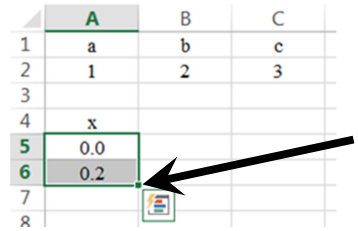
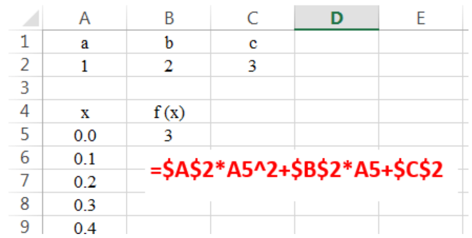
1.24 While using your calculator to solve equations is nice, solving them with Excel or Matlab is even better. These tools are more practical when you consider you must eventually show your work in a report or presentation. The following instructions were designed for Excel 2013. Most of these instructions will work for other versions as well. Don't forget you can also use the help file if, for instance, you can't figure out how to insert a scatter chart.



To quickly generate a sequence of numbers do the following:

a) Type the first 2 in the sequence
b) Highlight those two cells
c) Mouse over the bottom right corner (shown by arrow in figure at right)
d) The cursor should change to a solid black cross *without arrows*.
e) Click and drag down until the desired number is reached.
f) Adjust the sig figs by playing with the controls that look like this near the top middle of the screen.

Suppose we want Excel to compute $f(x) = ax^2 + bx + c$ for $x = 0$ to 2. Do the following:



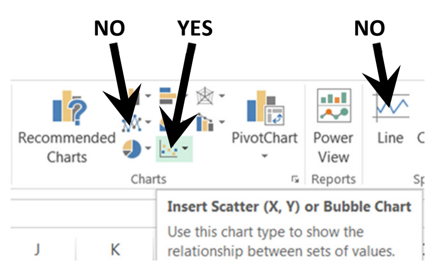
- Create the column of x values using the trick described above. I chose to use increments of 0.1 as you can see in the data table below.
- Make a column for $f(x)$
- <u>In cell B5</u> I typed "**=$A$2*A5^2+$B$2*A5+$C$2**". Note: upper or lower case letters both work just fine.
- Grab the bottom right corner of B5 and drag it down. Be sure to check you have a black cross without arrows before clicking!
- Adjust sig figs as needed.

Once the data looks right it is worth trying two things to prevent future problems.

1) Make a new column for $f(x)$ using the same procedure with the following exception. This time, forget to type the equals sign before the start of all that jibberish in B5. Notice it won't work without the equals sign.
2) Make a new column for $f(x)$ using the same procedure with the following exception. This time, type everything the same in B5 except change "**$C$2**" to "**C2**". Fill down. Notice the equation works but gives the wrong answers. This is obviously the more dangerous error because you might not notice and think you've done things correctly! **To avoid this error, check a random row or two for correctness with your calculator.**

To make a plot do the following

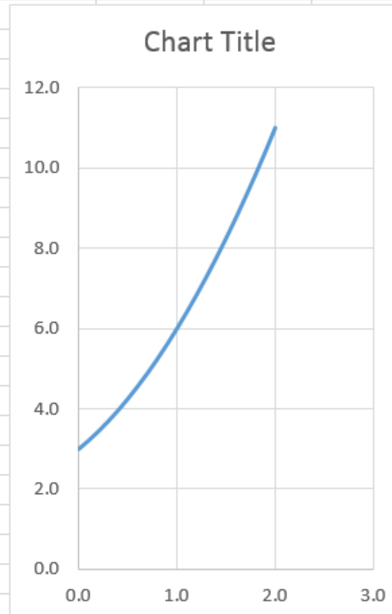
- Use the mouse to highlight the first column of data, numbers only. Press and hold control.
    - To highlight data in a column, place the cursor in the middle of the top cell in the column. The cursor should look like a white cross (not the black cross used to fill down).
    - Then click and drag down.
- Highlight the second column of data, numbers only.
- Ensure both columns have the same number of rows highlighted.
- Go to the top left of the screen and find the INSERT tab. Click on it.
- Near the middle of the top of the screen you should see something like the figure at right. Insert a SCATTER plot. Do <u>NOT</u> insert a LINE plot. TO see the type of chart you are inserting, mouse over the various charts until you find scatter. Check the next page to compare your chart to mine.



Do NOT insert a LINE plot. Use a SCATTER plot!!!!!!!!

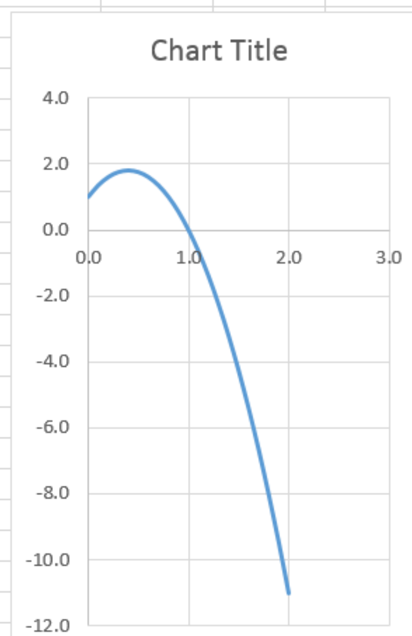
A line plot does not allow you to set your own increment size on the *x*-data. Forgetting this is confusing because your graph may seem like the correct shape but all the numbers, including the slope, will be incorrect! Hopefully your work looks like the upper figure at right. I resized and moved the chart a bit. Other than that, you should have the same stuff.

