



Title: How Gravity Works: Why Two Objects of Different Masses Hit the Ground at the Same Time?

NSF GK-12 Fellow: John Mischler (Boulder, CO)

Grade Level: 4th or 5th grade science

Objectives: The students will explore one aspect of the gravitational force (the interactions between momentum, mass, and gravitational pull). The students should come away with an understanding that (1) gravity is a pull between two objects that have mass and (2) how the gravitational force moves an object is dependent of its mass.

Boulder Valley School District Essential Learning: Students identify that gravity is the force that holds the parts of the Solar System together.

Background Information: Gravity is a very complex topic and is not completely understood by scientists today. It is important to first distinguish that gravity is a pull between two objects that have mass. We stand on the earth because our masses are attracted to the gigantic mass of the earth. In fact, all objects with mass have a gravitational field so that even two people standing next to each other are exerting a gravitational force on each other (although it is very small). This activity demonstrates that objects of different masses hit the ground at the same time when dropped from the same height. This is because of a difference in momentum. Simply stated, at the beginning of the drop the less-massive object will move faster than the more-massive object because the more-massive object takes longer to get going. Once the more-massive object does get moving however it moves faster than the less massive object because of its greater mass (greater attraction to the mass of the earth). It just so happens that these two competing forces (it is harder to get a more-massive object moving but once it is moving it moves faster) balance out and the less-massive and more-massive objects hit the ground at the same time.

References: <http://www.grc.nasa.gov/WWW/k-12/UEET/StudentSite/lessonplans.html>

Lesson Vocabulary: Gravity, Momentum, Mass, Air Resistance

Materials:

Each group needs...

-two water bottles

-a soft surface to drop the bottles onto (sand, a large bean bag, a cushion, etc.)

Preparation: Fill the bottles with water

Safety Information: When doing the water drops make sure they land on the soft surface so they do not burst or bounce and hit someone.

Engagement: Perform a preliminary drop with two objects of different masses. A good example is a bowling ball and a tennis ball. Do this outside if possible. Ask the students to predict which one will land first (they will invariably say the more massive object). Perform the drop and ask the students why the two hit the ground at the same time. Include a description of Galileo's experiment as well for some historical context.

Exploration: Now have each group perform object drops on their own with the two water bottles. Each group should have a responsible adult with them to facilitate the activity with the following steps:

1. Show the students the two water bottles (each completely full of water). Ask them to tell you which one will hit the ground first. They will guess that they will hit the ground at the same time. Have the students demonstrate this with the two full bottles.
2. Now empty half of the water from one bottle and ask the same question. The students will usually guess that the full bottle will hit the ground before the half full bottle. Have the students demonstrate that in fact they still hit the ground at the same time.
3. Repeat this procedure until one bottle is full and one is empty.
4. Discuss with the students what they observed and ask them for explanations that may explain this phenomenon.

Explanation: Use their answers to guide their understanding by introducing the concept of momentum. Momentum is simply a measure of how hard it is to get a stopped object moving or how hard it is to make a moving object stop. While the less-massive bottle was easier to get moving (smaller momentum) the more-massive bottle felt a stronger gravitational pull by the earth. These forces balanced and the objects hit the ground at the same time.

Elaboration/Extension: Demonstrate momentum by demonstrating that it is harder to push a heavier object than a lighter object. Momentum (also see inertia) can be measured by taking the full bottle and the half full bottle outside and dropping each into a container of shaving cream. The more-massive full bottle will make a larger “splash” than the smaller object even though they hit the shaving cream at the same time. While they hit the ground at the same time the splashes are different. Also show the Apollo 15 hammer/feather drop on the moon as an additional example (note that this only works because there is no air resistance).

Evaluation: In the coming days hold two objects up and ask the students which object would hit the ground first if they were dropped. After they answer ask a student why they think this and continue to reinforce the ideas of gravity and momentum.

Wrap-up: How are we attracted to the earth's surface? Why is it that when two objects of the same mass are dropped they hit the ground at the same time?