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Lab 4: Graphing Motion

Purpose

To learn how different types of graphs describe the motion of objects

Background

Line graphs are used to describe the motion of objects such as a rolling ball, a moving automobile, or an airplane in flight. There are different types of motion graphs that each express different properties of motion. Displacement graphs, x vs. y graphs, and velocity graphs may all be used to graph the exact same motion, but they each use different data and are used to communicate varying information. Newspapers and other media reports use many different graphs but these are commonly misunderstood. Careful examination can reveal information that would fill many data tables. A picture really is worth a thousand words!

Skills

Graphing, interpreting data, drawing conclusions

Procedure

1. Start *Virtual Physics* and select *Graphing Motion* from the list of assignments. The lab will open in the Mechanics laboratory.
2. The laboratory will be set up with a 10-kg ball on a table. Attached to the ball is a plunger to be used to hit the ball. You will hit the ball and observe it as it rolls across the table. You will record the position and velocity of the ball over a period of time in your electronic lab book and then use your data to make several graphs of the motion.
3. Click on the *Lab Book* to open it. Click on the red *Recording* button to start recording data. Start the ball rolling by clicking on the *Force* button and wait until the ball hits the end wall. Click the *Pause* button to stop the experiment. You should see a link appear in the *Lab Book*. This contains the position and velocity versus time data for the ball as it rolls across the table.
4. Click the *Reset* button. Repeat the experiment with a smaller mass. Change the mass to 8 kg using the *Parameters Palette*. Under the *Forces* Tab, change the angle to 90 degrees. This will move the plunger to hit the ball straight up. Double click in the Lab Book next to each link to label each with the corresponding mass and direction.
5. Reset the experiment and in the *Palette* change the *Elasticity* to 1. This will allow the ball to bounce off the wall. Repeat the experiment, this time stopping the experiment after the ball bounces and returns to $x = 0$. Label the link in the Lab Book *Bounce*.
6. Reset the experiment again and in the *Palette* change the *Elasticity* to 1 and under the *Forces* Tab, change the angle to 30 degrees. This will move the plunger to hit the ball at an angle. Repeat the experiment, stopping after 2 bounces off the wall. Label the link in the Lab Book *2D Bounce*.

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5. Drawing Conclusions In what way does a series circuit look like it would have the same current throughout?

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6. In what way would your answer to question 4 above be important for an electrician to know?

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Going Further

7. Now go back to the circuits and replace the resistors with light bulbs. The symbol for a light bulb is a white circle with an X in the middle. Place them on the engineering paper. Create a series circuit and a parallel circuit like the ones you made earlier. Then try removing one of the light bulbs. Record below what happens in each case. Also, record the relative brightnesses of the bulbs in each circuit.

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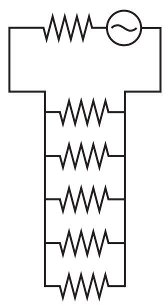

8. First add a new resistor in series to the beginning of the function generator. Change its resistance to equal 1 Ω.
9. Drag and set the other five resistors back onto the lines so that the circuit looks like a ladder with the resistors as the steps. Your final schematic should look like the picture on the right.
10. Using the same technique as Step 6, measure the voltage and current across each of the five resistors listed in Data Table 1. Remember that it is a DC source, so you must use the DC Voltmeter and DC Ammeter. Record your results in Data Table 3 below.

Data Table 3

Resistor Number	Voltage (V)	Current (A)
1		
2		
3		
4		
5		

Analyze and Conclude

1. **Classifying** What are the variables in this experiment?

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2. **Inferring** Which variables stay the same, and which change in the series circuit?

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3. Which variables stay the same, and which change in the parallel circuit?

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4. **Comparing and Contrasting** How do parallel and series circuits differ?

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5. Change the value of each resistor to the match the values found in Data Table 1. Assume that resistor 1 is the one connected to the positive side of the voltage source and resistor 5 is the one connected to the negative side of the voltage source.