	A	B	C
1	a	b	c
2	1	2	3
3			
4	x	f (x)	
5	0.0	3.0	
6	0.1	3.2	
7	0.2	3.4	
8	0.3	3.7	
9	0.4	4.0	
10	0.5	4.3	
11	0.6	4.6	
12	0.7	4.9	
13	0.8	5.2	
14	0.9	5.6	
15	1.0	6.0	
16	1.1	6.4	
17	1.2	6.8	
18	1.3	7.3	
19	1.4	7.8	
20	1.5	8.3	
21	1.6	8.8	
22	1.7	9.3	
23	1.8	9.8	
24	1.9	10.4	
25	2.0	11.0	

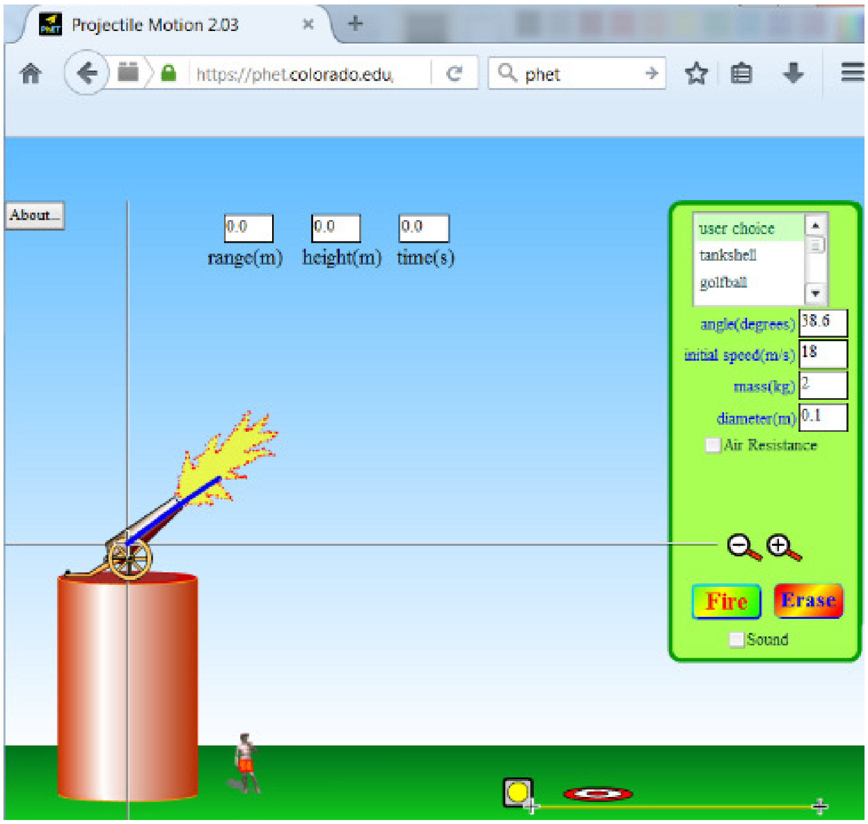


Now comes the cool part. Cells A2, B2, and C2 form a row of *constants*. You can now change the constants and the graph should auto-update. Try changing the values to A = -5, B = 4, and C = 1. Assuming you have done all your work correctly, you should now see a table and graph that look like the lower one at right.

	A	B	C
1	a	b	c
2	-5	4	1
3			
4	x	f (x)	
5	0.0	1.0	
6	0.1	1.4	
7	0.2	1.6	
8	0.3	1.8	
9	0.4	1.8	
10	0.5	1.8	
11	0.6	1.6	
12	0.7	1.4	
13	0.8	1.0	
14	0.9	0.5	
15	1.0	0.0	
16	1.1	-0.7	
17	1.2	-1.4	
18	1.3	-2.3	
19	1.4	-3.2	
20	1.5	-4.3	
21	1.6	-5.4	
22	1.7	-6.7	
23	1.8	-8.0	
24	1.9	-9.5	
25	2.0	-11.0	



Projectile Motion PhET
https://phet.colorado.edu/sims/projectile-motion/projectile-motion_en.html
Notice all the parameters you can change on the right side of the sim. To change the initial height, click on the red just below the wheel of the cannon. To measure the initial height, use the tape measure at the bottom of the screen. Notice the gridlines centered on the cannon that indicate the launch location.



2.10 Set the initial height to 19.6 m, initial speed to 0 m/s, and launch angle to 90°. Assume g = 9.8 m/s^2. This sets up a 1D motion problem in the vertical direction. The time to impact is 2 sec. For this question, do no math. Just discuss with your friends and take a guess. Then use the simulation to check your intuition.

