

Technologies for Learning - Velocity and Acceleration

The goal of this unit is to understand how different technologies and approaches can contribute to the understanding of velocity and acceleration. You will be using several different versions of the same experiment to learn first hand how these media affect the learning process. As you conduct your experiments you should also be considering implementation and curricular issues such as:

- how the different media could be combined to enhance student learning, and in what order you might present them
- what time and material constraints might dictate your choice of one medium over another
- which media you would choose for different types of learners
- what your particular learning goals are for your students.

The experiment that you will be doing is a classic physics experiment in which you roll a cart down an inclined plane. In this experiment you will investigate how the angle of the inclined plane affects the velocity and acceleration of the cart. Specifically, you will be answering the following questions:

- How does the angle of the inclined plane affect the distance that the cart travels once it leaves the plane?
- What happens to the velocity and acceleration of the cart as it proceeds down the plane and then onto the floor?
- How does friction affect the outcome of the experiment?
- Where does the cart hit maximum velocity and acceleration? What factors influence the velocity and acceleration?

At the end of each experiment you should be able to describe a theory that explains the velocity and acceleration of the cart as it proceeds down the ramp, how these are affected by the angle of inclination and predicts the distance that the cart travels after it leaves the ramp.

The four approaches that we will be using are:

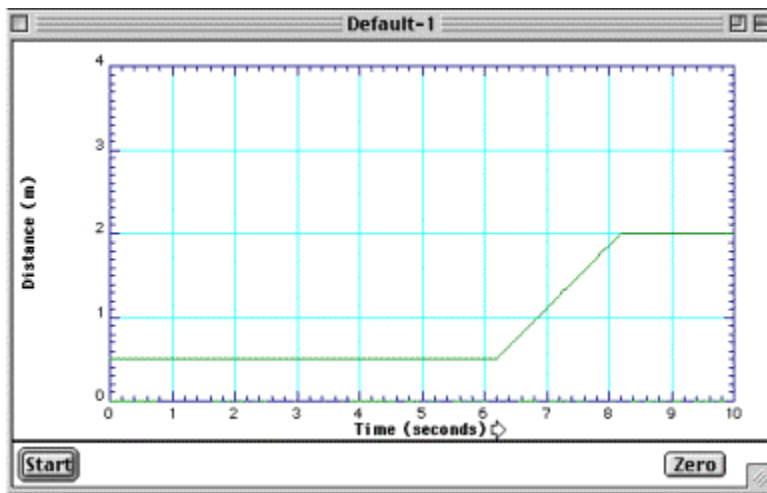
- Rolling a cart down an inclined plane. You will measure velocity and acceleration using a stopwatch and a ruler.
- Rolling a cart down an inclined plane. You will measure velocity and acceleration using the

sonic ranger that continuously outputs data to the computer.

- Using the Interactive Physics program to simulate rolling a cart down an inclined plane.
- Using the Stella modules that provide a system dynamics explanation of a cart rolling down an inclined plane.

Instructions for using the sonic ranger, the Interactive Physics program and the Stella modules are provided here.

Sonic Ranger



To start using the sonic ranger connect the sonic ranger to the CBL box using the gray cable. Then connect the TI-86 to the CBL box. Turn on the CBL box with the On/Halt button and turn the calculator on. On the calculator press PRGM and choose names by pressing F1. Press F1 again to

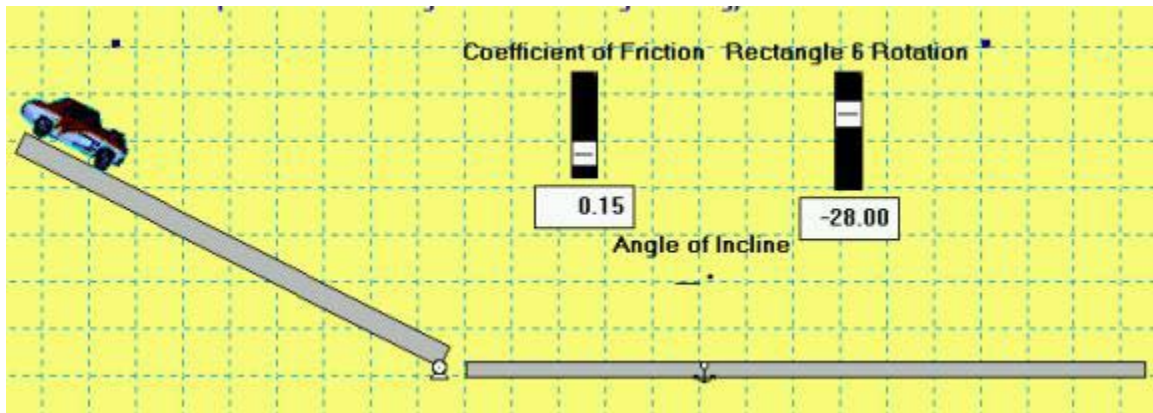
choose physics. Press Enter and then press Enter again.