Data Table 1

Resistor Number	Resistor Value (Ω)
1	120
2	500
3	200
4	135
5	10,000

6. Using the multimeter to measure the current and the voltages across each resistor. The symbol for the multimeter has a DMM in the middle of it. Click and drag the red lead to one side of the resistor. It should lock into place. Then click and drag the black lead to the other side of that same resistor to measure the drop in voltage across the resistor. You can read the voltage and current from the yellow multimeter display. To measure the current passing through the resistor, change the multimeter from VDC to IDC, which changes the variable being measured from voltage to current. Record your measurements in Data Table 2.

NOTE: For the ammeter to measure current, it should be placed with both leads on one side of the resistor. This is because the current must flow through the ammeter to measure it. However, the voltmeter needs to compare voltages at two points, so it should be hooked up across the resistor.

Data Table 2

Resistor Number	Voltage (V)	Current (A)
1		
2		
3		
4		
5		

7. Now, using the same resistors as before, you will build a parallel circuit. This is done by creating multiple paths for the current to follow. To do this, first move all the resistors to the bottom half of the paper, but don't delete them.

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Lab 32: Series and Parallel Circuits

Purpose

To build series and parallel circuits and study the differences between them

Background

Electricians are called upon whenever new buildings need electrical work. The electrician surveys the site and determines what kind of currents and voltages are required to satisfy the client's needs. Sometimes the circuit requires components to be connected like you would in plumbing so the water could flow. This is called a series circuit. Sometimes the components need to be connected in parallel, like the rungs on a ladder. Each type of circuit has its advantages. In this lab, you will study the advantages of and the differences between series and parallel circuits.

Skills Focus

Classifying, inferring, comparing and contrasting, drawing conclusions

Procedure

1. Start *Virtual Physics* and select *Series and Parallel Circuits* from the list of assignments. The lab will open in the Circuits laboratory.
2. The laboratory will be set up with a function generator set to 12 V DC already on the engineering paper, which is the schematic or plan of the circuit built on the breadboard. In this assignment, you will have to add resistors to create a circuit. To add resistors, simply click on the resistor symbol at the top of the engineering paper and drag it onto the paper. You may move resistors around by clicking them on the middle blue dot. You can also extend their leads by clicking on the end red dots and dragging them to where you want to connect them to other components. The line will be green if it is in an allowable location. You will notice that the breadboard will automatically populate with the resistors that you add to the schematic.
3. You need to build a circuit that has only one path for the current to follow. This is called a series circuit. Use only resistors to make this circuit. On the engineering paper, place five resistors in series using the resistor symbol at the top. First start by connecting the first resistor to an open end of the function generator. Then drag out a new resistor and place it next to the open end of the last placed resistor. Follow the same process until you have five resistors in series. Complete the circuit by connecting the last resistor you added to the other side of the voltage source.
4. Make sure that that there is only one path for the current to flow through the resistors you connected in Step 3. After you have placed the resistors on the circuit, you will need to change the resistance of each of the resistors as specified in Step 5. You can do this by clicking on the number next to the resistor. A small box will pop up where you can adjust the value of the resistor.

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7. The type of lens used in Step 6 is called a converging lens, because it helps light to converge down to a point. Glasses for farsighted people are used for looking at things that are close, to help the light to focus on the retina farther forward than it would normally. This is necessary because the eye in this case is misshapen enough to cause the light to focus too far behind the retina. If you turn off auto-focus and move the detector around, you can see precisely how the lens is made to focus the light at one specific distance into the eye for a focused image.

8. Repeat Step 6 with *Experiment 14: Nearsighted Eyeglasses: Diverging Lens*. Which side of the lens is more curved in this setup? Sketch the lens and describe which part of the lens is thicker.

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9. **Applying Concepts** The type of lens used in Step 6 is called a diverging lens. Explain what this type of lens would do for a nearsighted person.

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4. **Observing** Now you will confirm your predictions with the given lens. The focal point of this lens is 20.32 cm, or 8 in. Each of the pin locations, or holes, on the table is 2 inches apart. You will be placing the object at different distances from the lens, and then using the eye as a detector on the far side of the lens to find the location of the image produced by the lens. There is only one point at which an image is truly in focus. Turn off the autofocus feature in the detector screen by unchecking the Auto Focus box. Uncheck the grid box also to allow yourself to see the image better. Move the detector eye until the image is in focus. Record in the table below the distance from the lens to the image. Also record the Height Factor displayed in the bottom of the detector screen. This is the magnifying factor of the image from the original size of the object. Repeat the experiment for each of the different cases that you drew with the ray diagrams.