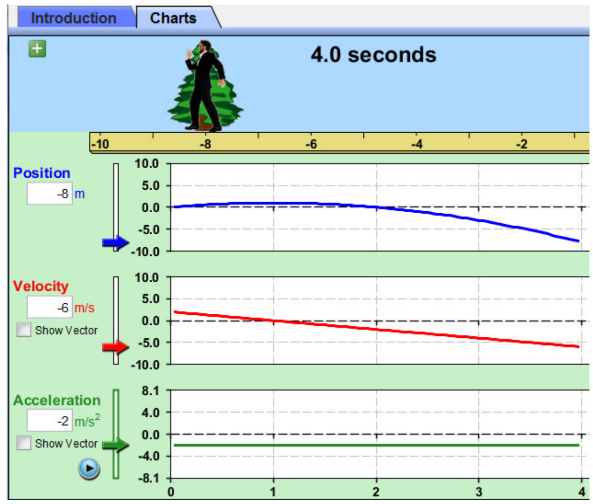
a) How much distance will the projectile cover in the first half the flight *time*? Is it more than, less than or equal to 10 m (half the total distance).
b) How much time is required to cover half the *distance*? Is it more than, less than, or equal to 1 s (half the flight time)?
c) If you turn on air resistance, by what % does the time to impact change? Try the different objects to see which is affected by air resistance the most…

This problem is done symbolically on the next page.

2.11 Set the initial height to 0 m, initial speed to 9.8 m/s, and launch angle to 90°. Assume g = 9.8 m/s^2. Again, rather than doing math, guess & discuss with your friends. We will do the problems algebraically on the next page.

a) What is the max height?
b) What is the time to max height?
c) What is the speed at max height?
d) What is the acceleration at max height?

2.16 Moving Man PhET



http://phet.colorado.edu/sims/moving-man/moving-man_en.jnlp

- Open the Moving Man simulation on the PhET website.
- Click the CHARTS tab near the top left of the screen.
- Remove the walls of the simulation (there should be a little "**x**" you can click on one of the walls).
- Set the graphing parameters to $x_0 = 0$ m, $v_0 = 2$ m/s, and $a = -2.0$ m/s^2.
- Run the simulation for about 4 seconds…don't worry about stopping it perfectly on 4 seconds.
- Tinker with the zoom in/out buttons on the right side of each graph to make the graphs easier to read. The bottom graph has the zoom button for the time axis.

a) Use the graph to determine the time intervals the man is moving forwards, backwards, at rest, speeding up, slowing down, or moving with constant speed. Hit the playback button to check your work.

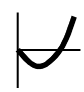
b) For 0, 1, 2, 3, & 4 seconds, determine the slope of the *xt* plot and compare it to the *vt* plot.

c) For each 1 second interval, determine the area under the *vt* curve to displacement (the CHANGE in position).

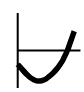
d) For 0, 1, 2, 3, & 4 seconds, determine the slope of the *vt* plot and compare it to the *at* plot.

e) For each 1 second interval, determine the area under the *at* curve to the CHANGE in velocity.

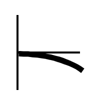
f) Reset the simulation. How would you set the initial parameters to alter the <u>position</u> graph to look like the one shown at right? Don't worry about the exact time the plot crosses the axis; worry about getting the shape qualitatively correct. Tinker with the PhET animation parameters to find out! If you now redid parts a-e, which answers would change; which would remain the same?



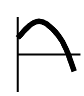
g) Reset the simulation. How would you set the initial parameters to alter the <u>position</u> graph to look like the one shown at right? Don't worry about the exact time the plot crosses the axis; worry about getting the shape qualitatively correct. Tinker with the PhET animation parameters to find out! If you now redid parts a-e, which answers would change; which would remain the same?



h) Reset the simulation. How would you set the initial parameters to alter the <u>position</u> graph to look like the one shown at right? Don't worry about the exact time the plot crosses the axis; worry about getting the shape qualitatively correct. Tinker with the PhET animation parameters to find out! If you now redid parts a-e, which answers would change; which would remain the same?



i) Reset the simulation. How would you set the initial parameters to alter the <u>position</u> graph to look like the one shown at right? Don't worry about the exact time the plot crosses the axis; worry about getting the shape qualitatively correct. Tinker with the PhET animation parameters to find out! If you now redid parts a-e, which answers would change; which would remain the same?



j) Select a set of initial parameters such that the man begins to the left of the origin while moving right and slowing down for 4 seconds.

k) Select a set of initial parameters such that the man always has positive position while moving left and speeding up for 4 seconds.

l) The vertical intercept of the *xt* plot is given by what parameter?

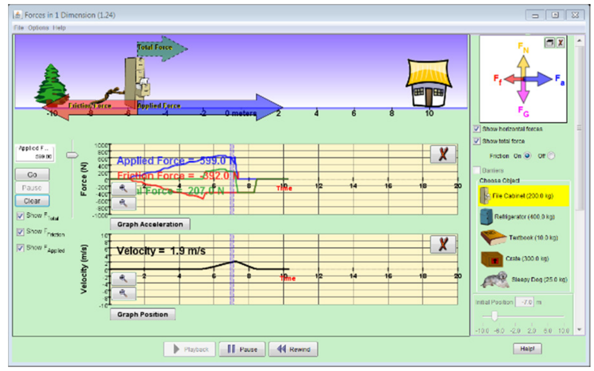
m) The initial slope of the *xt* plot is given by what parameter?

