

## Appendix F: Simulation Programs (LabSims)

*Note: Up-to-date information on using the LabSims can be found by pressing the “Sim Help” button at the lower left corner of a simulation window.*

A LabSim program is a computer simulation of some of the situations you encounter in the lab. Simulations let you do things you can't do in the real world, in order to see what happens in those circumstances. That may sound silly (why would anyone *care* about what happens in an unreal world), but is actually very useful. If your data doesn't match your predictions, a simulation can help you find out what is causing the difference by letting you look at the consequences of different potential causes, and seeing what effects they make in isolation, without getting confused with something else.

The LabSims are meant to let you “explore the experiment”, and to see the effects of different physical interactions. For example, suppose you thought your real experiment didn't match your predictions because of air resistance (which is present in the real world, but not in your predictions). A simulation lets you investigate the effects of air resistance by itself, without getting confused with other kinds of friction. Simulations also let you “turn up” air resistance to ridiculous levels, so you can see the form of its effects very clearly. If simulated air resistance does reproduce the problems you see in your data, then it might be the cause; if it fails to reproduce them, you should look elsewhere.

### USING THE LABSIMS

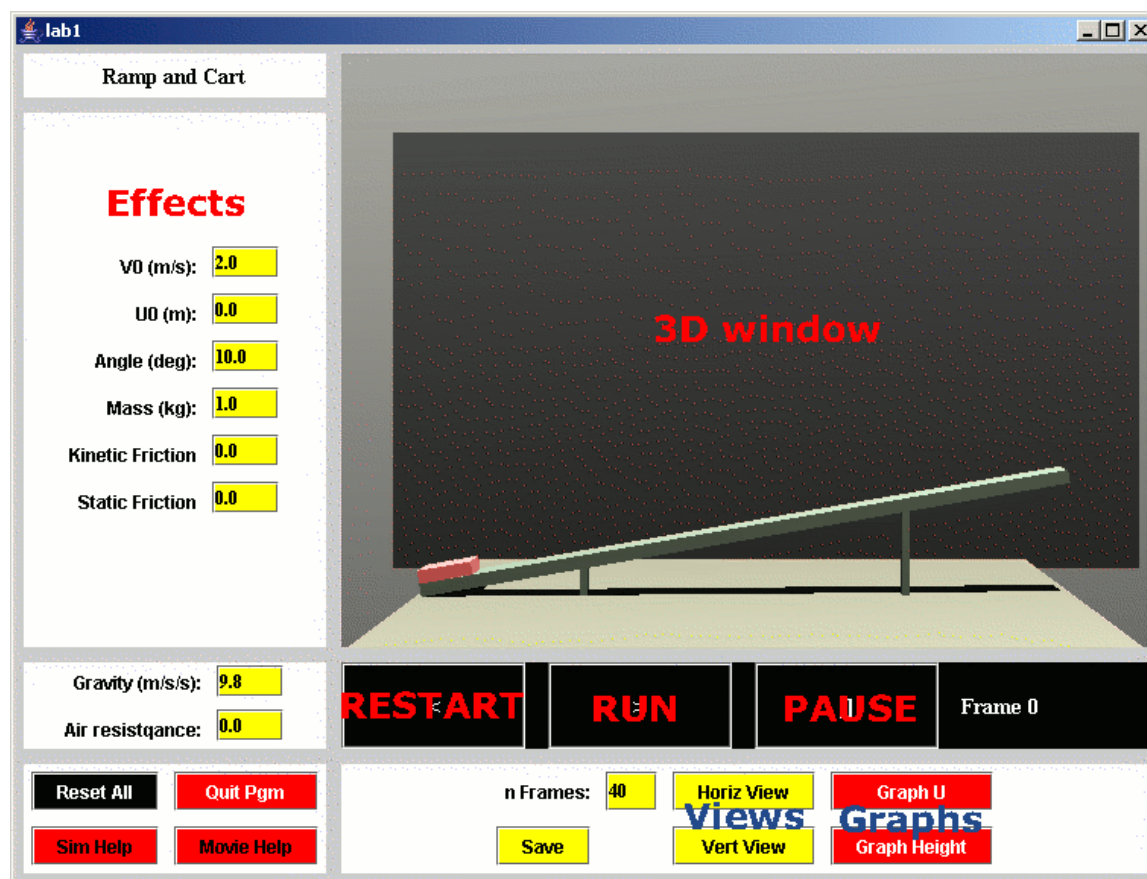
Once you get a LabSim program going, the easiest way to see what it does is to push the *Run* button, which is right under the 3D window (it's the black button with the “>” label). “Run” makes the LabSim go, using the *values in the yellow windows* to the left. You can change the length of a run by changing the *number of frames* (the current frame number is shown to the right of the run button). The “|<” button is a “*Rewind*”, which places all objects in their initial positions. The “||” button is “*Pause*”, which stops everything. The buttons are meant to look like those on a DVD player or VCR.