Choose collect data by pressing F2. Choose Time Graph by pressing F2. You will be prompted to enter the time between samples in seconds (I have used values around .05). Enter the number and press Enter. Then Enter the number of samples you would like to take and press Enter. Press Enter to accept the values and press F1 to confirm. You are now ready to collect your samples. Line up the gold disk on the front of the Motion Detector to be in line with the path of the car. Press enter to begin recording data.

The data will be collected. Press Enter to view your options for inspecting the data. You can look at graphs of Distance, Velocity, and Acceleration. Press the key that corresponds with the graph that you would like to see. Press enter to return to the Select a Graph menu. When you are looking at the graphs, the arrow keys can show you the time (x) and value (y) of the point in the graph. When you are done, hit next. If you would like you can immediately perform a new experiment with the same collection values, or reset the values to better accommodate your data.

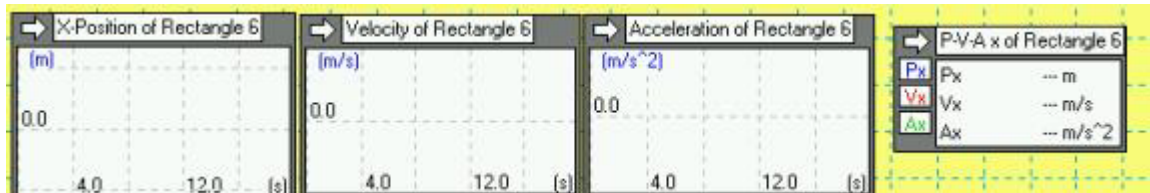
Interactive Physics

Running the Interactive Physics program is similar to running the sonic ranger, only the cart is on the screen. To change the angle of the inclined plane, click and drag on the left-hand side of the ramp. The ramp will move as you drag your mouse. You will need to reposition the cart appropriately by clicking and dragging it. You also might need to readjust the angle of the car using the **Rectangle 6 Rotation** slider. Finally, you can change the coefficient of friction using the other slider on the screen.



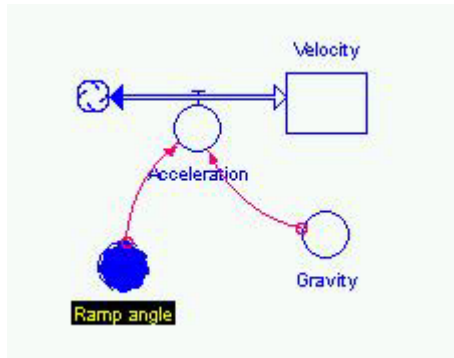
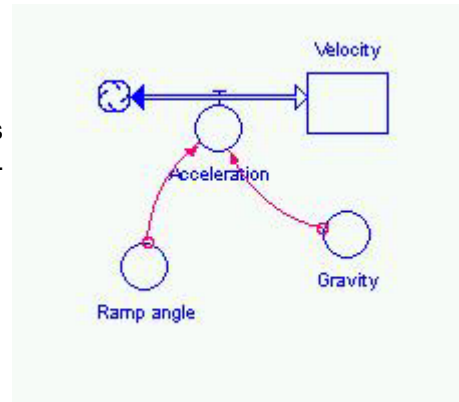
Once you have the model set up the way that you would like, click on the **Run** button. The car will keep running (even if it is not moving) until you hit the **Stop** button. You can also stop and restart the simulation if you would like. To get the car back to the top of the ramp, hit the **Reset** button.

As the car runs, you will see graphs with the x position, x velocity, and x acceleration printed at the bottom of the screen. You will also see live readouts of the values. You change the parameters of any graph by double-clicking on it.



