Lab 1: Density

Diet vs Regular Soft Drinks

Cans of soft drinks are so common that many people have done much of this exploration without realizing it. You, too, have probably cooled soft drink cans in ice water for a picnic. Here is your opportunity to see if you can make some generalizations about their behavior in water.

Materials

- 1 12-fl oz (355 mL) aluminum can of diet soft drink, unopened
- 1 12-fl oz (355 mL) aluminum can of regular (non-diet) soft drink, unopened (use same brand as the diet soft drink if possible)
- container of water large enough to totally submerge both beverage cans in an upright position
- measuring cup calibrated in mL
- (if available) plastic, glass, or steel containers of diet and regular soft drinks of equal volumes, unopened (Use containers made of the same material.)

Safety

Do not use water hotter than that from the tap since very hot water can cause the containers of soft drinks to explode, as well as cause severe burns.

Exploration

Step 1 Holding the unopened cans in an upright position, submerge both cans in the container of water. Let go and record their orientations and whether they sink or float.

Step 2 Repeat Step 1, but release the cans in a horizontal position. Record your observations. Explain any changes in orientation of the cans.

Step 3 What property of matter accounts for the cans floating or sinking? How does this property differ for each soft drink can? If each container is made of aluminum and occupies the same volume, what do your observations say about the mass of the contents? Read the content information on the cans. What, if any, are the differences in ingredients?

Step 4 With the measuring cup, measure the volume of the liquid in each can. How do these volumes compare to the volume of the can? How do you think the densities of the liquids compare? What would have to be done to determine the densities of the liquids?

Step 5 Completely fill the cans with water. Submerge them in water and record whether they sink or float. Look up the densities of water and aluminum in your textbook. How do these values contribute to the behavior of the cans of beverages?

Step 6 If materials are available, repeat Step 1 using plastic, glass, or steel containers of diet and regular soft drinks of equal volumes. Does the composition of the container make a difference in its floating/sinking behavior? Compare and contrast the results with those obtained for the aluminum cans.

Challenge

What factors account for the differences in density observed?

Lab 2- The force of Gravity

Topics covered in this lab:

The force of gravity
Newton's Laws

One of the topics we have discussed is acceleration, meaning that the velocity of the object under study was changing. What causes something to accelerate? In this lab you will investigate the forces that affect the motion of objects.

Gravity

Materials:

- Something to toss (Please choose an object that will not break)

Toss an object straight up into the air and catch it as it falls back down. Carefully watch the objects vertical position as a function of time. Repeat your toss enough times that you are sure that you understand the motion of the object.

In order to answer the following questions, imagine that you were able to measure the distance of the object above your hands, the velocity of the object, and the acceleration of the object, all as a function of time. You may want to reference the power point lecture of the diagrams in your text to help answer these questions. Please give detailed answers in complete sentences.

What is the velocity of the object at the very top of its path?

Is the velocity of the object changing during the entire flight or just at certain times?

Explain.

What is the acceleration of the object at the very top of its path?

Does the acceleration of the object change while it is in flight?

List all of the forces that are acting on the object while it is in flight.

You may want to refer to your text for the following:

Using the first grid provided on the following page, make a sketch of what you think the **distance** (above your hands) versus time graph would look like for the object.

Distance									

Time

Using the second grid provided on the following page make a sketch of what you think the **velocity** versus time graph would look like for the object.

Velocity									

Time

Using the third grid provided on the following page make a sketch of what you think the **acceleration** versus time graph would look like for the object.

Acceleration									

Time

Lab 3 (Motion) Universal Law of Gravitation

In 1657, English physicist Sir Isaac Newton (1643 – 17270) published *Philosophiæ Naturalis Principia Mathematica* more commonly referred to as The Principia. In the Principia, he outlined and provided astronomical proof of the inverse square law of gravitation which he summarized in his Law of Universal Gravitation which states that:

every particle attracts every other particle in the universe with a force that is proportional to the product of their masses and inversely proportional to the square of the distance between their centers.

