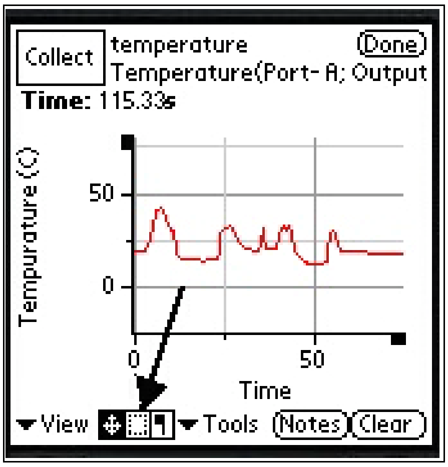


b. If you stretch or shrink the scale a great deal, it will switch by a factor of 1000, shown as 10^3 (for large numbers) or 10^-3 (for small numbers). For example, in the following screen, time is in milliseconds (1/1000 of a second) and light intensity is in kilolux (1000 lux).

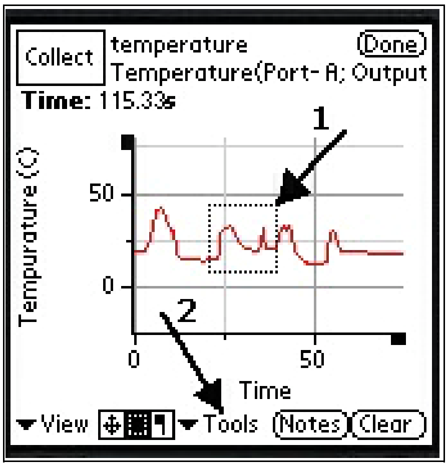


9. Zooming in on the graph

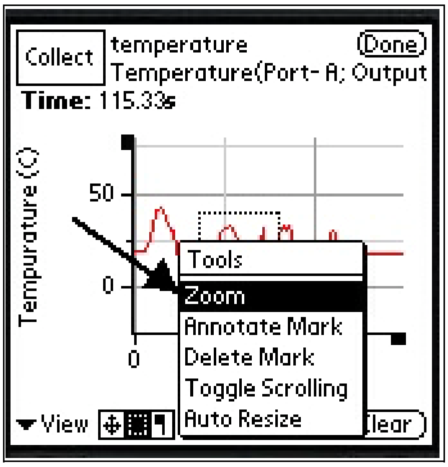
a. To zoom in on part of a graph, tap on the area selector at the bottom of the screen.



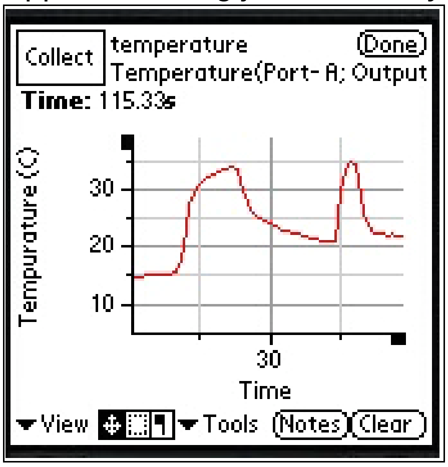
b. Drag the outline around the area of the graph you want to zoom in on, then tap Tools.



c. Click Zoom in the Tools list.

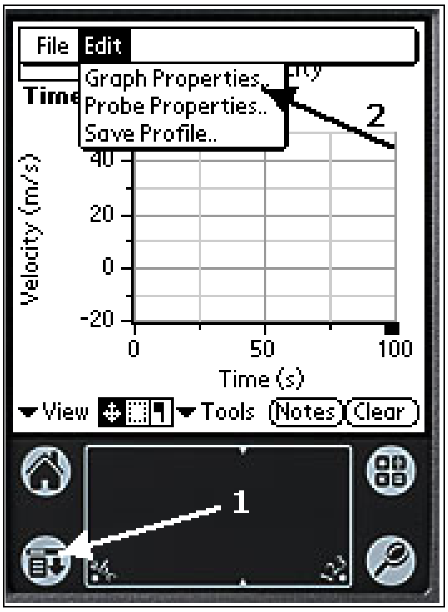


d. The graph will reappear showing just the area you selected.

