Gravity: How fast do objects fall?
Student Version

Kinematics is the study of how things move – their position, velocity, and acceleration. **Acceleration** is always due to some **force** acting on an object, in a car this force is provided by the engine or the brake pedal. Today, we will focus on a particular force that we experience constantly – the force of **gravity**. In this lab we'll use a computer program to mark the times at which washers on a string hit the ground, and use these measurements to calculate the velocity of the string and to see whether it accelerates. We'll also look at whether the **mass** of an object (the amount of "stuff" in it) affects how fast it falls.

Key Concepts:

- **Velocity** = change in distance ÷ change in time
- **Acceleration** = change in velocity over time (we say an object is *accelerating* if it is speeding up and *decelerating* if it is slowing down)
- Gravity accelerates all objects at the same rate (regardless of mass). This means that as an object begins to fall, it moves faster and faster (its velocity increases). Heavy and light falling objects will reach the ground at the same time

Part 1 – Distance versus Time for a Falling Object

In this first part you will measure the acceleration of gravity directly by calculating how the velocity of a falling object changes with time. You will use the microphone on your computer to accurately measure the time it takes for washers to fall different distances.

Procedure:

1. Separate the Data Diagram sheet from your lab. It should be the last page.
2. Your lab kit should include a long string with washers tied to it. One person should stand up and dangle the string so that it hangs down straight with the metal weight on the bottom just touching the ground. The other person should **use a meter stick to measure the distances between the washers. Fill in your results in the "Distances" column of the Data Diagram.**
3. **Place a large paperback book or workbook under a piece of aluminum foil on the floor. Place the computer on a chair nearby.**
4. Make sure Audacity is up on your computer. **Hit the Record button** (button with the red circle) and **tap the aluminum foil with your finger a few times, to make sure you can see the sound being graphed on the screen.** You may need to adjust the microphone volume up to increase the signal or down to decrease the noise. The volume can get adjusted using the slider next to the microphone icon:

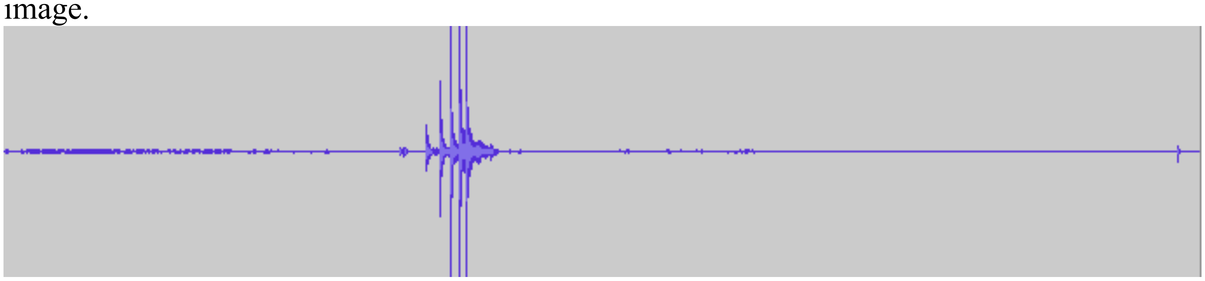
   

   Go to Edit->Undo to get rid of the test recording.
5. Two students should work together to carry out the experiment:
   Person 1: **dangle the string over the piece of aluminum foil so that the weight at the end is just touching the foil.** Stand on a chair if necessary.
   Person 2: **hit the record button on the computer** and tell Person 1 you have done so.

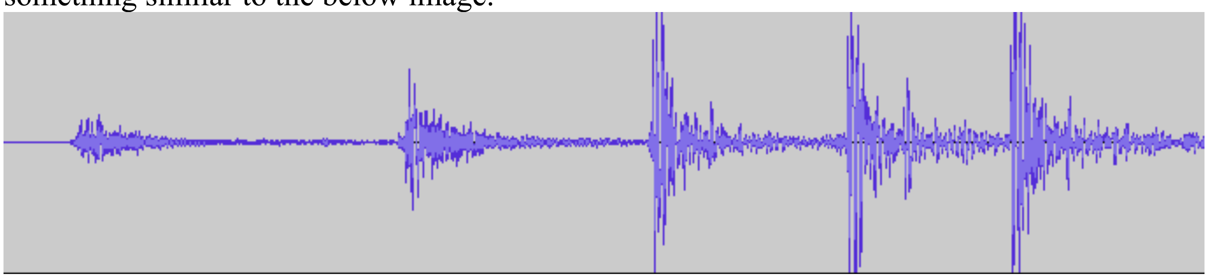
Person 1: After you get the signal from Person 2, **let go of the string.** The washers should fall one by one onto the foil, with each one making a sound when it strikes.

Person 2: **Stop the recording.**

6. Look at the Audacity display and **make sure that you can see 5 peaks on the graph corresponding to each of the washers hitting the ground.** If the signal looks too messy to make out the peaks, you may need to redo the experiment. It should look similar to the below image.



7. To find the time at which each washer hit the ground, **position the cursor over the peak in Audacity (using the mouse or arrow keys).** To see the peaks more closely, use the mouse to highlight all the peaks and then zoom in by going to View->Zoom to Selection getting something similar to the below image.