Mathematically, the Law of Gravitation is expressed as: $\boldsymbol{F = G\frac{m_1 m_2}{r^2}}$

where $\boldsymbol{F}$ is the force of attraction, $\boldsymbol{m_1}$ and $\boldsymbol{m_2}$, the mass, **r** the distance and **G** is Newton's Gravitational Constant.

Newton's universal law of gravitation is used extensively in the study of physics and astronomy. It is use to determine the mass of the earth, the sun, the moon and other celestial bodies and thus is an important component of any research involving the orbits and movement of planets and other bodies our solar system and beyond.

Objective: To determine Newton's gravitational constant (G) experimentally

Procedure

Go to: **http://phet.colorado.edu/sims/html/gravity-force-lab/latest/gravity-force-lab_en.html**

Spend a few minutes and familiarize yourself with the simulation. Then follow the steps outlined below:

a. Select a value for the blue mass and record the value in the column labelled $\mathbf{M_1}$
b. Select a value for the pink mass and record the value in the column labelled $\mathbf{M_2}$
c. Using the ruler, measure the distance between the masses (from the center of each mass – radius to radius) and record it in the table in column labelled **R**
d. Record the gravitational force (**F**) in scientific notation.
e. Use this equation [$\boldsymbol{A = \frac{m_1 m_2}{r^2}}$] to calculate and fill in column **A**
f. Conduct a total of 10 trials and record your values in **Table 1**

Trials	$\mathbf{M_1}$ (Kg)	$\mathbf{M_2}$ (Kg)	**R** (m)	**A** (kg^2/m^2)	**F** (N)
1					
2					
3					
4					
5					

6					
7					
8					
9					
10					

TABLE 1

Analysis

1. Identify the:
   a. Independent Variable ______________

   b. Dependent Variable ______________

2. (a) Create a graph of your results.

   (b) What do you notice about your graph?

   ____

   ____

3. i. What is the actual value of G? ________________________________

ii. What is your average calculated value of G?

iii. Calculate your experimental error (%).

4. What were the sources of error?

____

____

5. Do you think that the purpose of this lab was achieved?

____

____

6. State why or why not?

____

Lab 4: Newton's Law of Gravitation

Adapted from the following: http://swift.sonoma.edu/education/index.html

Essential questions that you can answer once you complete the lab:

• How do the acceleration and force due to gravity depend on the radius and mass of a planet?

• How does the mass of a falling body affect the rate at which it falls in a gravitational field?

Objectives: Students will…
• see that the acceleration of an object due to gravity is independent of its mass.

• determine what they would weigh on other planets.

• see that the force they feel from gravity depends on the radius and the mass of the planet.

Materials:
• Several objects of different masses and sizes, such as pencils, crumpled up aluminum foil, coins, fishing weights, etc. Make sure they are not breakable! Do not use flat sheets of paper or objects with wind resistance such as balloons.
• Calculator

Pre-Activity Reading:
Newton's Law of Gravitation and the Swift Satellite

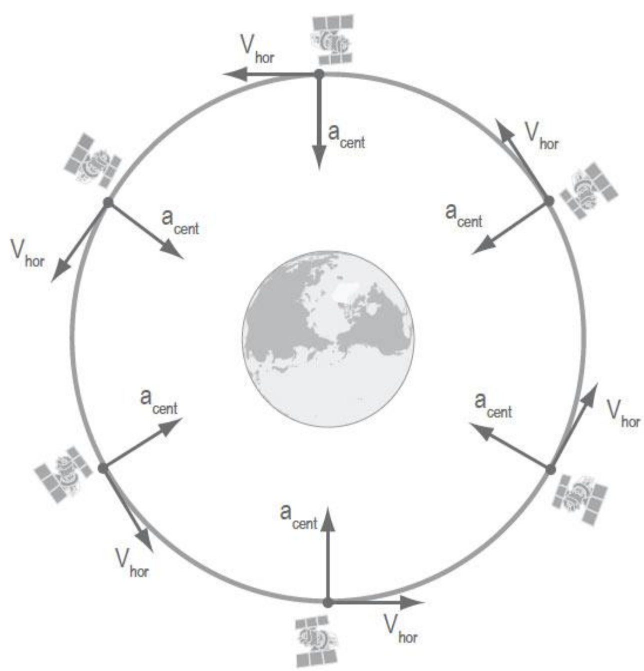
In this exercise we will study the relationship between the gravitational force on an object and its acceleration and velocity.