n) The vertical intercept of the *vt* plot is given by what parameter?

o) The initial slope of the *vt* plot is given by what parameter?

p) For fun, start the moving man with initial position 8 m, speed zero, and $a = -4\frac{\mathrm{m}}{\mathrm{s}^2}$. After 2 s, pause the animation and switch the acceleration to $a = +4\frac{\mathrm{m}}{\mathrm{s}^2}$. Press play. After an *additional* 4 seconds, pause the simulation again to switch back to $a = -4\frac{\mathrm{m}}{\mathrm{s}^2}$. After another additional 4 seconds, switch back to $a = +4\frac{\mathrm{m}}{\mathrm{s}^2}$.
Before hitting playback, look at the graphs and try to predict when the moving man will be speeding up and slowing down, moving right or left. Clear your plot then try "Expression Evaluator" under the Special Features.

Forces in 1D Motion PhET



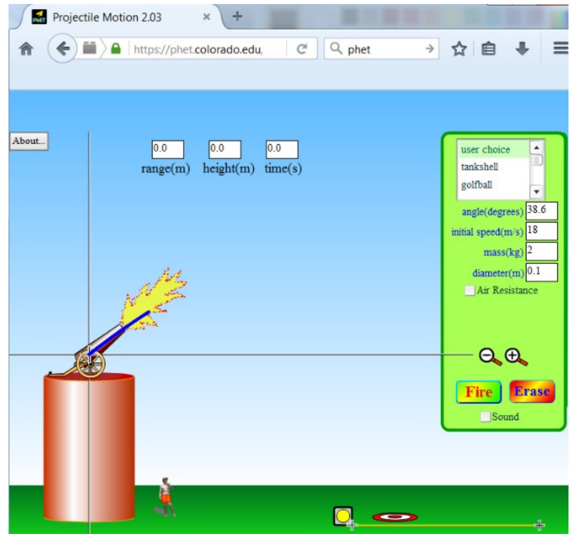
It is interesting at this time to see how what we have learned in 1D motion might be applied to somewhat realistic problems.

1) Open the simulation, put the cursor on the box, and push it left or right.
2) Once you get the hang of it, reset everything and start with the block at rest.
3) Hit the Go button to start recording.
4) Gradually increase the force on the block. Eventually the block will start to move, continue to increase the force applied to it.
5) Then stop applying a force to the block.
6) Once the block comes to rest, hit the Pause button.
7) Hit the playback button to watch the recording of the motion.
8) Predict what the graphs of position, velocity, and acceleration versus time should look like.
9) Check your work by selecting the appropriate graphs.

The next topic in this book is vectors. This animation gives a preview as to why vectors will be important. Look at all the different forces acting on the block in the simulation. Notice the free body diagram of the box. We will learn that net force relates to this diagram. Furthermore, net force relates to acceleration. In order to handle more complex problems where objects have multiple forces with non-right angles we must first handle vectors. We also must learn how to handle acceleration in more than one direction if we want to analyze objects moving in circles. All of these topics rely on vectors…

Projectile Motion PhET

https://phet.colorado.edu/sims/projectile-motion/projectile-motion_en.html



Notice all the parameters you can change on the right side of the sim. To change the initial height, click on the red just below the wheel of the cannon. To measure the initial height, use the tape measure at the bottom of the screen. Notice the gridlines centered on the cannon that indicate the location of the launch.

A level ground problem implies the launch position and impact position are at the same height. To do level ground simulations, assume the impact position is the point where the blue line crosses the grid line.

4.4 Set the muzzle speed to 19.6 m/s & angle to 45°. Air resistance should be turned off. Ensure the cannon is not raised up so you have a level ground problem. Fire a projectile and zoom until the entire path fits on the screen.

a) For a level ground problem, what angle gives the maximum range (largest horizontal displacement)?
b) What angles give the maximum and minimum flight times?
c) For a level ground problem, what angles give exactly half the maximum range?
d) Does changing the mass affect any of your previous answers?

Consider doing problems 4.8-4.11 now and then returning to do the other sim questions???

4.5 Set the muzzle speed to 19.6 m/s & angle to 45°. Set initial height to 10 m. Air resistance should be turned off. Fire a projectile and zoom until the entire path fits on the screen.

a) What angle gives the maximum range? Is it 45°, less than 45°, or more than 45°?
b) What angles give the maximum and minimum flight times?
c) Is the time to max height greater than, less than, or equal to half the total flight time?
d) Is the impact speed equal to, greater than, or less than the muzzle speed?
e) Is the impact angle greater than, less than, or equal to the launch angle?

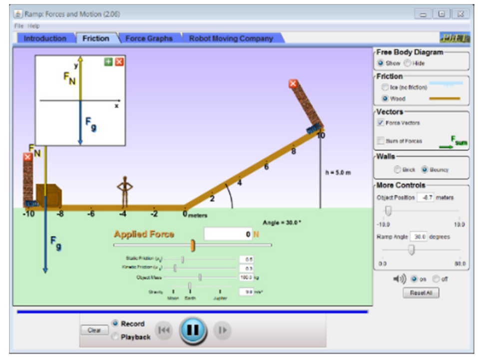
4.6 Consider a vertical launch with initial height 0 m, muzzle speed 19.6 m/s & angle 90°. Select the pumpkin as the projectile. Turn on air resistance. In this instance, air resistance is proportional to the square of the speed. You might not be able to use the simulation to figure these out but they are fun to think about. Some might be tricky!

a) How does air resistance affect the time of flight and max height?
b) How, if at all, does air resistance affect the magnitude of the acceleration for the purely vertical flight?
c) How does air resistance affect the speed at max height?
d) At what point or points in the flight is air resistance the greatest?
e) Does changing the mass affect your answers?