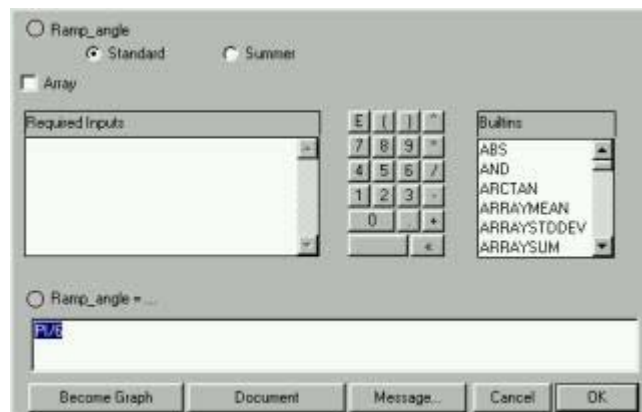
Stella

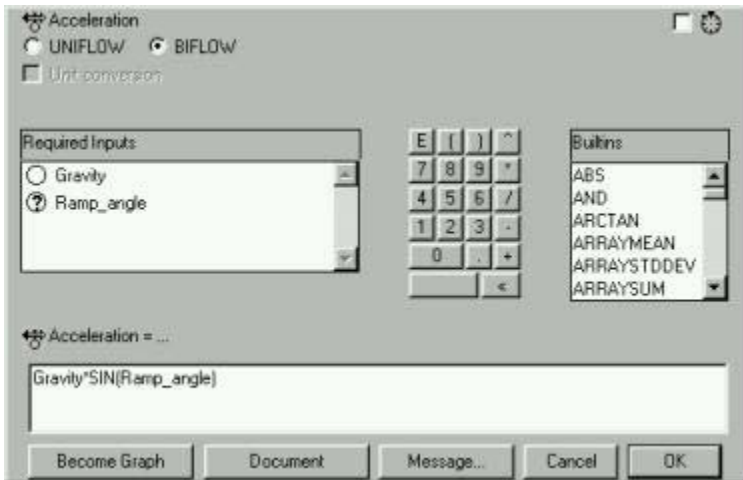
The Stella program provides a system dynamics model of the cart rolling down the inclined plane. There are three such models (v1, v2, and v3) that increase in complexity. The simplest model (v1) is a model of an infinitely long ramp, and does not include friction. The diagram of the model is shown here:



This is a standard stock and flow diagram. Stocks are quantities of something, and flows are rates that change those quantities. In this case, the stock is velocity and the flow is acceleration. That is, acceleration is a rate that changes velocity. The two inputs that effect acceleration are the Ramp angle and Gravity.

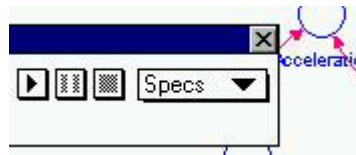
The circles that define these parameters are called Converters, and the arrows that connect them are called Connectors. You can change the value inside of one of the converters by double-clicking on it. This will open up a dialog box such as the one shown here. You can edit the value for ramp angle that is expressed in radians. In this case the current values is $\pi/6$



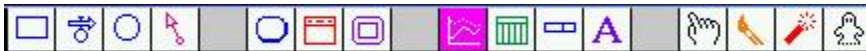


You can also check out the formula for the flows to see how they affect the stocks. In this case, double-clicking on acceleration would tell you that acceleration is equal to gravity * sin (ramp_angle).

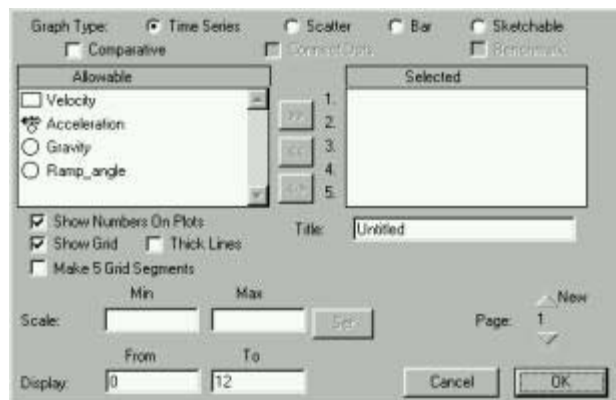
You run the model by going to the Run menu and selecting Run. This will bring up a similar palette to the one in Interactive Physics. To run the model click on the triangle.

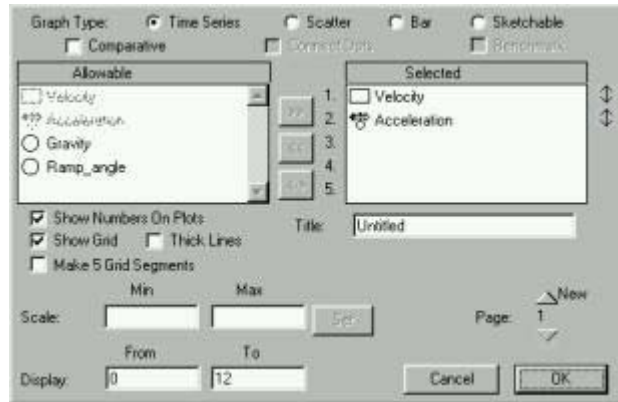


In order to see output, you will need to create a chart or graph. Click on the graph tool in the toolbar.



Click somewhere in the white space to create a new graph. This will bring up a graph dialog as shown here. Click on the variables that you want to plot in the Allowable column and then click on the right arrows to move them to the selected column. You can also change plot axes here. When you are done, click ok.





The graph that you create will show a time series plot of the variables that you chose. Making a table is a similar process. The values are immediately updated when you run the model again.

There are two more Stella models included here. The second one (v2) adds a ramp of finite length. Note this is implemented by having one equation for the top of the ramp, and another for the straight part. The last model (v3) adds friction, allows you to change the length of the ramp and to specify its angle in degrees.

Consider as you use these models how easy it is to learn from the different versions that vary in complexity and realism.