The following describes a satellite "Swift" that has been placed in orbit around the Earth. Just read over the following before doing the lab to gain a better understanding of how objects remain in orbit around the Earth.

Recall that as Swift enters its orbit, it has velocity that is purely “horizontal” – that is, it is moving parallel to the curved surface of the Earth at each point. However, the force of the Earth’s gravity on Swift is “vertical” – pointed towards the center of the Earth. Why then does Swift not fall to Earth immediately? The answer is that Swift moves horizontally at just the right rate so that as it falls vertically, its motion creates a circular path around the Earth. This balance between “horizontal” and “vertical” motion is what is meant by “being in orbit.” Swift will be able to stay in orbit for many years, as long as its horizontal velocity is maintained at a high enough rate. The special relationship between the horizontal velocity and the gravitational acceleration for any body that is orbiting another more massive body was worked out by Johannes Kepler years before Sir Isaac Newton figured out the Law of Universal Gravitation.

Eventually, the cumulative effect of the small number of atmospheric molecules hitting Swift in its orbit 600 km above Earth will cause the “horizontal” motion of the satellite to slow down; its horizontal motion will no longer be able to completely counteract its vertical motion. When this happens, Swift’s orbit will start to “decay.” As Swift spirals in closer to the Earth there will be even more atmospheric drag, which will cause Swift’s orbit to decay increasingly faster. Swift will end its life plunging in through the Earth’s atmosphere, probably sometime around 2014.

The relationship between the velocity and acceleration of Swift in its orbit is shown below.



Student Handout:

Newton’s Law of Gravitation

Name: ___________________________

Date: ________________

Materials:

• Several objects of different masses and sizes, such as pencils, crumpled up aluminum foil, coins, fishing weights, etc. Make sure they are not breakable!
• Calculator

Place all answers on the answer sheet provided.

You already know about gravity: it holds you down to the Earth. But there is more to gravity than that! In this activity you will investigate a few properties of gravity and see how it affects you – not just on Earth, but on other planets!

The goal of Part A is to determine the relationship between the acceleration due to gravity and the mass of an object. The goals of Part B are to determine how much you would weigh on other planets and how that weight is affected by the mass and radius of the planet.

Part A: The Fall of Objects

1) Obtain several objects of different masses and sizes, such as pencils, crumpled up aluminum foil, coins, fishing weights, etc. Make sure they are not breakable! Look over them: are they all the same size, the same weight?

Pick two of the objects that have different weights and sizes. They should be different enough that you can easily feel the difference. If they are dropped from the same height, will one hit the floor first, or will they hit at the same time? *Make a prediction about this, and record it on the answer sheet below.*

2) Now take the objects and hold them in front of you. Make sure the bottoms of the objects are the same height from the floor. Have another person kneel or lie down on the floor in front of you so they have a good view of where the objects will land.

Count backwards from three, and on “zero” drop the objects at the same time. Did one hit first? If so, which one? Note what happened on your worksheet. Repeat the procedure at least twice more to make sure you get consistent results.

3) Was your prediction accurate? Why or why not? Can you think of any ways your experiment might have been thrown off? Explain.

4) Now find two objects that are roughly the same size, but very different weights. Repeat the experiment, and again record your prediction and the results

5) Did the results surprise you? Why or why not?

Part B: The Gravity of the Situation:

Newton’s model of gravity is one of the most important scientific models in history. It applies to apples falling from trees, baseballs soaring into the outfield, and milk being spilled in your school cafeteria. The exact same model applies to other planets in our Solar System, too!

Use the Solar System table given below to determine the value of **g**, the acceleration due to gravity, for each of the other planets in the Solar System. Use the equation for acceleration in the box and the values for the masses and radii of the planets listed in the table. Complete the third column of the table with the value for the surface gravitational acceleration for each planet (and the Moon).