4.7 Set the initial height to 0 m, muzzle speed to 20 m/s & angle to 45°. Notice this is slightly different than the previous problem as the particle now travels in *two* dimensions instead of just *one*…Select the pumpkin as the projectile. Turn on air resistance. In this instance, air resistance is proportional to the square of the speed. Some might be tricky! You might not be able to use the simulation to figure these out but they are fun to think about.

a) At what point in the flight will air resistance equal zero?
b) How does air resistance affect the speed at max height?
c) How does air resistance affect the magnitude of acceleration at max height?

Note: This is a bit intense as a first introduction to friction. Skip it, do a bunch of problems, then come back and you should find this is better as a review exercise.



RAMP: Forces and Motion Phet

Open the simulation and click on the "Friction" tab.

You can make the man exert a force on the box using the slider below the screen or by dragging the box.

You can change the angle of the ramp by clicking and dragging it.

Once you play around with the controls a bit, you can press record and perform some interesting experiments.

6.1 Experiment 1a: Start with no applied force. Set the angle of the ramp to zero. Start with the block at rest. Gradually increase the applied force with the slider until the block starts to move. As the applied force increases, describe how the following change. Do they increase, decrease, or remain constant, or something else?

a) Weight of the block
b) Normal force on the block
c) Frictional force on the block
d) Maximum possible frictional force
e) Magnitude of the frictional force during the transition from static to kinetic friction
f) Coefficient of friction

6.2 Experiment 1b: Hit "Record" and repeat Experiment 1a. Predict the curves for plots of friction, weight, and normal force versus time. In particular, should any of the plots change linearly? What should happen to the forces at the transition from static to kinetic friction? After making your predications, use the "Force Graphs" tab at the top of the screen to check your predictions. Explain discrepancies between your predictions and the recorded graph. It may be useful to display the FBD and use the playback feature. If needed, go frame by frame.

6.3 Experiment 2a: Start with no applied force on the block and set the angle of the ramp to zero. Set the block position to 8.0 m. This time you will gradually increase the ramp angle until the block slips. As the angle increases, describe how the following change.

a) Weight of the block
b) Component of weight down the incline
c) Normal force on the block
d) Frictional force on the block
e) Maximum possible frictional force
f) Magnitude of the frictional force during the transition from static to kinetic friction
g) Coefficient of friction

6.4 Experiment 2b: Hit "Record" and repeat Experiment 2a. Predict the curves for plots of friction, the component of weight parallel to the ramp, and the normal force versus time. In particular, should any of the plots change linearly? What should happen to the forces at the transition from static to kinetic friction? After making your predications, use the "Force Graphs" tab at the top of the screen to check your predictions. Explain discrepancies between your predictions and the recorded graph.

6.5 Using the PhET simulation, is it possible to create a scenario where friction and *acceleration* point the same way? If the scenario is possible, is the block speeding up or slowing down? Is it even possible in real life?

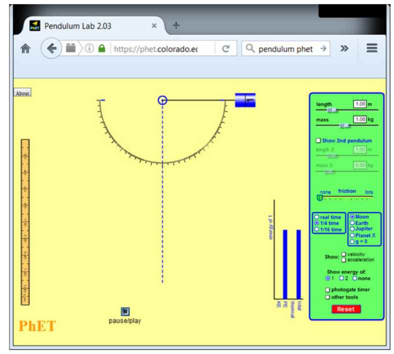
6.6 Using the PhET simulation, is it possible to create a scenario where friction and *velocity* point the same way? If the scenario is possible, is the block speeding up or slowing down? Is it even possible in real life?

6.7 Challenge: In the PhET simulation using the crate, the coefficients of friction are $\mu_s = 0.5$ and $\mu_k = 0.3$. Using these parameters I know the crate, when released from rest, slides the down the ramp for all angles exceeding 26.6°.

a) Using an angle greater than 25°, design a scenario wherein the block slides up the ramp and comes to rest.
b) Compare the directions and magnitudes of the frictional force before and after coming to rest.

6.41½ Pendulum PhET

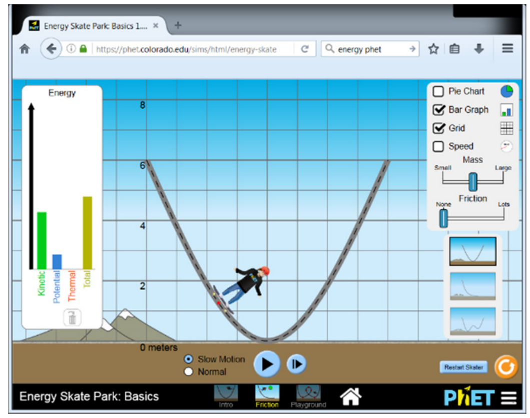
Open the pendulum simulation and set the length to 1.00 m.
Notice in the simulation hanging vertically is 0°.
Select the buttons for making the simulation run at ¼ time on the moon.
Select the buttons for showing both the veloicty and the acceleration.
Raise the mass to 90° on either side and release it from rest.



a) Compare the results of the simulation to your answers for the previous question.
b) How should doubling the mass affect $\vec{v}$ and $\vec{a}$? Take a guess!
c) How should doubling the length affect $\vec{v}$ and $\vec{a}$?
d) How does changing the planet (changing value of g) affect $\vec{v}$ and $\vec{a}$?