### 3D NAVIGATION

You can “walk” around in the 3D window by using the *arrow keys* (but first you **MUST** put the mouse in the 3D window). The arrows move you around rather like in a video game, with which you may have experience. Holding down *ALT* while you push the arrows lets you move up and down or back and forth (gamers call it a “*strafe*” button) and *CTRL* lets you tip up and down. Experiment with these.

### WHEN YOU GET LOST

If you get lost in the 3D space, click the “*Horiz View*”, “*Vert View*” or “*Reset All*” buttons. *Horiz View* brings you back to your starting point, *Vert View* puts you over the table looking down, and *Reset All* resets everything to where it was when the program started.



## PARAMETERS

The panel to the left of the 3D view has names and values of all the things you can vary in the experiment. For example, in the simulation pictured below you can adjust the cart's initial speed or position, change the ramp angle, change the cart's mass, or create friction. You *change them by typing in new values*, then see what happens by pushing *Rewind* and then *Run*. If you change so many things you don't know where you are anymore, and you just want to get back to some reasonable defaults, click on "Reset All." in the lower left panel.

## GRAPHS

A Powerful way to visualize motion using the LabSims is with real time **graphs**. If you *push one of the red graph buttons* at the bottom right, a separate window will pop up. The new window will be rather empty until you do a run in the 3D window, after which it will have graphs of position and speed. The top graph is the position, and the bottom one is speed (which component of position and speed depends on the button). You can change the limits on the graphs, redraw the plot and so on with the *boxes on the left side of the graph window*.

Sometimes a Graph window may appear to lose part of its information. Press the **Redraw** button to fix the problem.

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Graphs are extremely useful for comparing different runs and checking for differences. Explore this by doing one run, then changing something and doing it again (*click on the new color button* after the first run).

Graphs also let you simulate the effects of **MEASUREMENT UNCERTAINTY**. You can never get perfect data in the laboratory. With the simulations you can see the difference between “perfect” data and what you get with imprecise “position clicks” in VideoTOOL. You may discover that it is worth your time to take VideoTOOL data very carefully.

To see the effect of measurement uncertainty, do a run. Then simulate uncertainty on the graph by pressing the “*Add error*” button in the graph window. This adds randomly distributed errors to the position measurements. Experiment with different measurement uncertainties by changing the “error” parameter in the pink box, or by adding error several times (just press *Add Error* several times). The velocity values are recalculated when you add error to the positions, so you can see what happens to velocity if position measurements are not made precisely.

To compare the effects of measurement uncertainty to other effects (air resistance, for example) go through the process of adding error to a clean run. *Change Color* on the graph, and then do another run with the other effect (air resistance, for example). Now you have two sets of graphs to compare.

## MAKING MOVIES

*Click the “Movie Help” button in any simulation for up-to-date information on this function.*

Possibly the most useful, but currently the slowest, way to use the LabSims is to make a movie with them, and then to analyze the simulation movie in the same way you analyze real video data.

To make a movie, first you should clean out any old frames by clicking the “Cleanup” button on the computer desktop. Then you should play around with the LabSim until you have a run and a camera position you like. Click on the yellow “Save” button, which writes a little file to disk with the positions of the apparatus in every frame. Now click on the “Make Frames for Lab x” button on the desktop, which will start up a program called PoVRay. PoVRay makes high quality movie frames of the experiment (it will take a couple minutes). Finally you can turn the frames into a movie (which will be in `c:\labSim\frames\simMovie.avi`) by clicking on the “Make movie from frames” button. Then you can read the movie into VideoTOOL and analyze it with that.