Use this equation to solve for the second column (Acceleration) on the following chart in Part B.

$$g = GM/R^2$$

where M = mass, R = radius,

and $G = 6.672 \times 10^{-11}$ N m^2/kg^2

Answer Sheet　　　　　　　　　Name_____________

Part A: The Fall of Objects
Answer the following (use a separate sheet of paper if necessary):

1. My predictions:

2. This is what I observed:

3. Accurate predictions?

4. Observations of second experiment:

5. Were you surprised? Why or why not?

Part B: The Gravity of the Situation - Complete the solar system data chart:

Planet Name	Mass (kg)	Radius (m)	Acceleration (m/sec^2)	*Acceleration compared to Earth(m/sec^2)
Mercury	3.3×10^{23}	2.4×10^{6}		
Venus	4.9×10^{24}	6.1×10^{6}		
Earth	6.0×10^{24}	6.4×10^{6}	9.8 m/sec^2	1
Moon	7.4×10^{22}	1.7×10^{6}		
Mars	6.4×10^{23}	3.4×10^{6}		
Jupiter	1.9×10^{27}	7.1×10^{7}		
Saturn	5.7×10^{26}	6.0×10^{7}		
Uranus	8.7×10^{25}	2.6×10^{7}		

Neptune	1.0×10^{26}	2.5×10^{7}
Pluto	1.3×10^{22}	1.2×10^{6}

Once you complete the third column, you can see how strong (or weak) gravity is on other planets. A better way to understand this is to compare the gravity of the planets with the Earth's. *So in the last column, divide the gravity you got for the other planets by the Earth's gravity (for example, after you do this, you will get the Earth's gravity = 1, since you are dividing the number you got for Earth's gravity by itself).

a. Would you weigh more or less on Mercury than you do on Earth?

b. How about Jupiter?

c. How much would you weigh on the Moon?

d. What is the difference between mass and weight?

Lab 5 Kinetic vs. Potential Energy

A virtual lab experiment.

Concepts and terminology:

g = gravitational acceleration=9.81 m/s^2
k = force constant of a spring when stretched or compressed
m = mass of an object
h = height of an object measured from the ground
v = speed of an object
x = amount of stretch or compression of a spring

KE = Kinetic energy, energy associate with motion (speed)
KE = $\frac{1}{2} m v^2$ <-- formula of KE of all object traveling at a speed v.

PE = Potential Energy = **mgh** <-- the high up the object, the more PE
PE = $\frac{1}{2} k x^2$ <-- More stretch in x means much more potential energy stored

Explanation:

In science there are two kind energies: the kinetic energy and potential energy.
All other energy associated terms such as nuclear energy, chemical energy, and thermal energy are related to these two kinds of basic energy concept.

Kinetic energy (KE) is associated with motion and is proportional to velocity squared:

$KE = ½ mv^2$

Potential energy (PE) is associated with the presence of a restoring force, for example, a bent or twisted plastic ruler has
a tendency to restore it self; same for a spring, or lifting an object agains the gravity etc. The potential energy of an object
in the presence of gravity is

$PE = m*g *h =mgh$ <-- An object elevated has this much potential energy

For a mass attached to a spring stretched or compressed by a distance x is

$PE = ½ k x^2$ <-- more stretch/compression, more PE the system has.

Implications: **PE** depends on how much work is done by the restoring force when the object is lifted or deformed.
In case of gravity, potential energy is gained or lost by changing its vertical position, without suffering shape change.
however, a bent plastic ruler has more PE than unbent one is a result of shape changing;
yet the same ruler on a desk has more gravitational PE than when it's on the floor regardless of its shape.

Energy conversions

In the presence of gravity, an object, e.g., a ball, tossed into the air has both potential energy and kinetic energy.
The total energy is the sum of the two. Let's neglect the air resistance, on its way up, the ball gains potential energy
but slows down, thus has less kinetic energy. When it reaches the maximum height, the KE becomes zero
(it stops there, v=0, so KE=0), but the PE there is maximum and equals to the total energy.
After reaching the maximum height, the ball starts to fall. On its way down, the PE energy decreases while it picks up speed,
increasing its KE.