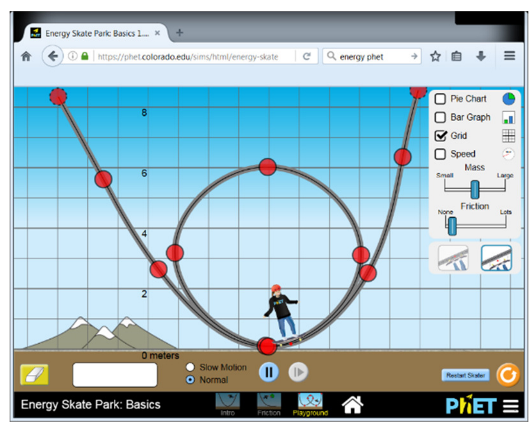
Run the sim and see if your intuition is correct.

Energy Skate Park PhET
Open the simulation.
At the bottom of the screen, switch to the Friction Tab.
Turn on the grid and bar chart. Slide friction to "None"
Notice there are 3 preset track options below the friction slider.
To simplify the model, the center of mass of the skateboarder is located at the red dot midway between the wheels.
If you don't like this assumption, just imagine there is no rider on the skateboard.
The bottom of the track is assumed to be our reference level ($U = 0$).



8.1 Using the track shown at right, make sure you have the friction slider set to "None". Assume the girl will be released from rest when the red dot is 2 m off the ground.

a) At what height potential and kinetic energy equal?
b) How does speed at this height compare to the speed at the bottom? Is it double, half, or something else? Explain.
c) What should the bar graph look like for each of the following heights: 2 m, 1 m, and 0 m above the ground.
d) From what height must the skater be released to double the speed at the bottom?
e) Slide friction to "Lots" and release the girl from rest with the red dot at 6. Predict what the bar graph should look like at the bottom and after reaching the top at the other side.
f) If you repeat the experiment with half the mass, do you have more or less speed at the bottom? Use the mass slider and see…
g) **Challenge:** With friciton on, we know the max height of the rider drops with each pass. Should it drop by the same % each pass, the same distance each pass, or something else? Try the sim but assume your calculations are only good to about 1-2 sig figs. Consider adjusting the friction the skater stops on a gridline after the first pass. I used about 2/3 of max friction.

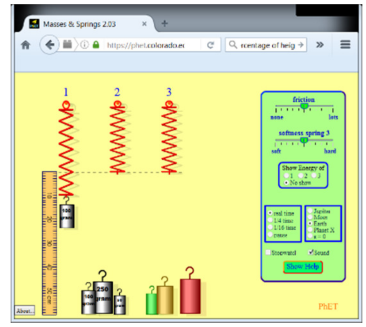


8.2 Now switch to Playground tab at the bottom of the screen. Create a track like the one shown. Try to make the track 8 m tall with a 6 m diameter circle. Set friction to "None" and be sure to click the button that allows the girl to fall off the track. Assume you will start the girl from rest with the red dot at 8 m.

a) Predict what the energy bar graph should look like at the start.
b) Predict what the energy bar graph should look like at the bottom.
c) Predict what the energy bar graph looks like at the top of the loop.
d) Predict the minimum starting height required for the girl to complete circular motion in the loop with out coming off the track a as a projectile.
e) If you double the mass will the girl require a larger or smaller minimum starting height?

Masses and Springs PhET

8.8 Determine the spring constant



Open the simulation and hang a 100 g mass on the spring and let system reach equilibrium. Notice equilibrium position is not the same as the unstretched position.

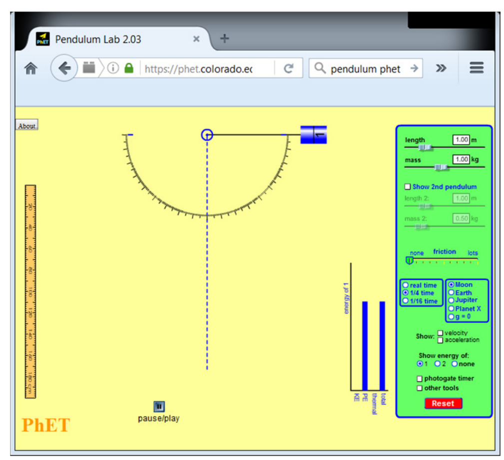
a) Align the ruler carefully and try to get two sig figs on the amount of stretch.
b) Determine the spring constant using an FBD.
c) Check your calculation by predicting how far the 250 g mass will stretch the spring and check it with the simulation.