Data Table 1

Distance of object from lens (cm)	Distance of image from lens (cm)	Inverted? (yes/no)	Image bigger or smaller than object?	Height Factor

5. Did the data you collected and the images you observed match your predictions from the ray diagrams? Explain.

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6. You have been using a symmetrical lens that has the same curvature on each side, which creates more predictable images, as you have observed. Now you will test two types of lenses that are used in glasses and are more complicated. Click on the Clipboard on the right side of the table to bring up a list of preset experiments. Select *Experiment 15: Farsighted Eyeglasses: Converging Lens*. The table is set up with a candle, lens and detector as before, but the lens is different because it is the type of lens that is used in glasses for farsighted people, and in reading glasses. Right click on the lens to pop up the control panel. The values for r1 and r2 reported are measures of the curvature of the lens. r1 is the first side of the lens that the light from the candle strikes. A small radius of curvature means that the lens is more curved, or that it would be part of a circle of smaller radius. Which side of the lens is more curved? Draw a picture of what the lens would look like with the different radii of curvature. Which part of the lens is thicker—the middle or the edges?

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Name ____________________ Date ________________ Class __________

Lab 27: Lenses

Problem

To make predictions about and study the formation of images with ray diagrams and lenses. Also to study the two common types of eyeglasses

Background

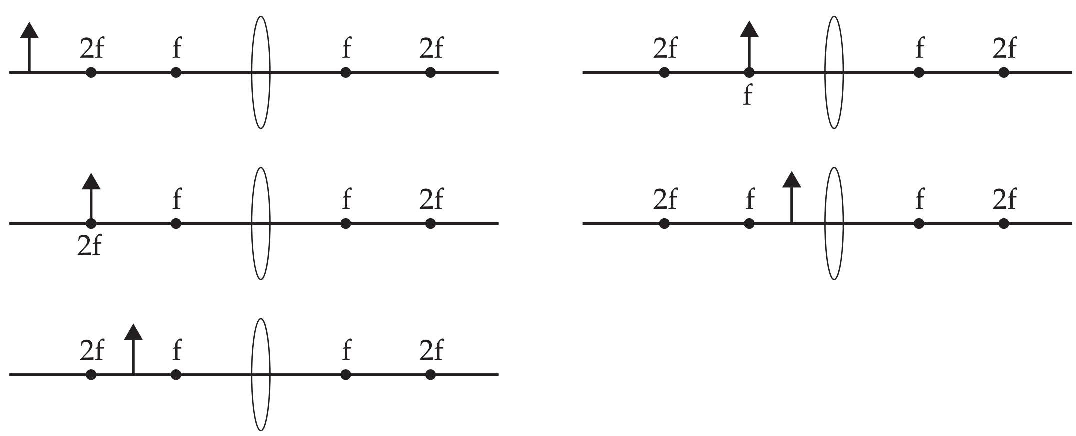
Did you know that the film for the movies in theaters is placed in the projector upside down? Projectors have convex lenses inside which flip the image on the film and magnify it so it can be projected up on a screen a long distance away. That is a type of image that you can see without even looking through the lens. However, there are many images that you can only see by looking through a lens. To see magnified objects with a microscope or magnifying glass, you must look through the lens and carefully adjust the distance of the lens from the object to see the image clearly with your eye. The distance of an object from a lens and from the lens to the image are variables that can be controlled for many different applications, from eyeglasses to cameras to light houses.

Skills Focus

Graphing, observing, applying concepts

Procedure

1. Start *Virtual Physics* and select *Lenses* from the list of assignments. The lab will open in the Optics laboratory.
2. The laboratory will be set up with a candle on an optics table with a convex lens in front of it. An eye will be on the other side of the lens so it can look at the image produced by the candle through the lens. You will observe the image of the candle from various distances to determine how images are changed in a convex lens.
3. **Graphing** Lenses produce very different images of on object depending on where the object is with respect to the lens. Ray diagrams are often used to construct the image that would be viewed through a lens. The following is a set of ray diagrams for a convex lens. Draw the necessary rays to determine where the image will be in each of the cases.