Since the increase in one form of energy, say PE, causes the decrease of the other form, i.e., KE, we say
the PE is converted in KE and vice versa. Analogy:let PE be cash you have and KE be items purchased.
You have $100 total. Then the more KE (items purchased) you have, the less PE (cash) you have left, or vice versa.

Conservation of Energy

In the absence of friction such as rubbing against a surface or moving through air or fluid, energy is said to conserved.
Conservation here means the total amount (sum of KE and PE) stay the same. Let TE = total energy, then

TE = KE + PE = constant. <-- meaning a conserved quantity; conserved means changeless.

Example

KE + PE = 100J (J = Joule)
0 + 100J = 100J
20J + 80J = 100J

50J + 50J = 100J
10J + 90J = 100 J

Notice that the total never changes, always 100J; but individual KE or PE does change.
Note that when one energy form increase, the other form must decrease.
So when a object is tossed into the air, the total energy doesn't change at any give point, but KE or PE changes all the time. When the ball leaves your hand, it has some KE.
At maximum height, KE is zero. But when it comes back just before striking your hand, its KE has completely recovered.

Total energy involving friction

Summarizing the above

- KE can convert to PE and vice versa
- TE = Total Energy = KE + PE if there is no friction.

What if friction is involved, then we must include the friction in the total energy

TE = KE + PE + frictional energy If friction is involved

Frictional energy = energy dissipated due to friction;

Friction slows things down, taking away KE and converts it into heat.

There is one big catch: once KE is dissipated as frictional (heat) energy, it can't
can not be converted back KE or PE of object again.

Eventually, the object will drain all its potential energy into KE, and from KE to friction energy, until it stops, losing all its energy.

Your job is learn these concepts above by doing a virtual lab.

Virtual Lab Activities

Part I. Pre-lab navigations

If you don’t want to waste time, complete the pre-lab navigation exercise above first before .

As you need some training beforehand, click the link below to perform pre-lab exercises, followed by Experiment A and B.

-- Inform your instructor immediately if the link is not active --

https://phet.colorado.edu/sims/html/energy-skate-park-basics/latest/energy-skate-park-basics_en.html

Pre-lab training instructions:

A. Once you get the app going, practice going in and out of any of the three possible scenarios in the app, i.e., Intro, Friction or Playground.
To **exit** a scenario**,** hit the **House Icon**.

B. Complete the followings to practice navigations.

1. Double **click Intro** and then **select the parabola curve** if it is not already displayed.
2. **Lift** the girl skater **and drop** her at either side the **U-ramp** above or at the midpoint
3. **Let go** to observe what happens. Also observe if any changes happened to vertical bars
4. **Toggle to the Slow Motion** and observe what happens, then **toggle back to normal.**
5. **Click Play/Pause button** [||] **to stop the motion**
6. While the skater is going **down ramp, click and hold the Fast-Forward** [|>] **button** to move her to the bottom of the ramp and let go there.
   If you **miss** it, **press [Restart Skater] and try again**.
7. Hit the **Reset** button <-- Look for the circle with a turnaround arrow.
8. **Relocate** the girl **on the other side** of the ramp while she is having fun.
9. On the Data Collection panel
   i. Click the checkbox to **turn on** the **Bar Graph** and observe changes in the green Kinetic Energy (KE) bar and the blue Potential Energy (PE), and the total energy bars. What is the relationship between KE and PE and TE?
   ii. Click to **turn on the Grid** and the **Speed**, then
      - - Practice measuring maximum and minimum height from the base of the bottom of the skate, **Red Dot**, to the ground.
        Estimate the height corresponding to the maximum PE, and do the same for the KE.
        What is the height between the ground and the midpoint?
      - - Moving too fast to see record these locations clearly?
        Combine **Pause, Slow Motion**, [click and hold or click repeatedly] **Fast Forward** buttons to move the skater until the locate maximum PE or KE is reached. Read (determine)
         - - At what height does the speed become zero? When PE is zero? Does TE of the girl change at different points alone the ramp?
         - - Next, practice observing how is the height related to speeds, KE, PE. How is potential energy and kinetic energy? Hint: what happens to PE when PE increases. So **not just seeing** things are **moving**, **but** also seeing **changes in PE & KE associated** with motion and potential.