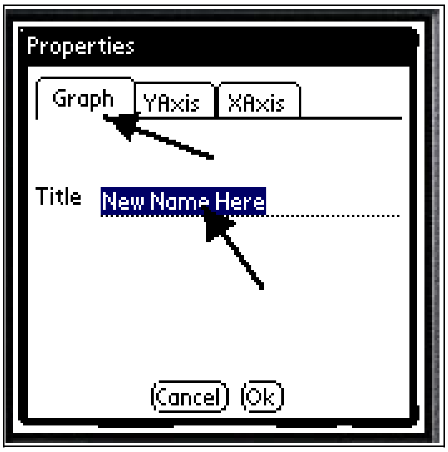


10. Changing graph properties

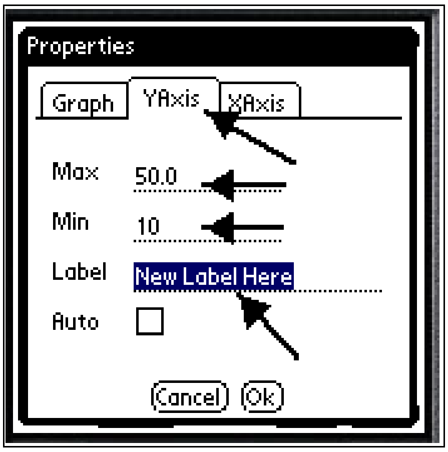
a. To change graph properties, tap the Palm menu icon at the bottom left corner, then the Edit menu item. Tap Graph Properties.



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



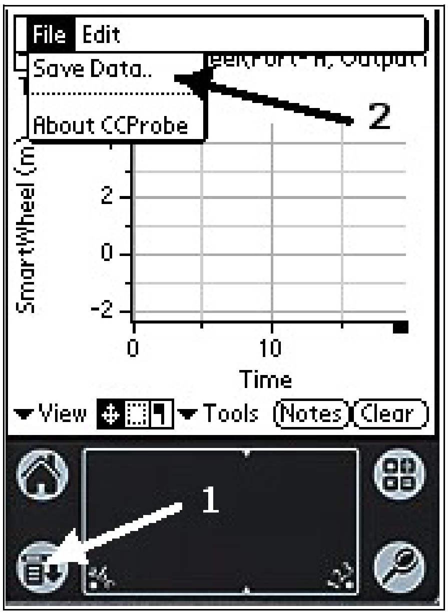
c. To change the range and the label of an axis, tap on the YAxis or XAxis tab. Write in the Max, the Min, and the Label, and then tap OK.



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

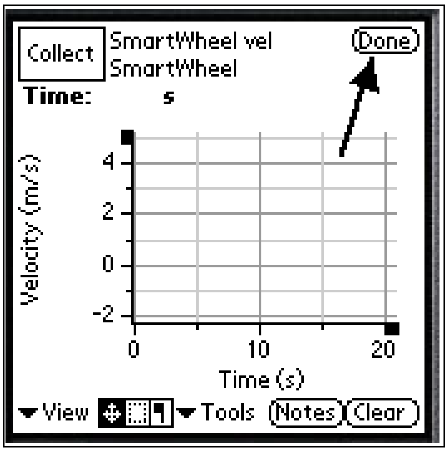
a. To save your data, tap the Palm menu icon at the bottom left corner. Then tap Save Data in the File menu. The menu will disappear when the data is saved. This may take several seconds.



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 Trials I and II, the cart has two forms of energy. The first, gravitational potential energy, is proportional to an object's height above the Earth. The higher an object, the more gravitational potential energy it has. When did the cart have the greatest potential energy? Why?

2. The second form is kinetic energy, also called energy of motion. It depends on an object's velocity. When did the cart have the greatest kinetic energy? Why?

3. Do you think the cart has as much kinetic energy at the bottom of the ramp as it had potential energy at the top of the ramp? Why?

4. Energy can also be stored in a stretched rubber band. It's another form of potential energy. If you "hang" a cart down a ramp with a rubber band, then let it bounce up and down, energy is going from (gravitational potential) to (kinetic) to (rubber band potential). Look at your data from Trial III. Draw the graph. Where on the graph is each kind of energy the greatest?

5. After the cart leaves the ramp, it slows down, losing its kinetic energy. Where does the energy go?

6. We often want to store energy for later use. The useful energy might not always be kinetic energy - it might be light from a bulb, or heat in a room. How many examples of this can you list? List the form of stored energy and the form of useful energy that comes from it.

Further Investigations

- Add weight to the cart. Does that affect its final velocity? Do you think a heavier cart has more energy than a lighter cart, when they're going at the same speed? Where does the additional energy come from?
- Calculate the cart's potential energy (PE) and kinetic energy (KE). Here's how:

  PE (joules) = mass(kg) * 9.8(m/s*s) * height(m)

  KE (joules) = 0.5 * mass(kg) * velocity(m/s) * velocity(m/s)

  Use the Force probe to measure the mass (weight/9.8 (m/s*s) of the cart. The height of the cart is the distance up the ramp times its slope (height of the ramp/length of the ramp).

- How are potential energy and kinetic energy related as the cart rolls down the ramp? To find out, place the cart with the back wheels at the bottom of the ramp and start recording both velocity and position. By hand, roll the cart up to the top of the ramp and let it roll back down the ramp. After collecting your data, pick five times and mark both them on both the velocity and the position graphs. One mark should be at the top and one just as the cart reaches the bottom of the ramp.

  Calculate the PE and KE (refer to the above formulas) at each of these times. In this case, the height of the cart in the formula for PE is equal to the slope of the ramp times the position reading. Add the PE and KE together. Does the sum remain constant? Should it remain constant?