8.9 Observe Oscillations

Remove all masses from the springs.
Turn off friction.
Click "Show Energy of 1"
Set the simulation to ¼ time.
We now have an ideal mass-spring system (friction & mass of spring are negligible).
Pick up the 100 g mass and hang it on the first spring.
Release the mass when the spring is in the unstretched position.

a) Predict what the energy bar graph looks like at the instant the mass is released.
b) Predict what the energy bar graph looks like when it first reaches the equilibrium position.
c) Predict what the energy bar graph looks like when the mass first reverses direction.
d) Predict the maximum stretch of the spring.
e) Which of the following quantities are zero at max stretch position: $\vec{F}_{spring}$, $\vec{F}_{net}$, $\vec{v}$, $\vec{a}$?
f) Which of the following quantities are zero at the equilibrium position: $\vec{F}_{spring}$, $\vec{F}_{net}$, $\vec{v}$, $\vec{a}$?
g) Which of the following quantities are zero at the unstretched position: $\vec{F}_{spring}$, $\vec{F}_{net}$, $\vec{v}$, $\vec{a}$?
h) If we add in friction, will it increase or decrease the equilibrium position?

Pendulum PhET

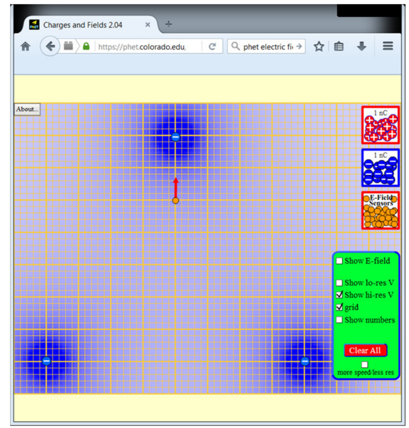


8.15 Open the pendulum simulation and set the length to 1.00 m.
Notice in the simulation hanging vertically is 0°.
Select the buttons for making the simulation run at ¼ time on the moon.
Click the button to "Show energy of 1".
Raise the mass to 90° on either side and release it from rest.

a) Assume $U_G = 0$ at the bottom of the swing.
b) At what angle does kinetic energy equal potential energy?
c) The maximum speed occurs at the bottom of the swing ($\theta = 0$). At what angle is the speed half of the maximum?

Run the simulation to check your work. You can display the velocity arrow with a button on the right side. If you click other tools you will find a tape measure that can be used to measure the relative sizes of horizontal arrows.

PHeT Charges and Fields



One of the things I find interesting about gravitational problems is how similar they are to electric problems. The force and potential energy equations look nearly identical. I hope to exploit this mathematical similarity to teach about gravitation problems. To make this work:

- For an N mass system, place negative charges as the first $N-1$ point masses.
- For the N^{th} mass place an electric field sensor.
- The arrow shown by the electric field sensor points in the direction of the force acting on the N^{th} mass.

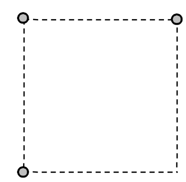
The figure at right shows an example. The first three masses form the equilateral triangle. The fourth mass is just below the top of the triangle. Major gridlines indicate 0.5 m. A tape measure feature can also measure distances. If you click "Show numbers" the sensor reads out a number in V/m. Ignore the units, the number is proportional to the gravitational force.

13.4a Start with a single mass (negative charge) in the middle of the screen. Place the N^{th} mass (the electric field sensor) somewhere randomly. Notice the force exerted on the N^{th} mass by the other mass points towards the other mass. Drag the sensor around a bit to see how the direction and magnitude of the force changes with position. Compare the force at when the two masses are separated by 1 major unit and 2 major units. Does the force cut in half when you double the distance? By what numerical factor does the force change when distance doubles?

13.4b Place two masses separated vertically by about 4 units (2 m).

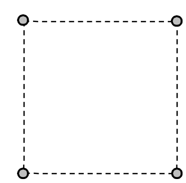
a) Predict the direction of the net gravitational force on the N^{th} mass placed halfway between the two masses.
b) Predict the direction of the net force on the N^{th} mass if it is placed lightly left or right of the midpoint.
c) As you slide it left or right, where do you put the N^{th} mass to maximize the net gravitational force on it?

13.4c Create a square with a mass at 3 of the corners. I used sides with a length of 4 major units (2 m). Predict the direction of the net gravitational force if the N^{th} mass is placed



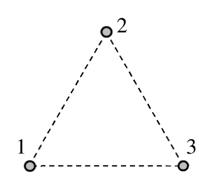
a) At the remaining corner.
b) At the center of the square.
c) Which of the above two arrangements produces a larger force on the N^{th} mass? In problem 13.7 you will calculate the force at each of these points.

13.4d Create a square with a mass at each corner. I used sides with a length of 4 major units (2 m). Predict the direction of the net gravitational force if the N^{th} mass is placed



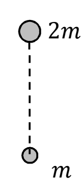
d) At the center of the square.
e) At the middle of one of the sides of the square.
f) One major unit (0.5 m) from one of the corners.

13.4e An equilateral triangle may be made by placing two masses 4 units (2 m) apart with the third mass halfway between and up $3.46 \approx 3.5$ units (1.5 m). Create such a triangle. Predict the direction of the net gravitational force if the N^{th} mass is placed



a) At the center of the triangle (halfway between and 1.15 units $\approx$ 0.6 m up).
b) At the midpoint of a side of the triangle.