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6. **Interpreting Graphs** What do the shapes of the velocity-time graphs tell you about the acceleration throughout the experiment? Is the acceleration constant or does it change? Where do you see positive acceleration and where do you see deceleration?

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7. **Applying Concepts** What do you think would happen if you repeated the same lab with a more massive sled?

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3. What happens to the shapes of the position versus time graphs after the rockets turn off? Recall that the slope of a position vs. time graph is the velocity of the object.

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4. Applying Concepts What forces are acting on the sled throughout the experiment? List the forces that are acting on it in the different stages of motion.

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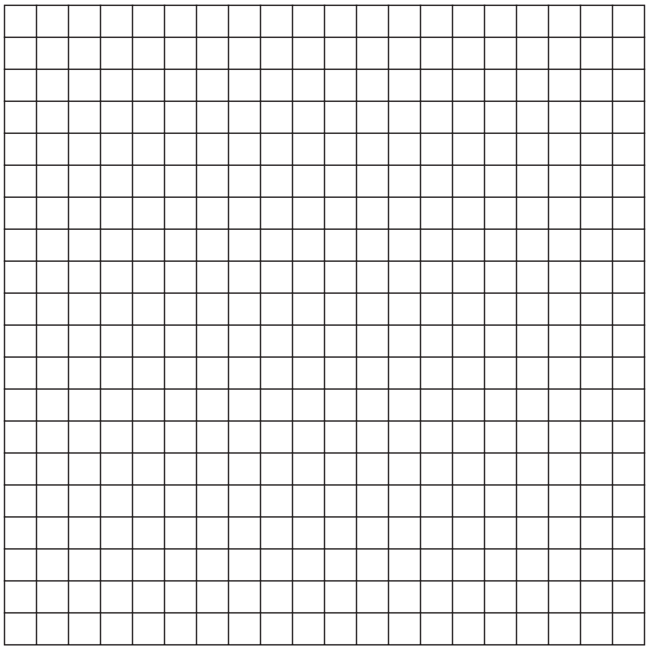
5. Graphing Now graph velocity versus time for each of the five different experiments. Use the v_tot data found in the data links saved in your lab book. Label the horizontal axis *Time* (*s*) and the vertical axis *Velocity* (*m/s*). Use the same colors that you used in the position graphs. Identify on the graphs the place where the rocket finished firing.



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Material of the Sled	Material of the Table	Sliding Distance (m)	Sliding Time (s)
Wood	Plastic		

Analyze and Conclude

1. **Graphing** On the grid below, graph the position versus time for each of the five different experiments. Use the data found in the data links saved in your lab book. Label the horizontal axis *Time (s)*. Label the vertical axis *Distance (m)*. Use a different color for each graph. You will need to scale the graphs to fit your data. Identify on the graphs the place where the rocket finished firing.

2. **Interpreting Data** As the friction increases, what happens to the shape of the position versus time graphs during the firing interval? Explain why.

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Lab 9: Acceleration and Friction

Purpose

To investigate the effect that friction has on the acceleration of an object

Background

Have you ever tried to ride a bike with flat tires, or push a heavy crate across a rough floor? Chances are you couldn't get the bike or the crate to move very fast. What makes these activities so hard is the large amount of friction involved. Friction affects motion just as all other forces affect acceleration. But when multiple forces act on an object together, the result can be unpredictable. All motion is due to a complex interplay of different balanced and unbalanced forces, and often the effects are only visible by examining the resulting accelerations.