10. Exit the practice

Part II. Virtual Experimentations <-- Do Part I first if you don't want to waste time)

A) Conservation of Energy without Friction

1. Enter **Intro** (frictionless) and set up the screen just like the above. Make sure you check Bar Chart, Grid, and Speed on to re-create the scenario above.
2. Drop the skater to either side of the U-ramp, at exactly 6.0 m above the ground

   before releasing her. (Note: the red dot below the skate must touch the 6.0 m

   line). Be very accurate, points will be taken off for inaccuracy.

3. Observe the change in potential bar and kinetic energy bar when the skater is at various positions and record the data on the data table. Note: PE or KE are measured and expressed in terms of total energy, e.g. KE = 25% TE
4. Reset the Experiment. Use the mass slider to change the mass of skater to the **smallest** possible. Repeat the experiment by releasing the skater at 6.0m.
   Record the PE, KE, and Speed in chart below. Record the data sheet provided.

5. Reset the Experiment. Use the mass slider to change the mass of skater to the **biggest** possible. Repeat the experiment by releasing the skater at 6.0m.
   6. Record the PE, KE, and Speed in chart below. Record the data sheet provide.

B) **Conservation of energy without friction**.
-- This is more like the reality --

6. While the simulation is still running in the last part of Experiment A, **click** on the F**riction** icon (located below the Play/Pause button)

7. Observed what happened until everything stops. Record how many cycles of ups and downs before the skater stops.
One cycle is defined as how many times it goes down (or up) on the same side of the ramp.

8. Repeat the experiment by hitting the [Restart Skater] button. Pay attention to Bar chart carefully this time.
Repeat this as many as needed to understand what is happening. Record the PE and KE in the first and 3rd cycle.

Data sheet

Copy and paste the 3 tables below, including captions and paste them into your word document.
Fill up the table while doing the experiments. Upload the table as part of your lab report.

Note: Report KE and PE in percent of % TE

	Height at 6m	Height at 3m	Height at 0 m
Speed			
KE (%)			
PE (%)			
TE (%)			

Fig. 1. Default skater mass

	Height at 6m	Height at 3m	Height at 0 m
Speed			
KE (%)			
PE (%)			

TE (%)			

Fig. 2. Skater with the smallest mass possible

	Height at 6m	Height at 3m	Height at 0 m
Speed			
KE (%)			
PE (%)			
TE (%)			

Fig. 3. Skater with the largest mass possible

Report

A. Virtual Experiment A: Conservation of Energy without Friction

Summary instructions.
Title: create a title on your own
Objective: mention what is the experiment try to test or what concept to prove. Test one idea only.
Materials and methods:
Since this is a virtual experiment, so the materials and method are virtual too. What are considered as a virtual material and method then?
What are involved in the experiment? Whatever involved is considered materials or subjects. Methods is how do you conduct the virtual experiment.
You can mention the app as a part of the materials and method, but don't forget the skater and yourself.
Results and discussions: You must show the data collected in tables in format provided above. You may comment on the results briefly if they are consistent.
Conclusion: Based on the result, what can you say about the objective? Have you achieved it? If not why?

Q/A's

Carefully study the data recorded in the tables above, and repeat the experiment if needed while answering the following questions:
(Answer the first question, and then answer odd number questions if you last digit SSN is odd; even answer even number questions.)