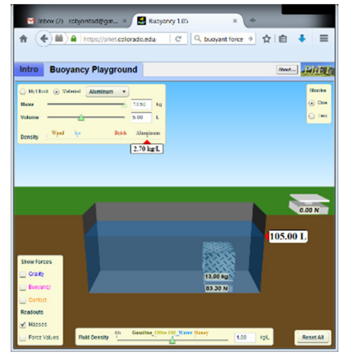
13.4f Place two masses separated vertically by about 9 units (4.5 m according to the simulation's scale). Place an extra mass on the top mass. This effectively doubles the mass at that point.



a) Predict the direction of the force if the N^{th} mass is placed at the midpoint between the two masses.
b) Where the N^{th} mass is in equilibrium? At the center of mass (3 units from bottom) or somewhere else?

Note: if you click "Show hi-res V" the potential is shown. The intensity of blue indicates the amount of potential energy if the N^{th} mass is placed there.

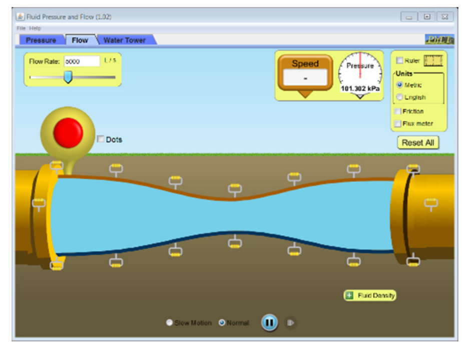
14.16 Buoyancy PhET



Do a web search for "buoyancy PhET" and open the simulation.
Display buoyant force, contact force, and weight in the simulation.
For the following questions predict the answer yourself, discuss with your neighbor, then we'll look at the simulation as a group.

a) If we use a wood block and a brick block of equal mass which should block have the larger buoyant force?
b) If we use a wood block and a brick block of equal volume, which block should have the larger buoyant force?
c) If a block of wood is held beneath the water and released from rest, how should the buoyant force change as the block rises to the surface? Is the acceleration constant?
d) Suppose a brick and a wood block each have volume 6.48 L and are in the tank of fluid. The density of the fluid is gradually decreased. For what density value (or values) will the two objects experience the same buoyant force? For what values of fluid density do you feel the buoyant force is negligible?

Fluid Pressure and Flow PhET



Open the simulation and click on the Flow tab. Turn off the dots. Use the little handles to symmetrically decrease the middle of the pipe. When you press the red button a group of black dots will appear to aid in tracking a group of fluid particles as they flow down the pipe. Predict answers to these questions, discuss with your neighbor, then we will discuss while watching the simulation as a group.

14.25 First consider the pipe design shown in the figure at right.

a) Rank the speeds at the left end, middle, and right end of the pipe.
b) Rank the volume flow rates at the same three spots.
c) Rank the fluid pressure at the same three spots.

14.26 Now revise the shape of the pipe such that the pipe has roughly uniform diameter but the left end is at the highest elevation and the right end is at the lowest elevation.

a) Rank the speeds at the left end, middle, and right end of the pipe.
b) Rank the volume flow rates at the same three spots.
c) Rank the fluid pressure at the same three spots.

14.27 Now consider the following.

a) What happens as the diameter of the pipe system increases. How are flow rate, speed, and pressure affected? Which, if any, are unaffected?
b) What happens as the elevation of the pipe system increases. How are flow rate, speed, and pressure affected? Which, if any, are unaffected?
c) Design a system with different input and output elevations but with roughly uniform pressure throughout.
d) Design a system with uniform elevation but decreasing pressure throughout.
e) Design system with both pressure and speed decreasing along the entire length of the pipe.
f) Which of the following should be affected if we alter the fluid density: flux, speed, volume flow rate?
g) At some point we can turn on the friction to make the simulation more realistic. How will this affect the spacing of the black dots as they flow in the pipe?

Further Reading

It is impossible to understand any of the topics thoroughly with only a freshman physics textbook has. Fluids are some of the most challenging and rewarding topics to read about online. If you are interested in looking into one or more of these topics, consider trying out the suggested words in your search engine. Disclaimer: do not assume high school or college physics instructors are experts in fluid dynamics; seek out a reputable source such as a professional engineer specializing in fluid dynamics.

Topic	**Recommended words for search engine**
Fun stuff	10 amazing liquid tricks
Poiseuille's Law	Poiseuille blood flow
Coanda effect	Cabrillo Coanda Terry Colon Coanda
Non-Newtonian fluids	Spangler Oobleck Oobleck speaker
Soap bubbles	Exploratorium Soap Bubble Shapes Giant CO2 bubble
Surface tension	Physics girl seven surface
Magnus effect	Veritasium Magnus Paradoxical pop-up
Capillary Action	Capillary hyperphysics Tree frog versus gecko scientific
Water towers	How water towers work
Lift	NASA lift lies Terry Colon How Planes Fly Av8n airfoils
Siphons	Siphons TPT-final Hawaii "siphon in a vacuum" Note: the earliest reference I found of a siphon operating vacuum dates to 1914!
Smoke Rings	Smoke Ring Spangler
Stability of boats	Center of buoyancy Ship stability