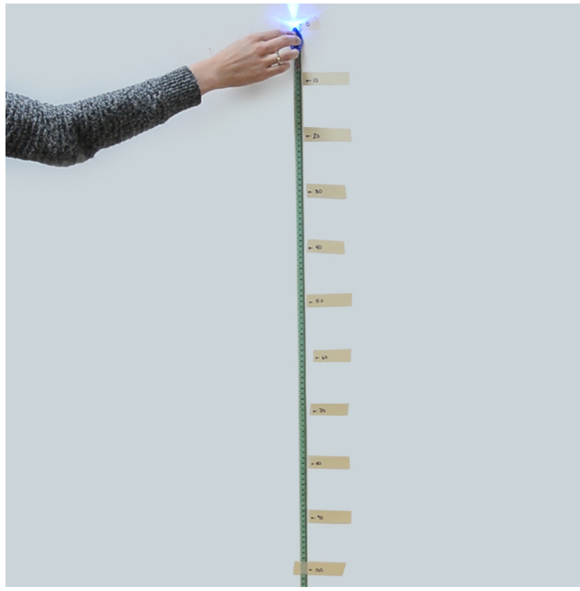


Falling for Gravity

"g" that's interesting!

Calculate the acceleration of gravity using simple materials, a cell phone, and a computer to record, watch, and analyze the motion of a dropped object.

Tools and Materials

- Two-meter measuring tape or two meter sticks
- Masking tape
- Marker pen
- Small, cheap, rugged flashlight
- Towel, carpeting, or other soft material for the dropped flashlight to land on
- Partner
- Digital camera with video capability (the HD camera on a phone should work fine)
- Computer with a program that lets you play videos frame by frame (not shown)
- Pencil and paper to record data (not shown)

Assembly

1. Locate a wall with a nonreflective surface. This Snack will not work in front of a whiteboard or window.
2. Tape the two-meter measuring tape to a flat wall. Position the measuring tape so that the 0 cm mark is at the top and the remainder hangs straight down. (If using meter sticks, tape and stack the two sticks together to make a total length of two meters.)
3. Directly below your measuring tape, place a towel, carpeting, or other material that will soften the impact of dropping the flashlight on the floor.
4. To make the measurements more visible, add extra marks on pieces of masking tape and stick them next to the measuring tape every 5 or 10 centimeters.

To Do and Notice

Collect your data

Have one partner stand next to the measuring tape. Turn on the flashlight and point it upward. Make sure your flashlight is on a non-blinking setting. Place the light as close to the 0 cm mark as possible and against the measuring tape. If possible, use only one finger to hold the flashlight still until the time of release. Have someone else film the drop with a digital camera (in HD at standard 30 frames per second).

Check your video to make sure you got the shot. Digital video is easy to erase and reshoot. Redo it if you didn't get a clear view of your flashlight's light falling straight down. Transfer your video file to a computer.

Record your data

Make a table with two columns to record your data. Label the columns "Time in seconds" and "Distance in meters." (See the sample table below.)

Sample Data

Time in seconds	Distance in meters
0	0
0.033	0.005
0.066	0.02
0.099	0.04
0.132	0.07
0.165	0.11
0.198	0.16
0.231	0.23
0.264	0.31
0.297	0.40
0.330	0.51

Time Data: Since your camera records 30 frames a second, each frame represents only 1/30 of a second, or about 0.033 seconds. That means each frame will add an additional 0.033 seconds.

Distance Data: In your video player, find the frame just before your flashlight drops. (Note that frame-by-frame players usually let you move forward or backward via arrow keys. The frame you're now at is time 0s and distance 0m.)

Now, step by step, record the distance in meters dropped and the corresponding time of the flashlight's fall. Watch the screen closely. Notice that, during the first few steps, the flashlight doesn't fall very much.

If your flashlight leaves a streak of light, only record the location at the bottom of the streak (the streak is a $1/30^{th}$ of a second record of the light's fall).

Calculate the acceleration due to gravity

Acceleration describes how fast the rate of something changes.

Acceleration = $(V_{final} - V_{initial})$ / the time to make this change

Here's an example using our data (see the table above):
$V_{initial}$ is the flashlight's velocity just before it's dropped, or 0m/s; V_{final} is the velocity of the light at the end of the drop.

In our case, at time 0.297 to 0.33s (time=0.033s), the distance traveled is from 0.4m to 0.51m (distance=0.11m).

V = distance/time

So, V_{final} = 0.11m/0.033s = 3.33m/s

The time it takes to make that change is 0.33s

Acceleration = (3.33m/s – 0m/s)/0.33s = 10m/s^2

Use your own data to calculate the acceleration of the flashlight you drop.

In your own experiments, you can collect data from shorter or longer distances.

What's Going On?

Gravity is a force that draws objects to one another. In this case, the objects are the flashlight and the earth. This fundamental interaction of nature causes objects like the flashlight to move toward the earth faster and faster.

Look at your data. You might notice that the distances between successive time intervals increase. This also means the object’s velocity is increasing, and increasing velocity is known as acceleration. You might have heard a car commercial use the phrase “Zero to sixty in five seconds,” or some such thing. That means the car went from one velocity to another in a certain period of time—that’s acceleration!

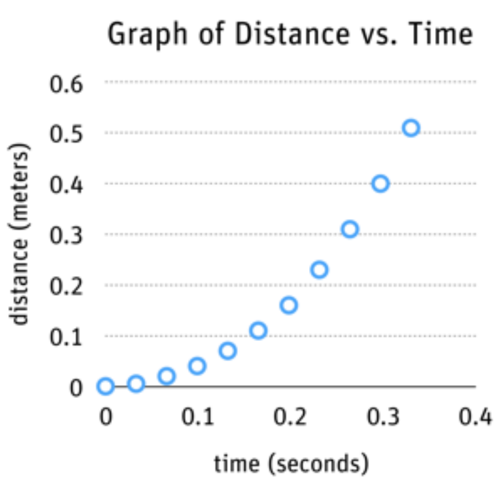
Things accelerate toward the earth at a constant rate. Your data should show that this rate is about 9.8 meters per second per second, or 9.8 m/s^2. Scientists, engineers, teachers, and students also know this constant as, simply, *g*.

Going Further

Graphing is a great way to see what’s going on with your data. Try plotting distance vs. time.

Is your graph a straight line? Is it a curve?

It should be a curve with the formula: $d = 1/2\ g\ t^2$. The graph of our sample data is shown below.



Teaching Tips

Put an object on a scale. Is it moving? Although it doesn't look like it, your object is actually accelerating toward the earth. The scale's pan is pushing again your object and forcing it from moving downward. The weight you read on your device is a result of the object's mass and g.

Try doing this activity again, but drop lightweight objects with lots of surface area, such as coffee filters or feathers, and see how the results differ. Although g is still at work here, air resistance also plays a role.