Look at the bottom of the Audacity window. There should be a line that says "Selection Start:", make sure the time there is set to **hh:mm:ss + milliseconds.** These numbers give the time corresponding to the cursor. **In the "Times" column, fill in the time at which each washer hit the ground.**

Q1. What does a time of 0 correspond to in this experiment?

Q2. What happens to the sound peaks as more washers fall – do they remain equally spaced, move closer together, or farther apart from each other?

Q3. Do you think the washers are falling faster, slower, or with the same rate as more of them hit the ground?

8. **Fill in the "Time Interval" column with the time difference between each pair of washers hitting the ground.**

   Q4. Do the time intervals between the washers hitting the ground increase, decrease, or stay the same as more washers hit?

9. **Calculate the velocity of the string at two different points.** Remember, velocity is the distance traveled divided by the time.

   Velocity (washers 2 & 3 falling) = distance ÷ time interval: ______________cm/sec
   Velocity (washers 4 & 5 falling) = distance ÷ time interval: ______________cm/sec

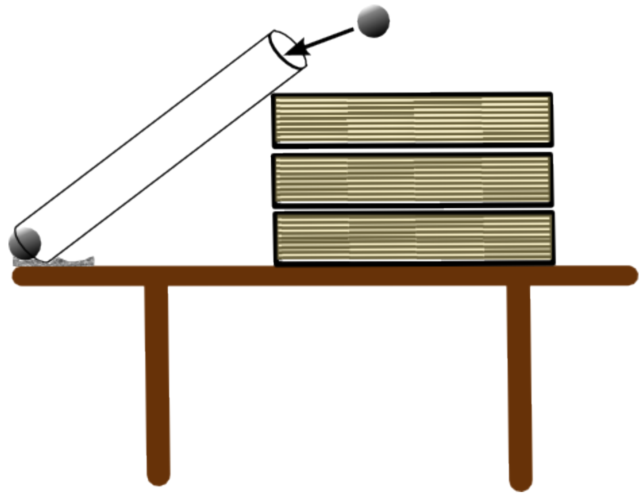
   Q5. What happens to the velocity as more washers fall? Is the string accelerating, decelerating, or going at a constant velocity?

   Q6. If you waited a long time after starting the recording before dropping the string, which results, if any would change?

Distances:	*increase / decrease / stay the same*
Times:	*increase / decrease / stay the same*
Time intervals:	*increase / decrease / stay the same*
Velocities:	*increase / decrease / stay the same*

   Q7. Adam jumps off a table at the same time as Bob jumps off a roof. When they hit the ground, which of them will be falling faster (or will they both be falling at the same rate)?

Part 2 – Gravity and Mass



In this part, you will measure the acceleration of gravity in another way, and also look at the effect of the mass of the falling object.

Procedure:

1. **Use 2 to 3 books to angle your paper towel tube to make a ramp near the edge of the table. Place a marble at the very edge of the table, right next to an open end of the tube.** If you have trouble with the marble rolling away from the edge, use a piece of aluminum foil to make a slightly rough surface for it to lie on.
2. **Roll another marble down the paper towel tube so that it knocks your first marble off the table. Place a piece of aluminum foil on the floor approximately where the first marble fell. Reset your ramp and marble at the edge of the table as before.**
3. Just like in Part 1, one person should be in charge of recording, and one person should perform the experiment. Make sure the microphone of your computer is near the marble on the edge of the table.
4. Person 1: **press the record button on Audacity**
   Person 2: **Roll the 2nd marble down the paper towel tube so that it knocks the first marble off the table**
   Person 1: **stop the recording**
5. Look at the graph of sound that you recorded and **find the peaks where the microphone heard the two marbles hitting and where the first marble hit the foil on the floor.** Zoom in and/or play back the recording if you aren't sure which peaks are the right ones.
6. **Find the time interval between when the marble was struck and when it hit the floor**.

Time when marble was struck: ____________
Time when marble hit the ground: __________
Time interval for the marble to fall (difference of the above): _________

7. **Now repeat the experiment using a ping-pong ball at the edge of the table.**

Time when ping-pong ball was struck: ____________
Time when ping-pong ball hit the ground: __________
Time interval for ping-pong ball to fall: _________

8. **(OPTIONAL) If you have time, repeat steps 6 & 7 once more so that you have two measurements of the time interval for both the marble and the ping-pong ball.**

Q8. Was there a significant difference in the time of falling for the ping-pong ball versus the marble?

Q9. Does the time of falling depend on the mass of the object?

Q10. Which traveled a greater distance overall in the time it took to reach the ground, the marble or the ping-pong ball? What does that mean about the horizontal speed of each ball as it rolled off the table?

Q11. If you shoot a bullet out of a gun and at the same time drop an apple (starting from the same height), which will reach the ground first?

Q12. If gravity makes all objects fall equally fast, then why does a sheet of paper fall slower than a pebble? Why does a skydiver with a parachute fall slower than one without? (both reasons are the same)

Data Diagram:

(Keep this page separate from the rest of the lab so that you can refer to it easily)