1. A bowling ball is 20 kg is tossed straight up in the air from the ground up and reached a height of 2m. What is it's potential energy, kinetic energy and total energy. See formula found in **Concepts and Terminology**
2. Doest the mass of the skater affects the total energy in all three trials of skater of different masses?
3. In all three cases, where do the skater's maximum and minimum kinetic energy occur and at what speed? Is there a change in the total energy?
4. In all three cases, where do the skater's maximum and minimum potential energy occur and at what speed? Is there a change in the total energy?
5. When total energy (PE+KE) doesn’t change, the energy is said to be conserved.
   Is the energy conserved in all three cases?
6. Based on the data, when PE increase from one position to the other, what exactly happened to the change in KE? And vice versa?
7. When the skater is located between midpoint and the maximum height, which energy is more, the kinetic energy or the potential energy?

8. Does the total energy there (at the mid-point) stay the same as at the minimum and maximum height?

B. Virtual Experiment B: Conservation of energy without friction.

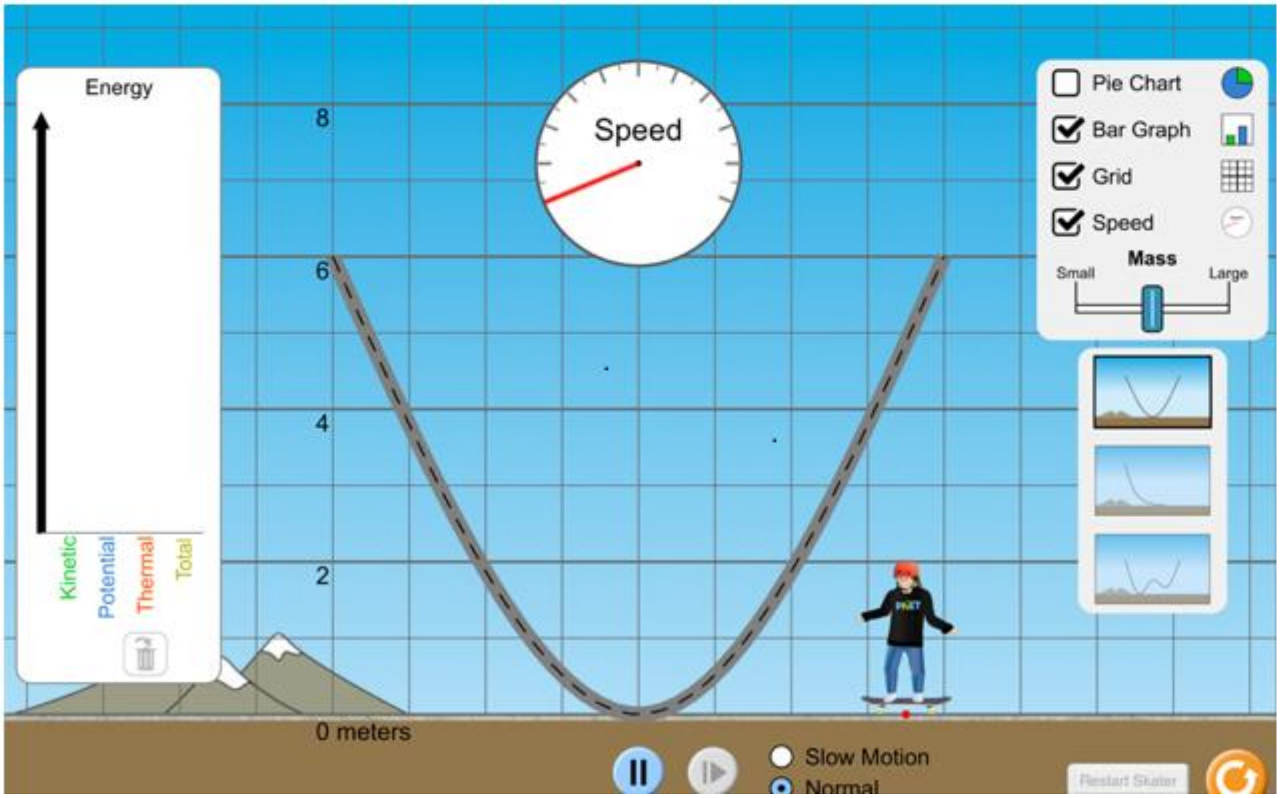
Feel free to repeat the experiment in order to answer the questions.

Summary: See Summary instructions for Experiment A.