Skills Focus

Graphing, interpreting data, applying concepts

Procedure

1. Start *Virtual Physics* and select *Acceleration and Friction* from the list of assignments. The lab will open in the Mechanics laboratory.
2. The laboratory will be set up with a sled on a table. The surface of the table can be changed to be made of different materials. Attached to the sled is a small rocket that will be used to push the sled. Click on the *Lab Book* to open it.
3. Click on the red *Recording* button to save the position versus time data. Click on the *Force* button to start moving the sled. The rocket will turn off automatically after two seconds. When the sled has stopped moving, click on the *Pause* button to stop the experiment and stop recording data. A new data link should appear in your lab book. Record what happens to the sled in the table on the next page.
4. You will try other types of materials for the sled and the table to see how long it takes the sleds in each case to stop. Remember to click the *Reset* button before trying new materials. In the *Parameters Palette* choose the materials under the *Frictions* tab. Choose a variety of different types. For each trial, record the materials of the sled and table, the distance the sled travels until it stops, and the time it takes the sled to stop in the table below. If the sled reaches the end of the table, the experiment will stop automatically. Double click next to each link in the lab book to label the link with the materials.

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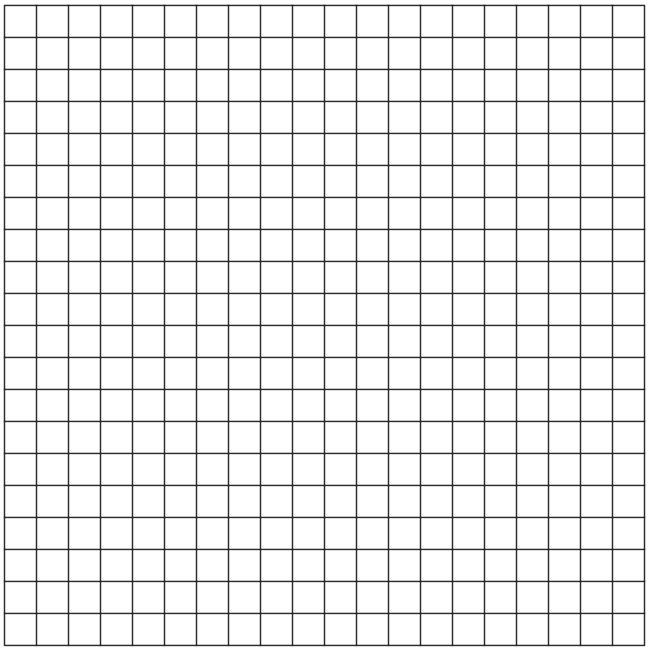

3. **Interpreting Data** Do any of the angles make the ball travel the same horizontal distance?

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Explain why two different angles cause the ball to travel the same horizontal distance.

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4. **Drawing Conclusions** What effect does the mass of the ball have on the distance the ball traveled?

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5. **Interpreting Data** How did the distance the ball traveled change with air resistance?

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6. **Applying Concepts** Which do you think would travel farther with air resistance: a ball shot up at 75° or out at an angle of 15°? Explain your prediction, then test it.

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4. Click the *Reset* button to reset the experiment to the beginning. Change the angle of the plunger to 15° using the *Forces* tab in the *Parameters Palette* and repeat Step 3. Repeat the experiment two more times using the angles shown in the table.

Data Table

Angle	Force (N)	Mass of Ball (kg)	Air Resistance?	Distance Traveled (m)
45°	100	0.2	no	
15°	100	0.2	no	
30°	100	0.2	no	
75°	100	0.2	no	
	100		no	
45°	100	0.2	yes	

5. To see how the mass of the ball affects its motion, hit another ball of a different mass from the angle you think will make the ball go farther. Reset the experiment with the *Reset* button. Use the *Forces* tab in the *Parameters Palette* to change the angle of the plunger to your chosen angle. Change the mass to either a larger or smaller mass, whatever you think will make the ball go farther. Repeat Step 3 to collect your data.
6. Now you can test to see how air resistance would affect the motion. Reset the experiment with the *Reset* button. Drag the air resistance icon down into the work area, and repeat Step 3 to collect your data.

Analyze and Conclude

1. **Interpreting Data** Which ball traveled the farthest?

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   How does the angle affect how far the ball goes? Explain.