9. How many times does the girl skater swing up and down before she stops completely? Estimate how much kinetic energy she has lost each trip?

10. A trip is from the highest point possible to the lowest point on the ramp. Why and Why not?

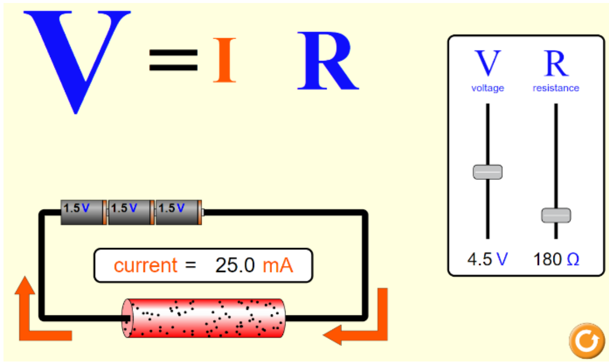
11. Challenge: The skater starts with maximum [potential] energy, later becomes motionless and has zero PE and KE combined. The potential energy is originally possessed by the skater. What has happened to the potential energy when she becomes motionless at the bottom? Is the energy still conserved? If so, where does the energy go? Where can you find the energy that is no longer associated with the skater?



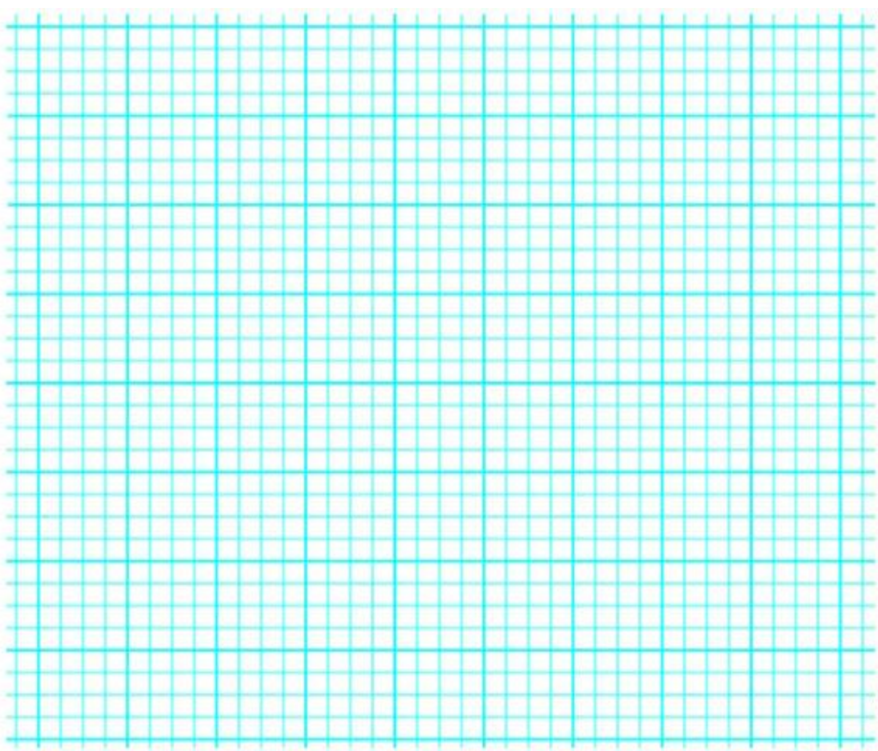
Lab 6
Verification of Ohm’s Law

Activity Link: http://phet.colorado.edu/sims/html/ohms-law/latest/ohms-law_en.html

Please go to the above link, set Resistance “R” = 180 Ω, vary the Voltage “V” and record the Current “I” in Ampere unit in the following Table. Plot the Voltage “V” versus Current “I” graph putting Voltage in y axis and current in x axis in the following graph paper. You will see a straight line and find the slope of the line. Is the slope value is around 180 Ω? YES or NO?



V (Volts)	I (mA)	I (A)



Note: Do not forget to convert milliampere (mA) to Ampere (A) unit in the Data Table.