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2. **Graphing** On the grid on the next page, graph the *x*-position versus *y*-position for each of the five different experiments. Use the data found in the data links saved in your *Lab Book*. Plot *Distance (m)* on the horizontal axis and *Height (m)* on the vertical axis. Decide on the proper scales for the axes. Use a different color for each angle. Label which line corresponds to each angle. Identify the graph of the ball that has a different mass and also which graph has air resistance.

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Lab 7: Gravity and Projectile Motion

Purpose

To study projectile motion with different launch angles and with and without air resistance

Background

On the basketball court, the baseball field, and at the football game, balls are thrown or hit. These balls follow a path through the air that depends on the initial velocity and angle of the ball's path. Surprisingly, if air resistance is ignored, the horizontal velocity of a thrown ball is constant. Only the vertical velocity changes as the ball flies through the air. What forces accelerate the ball? Just gravity! Gravity slows the ball down as it rises and speeds it up on its way down.

Skills Focus

Predicting, interpreting data, graphing, drawing conclusions, applying concepts

Procedure

1. Start *Virtual Physics* and select *Gravity and Projectile Motion* from the list of assignments. The lab will open in the Mechanics laboratory.
2. The laboratory will be set up with a 200-g ball (the approximate weight of a baseball) at the bottom of the experiment window. Attached to the bottom of the ball is a plunger used to hit the ball up into the air. Gravity will pull the ball down. There is no air resistance. Observe how far the ball travels when hit at different angles. The plunger is initially set to hit the ball with a force of 100 N at an angle of 45°.

   Predicting What would happen if the ball were hit into the air and there was no gravity or air resistance? How far would it go?

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3. Click on the *Lab Book* to open it. Click the red *Recording* button to start recording data. Start the experiment by clicking on the *Force* button and observe the path of the ball. The experiment will stop when the ball falls to the bottom of the screen. You will see a link appear in the lab book. Double click next to the link to label it as 45 degrees. It contains the position versus time data for the ball flying through the air. Record the horizontal distance (the maximum x-distance) the ball traveled in the table on the next page. You will need to look in the link for the x-distance closest to when $y = 0$.

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5. **Interpreting Data** When the ball got back to $x = 0$, what was the total displacement? How did the velocity of the ball change when it bounced?

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6. **Graphing** Use the 2D Bounce data to make another graph below. Click on the fourth data link in your lab book to view the data and use the x(m) and y(m) data to make a graph of the physical position of the ball on the table. Your graph should show the x- and y- positions that the ball traveled, with the x data shown on the x-axis and the y data on the y-axis. Label the axes with the proper variable and its units. You will need to scale the graph to fit your data. Remember that this is not a position versus time graph, it is just a graph of the physical location. Have your first point in the bottom left hand corner of the graph be $x = 0$, $y = 0$.

7. **Drawing Conclusions** You have drawn several different types of graphs. How did each graph communicate different information?

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Name ______________________ Date ________________ Class __________

Analyze and Conclude

1. **Graphing** Click on the first data link in your lab book to view the data from the first experiment. Use the *x*(m) position data to graph the motion of the first ball over time. Your graph should show the distance the ball traveled versus time, with *Time* shown on the *x*-axis and *Distance* on the *y*-axis. Also graph the position data of the second (lighter) ball on the same graph. Use the *y*(m) data to find the distance of the ball from the origin over time. Label the axes with the proper variables and their units. Use a different color to connect the points for each ball. Scale the graph to fit your data. Just plot a few of the points from each line, enough to be able to draw the whole graph accurately. Remember that you are just plotting distance, not direction.

2. **Interpreting Data** What does each point on the graph represent?

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3. What is the difference between the two lines you graphed? What do the slopes of the lines tell you about each ball?

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4. **Graphing** Click on the third data link in your lab book to view the data from the first bouncing experiment. Use the *x*(m) position data to graph the motion of the first ball over time on the left grid on the next page. Your graph should show the distance the ball traveled versus the *Time*, with time shown on the *x*-axis and *Distance* on the *y*-axis. Label the axes with the proper variables and their units. Scale the graph to fit the data. Then graph velocity versus time on the right grid on the next page using the v_tot data in the link. Remember to label your axes with time on the *x*-axis and velocity on the *y*-axis.