Gravity Works
3rd Grade
Michael Rauscher, Michelle Castle, and Karen Menapace

Benchmarks & Objective:

- PS-1 Describe an objects position by locating it relative to another object or the background.
- PS-2 Describe an objects motion by tracing and measuring its position over time.
- PS-3 Identify contact/non-contact forces that affect motion of an object (e.g., gravity, magnetism and collision).
- PS-4 Predict the changes when an object experiences a force (e.g., a push or pull, weight and friction).

Target Concept:

Gravity is perhaps the most constant, reliable "force" that we interact with. It is predictable and essentially inescapable, but not magical. The goal is to abolish the misconceptions students inevitably will have formed already about gravity and explain how it is a tool that can be utilized by scientists if they properly understand how it works. Our specific objective is to show how gravity accelerates a mass to produce a force (i.e., a direct application of the 2nd Law of motion). Thus all objects will experience a similar acceleration due to gravity regardless of their size, shape, or mass. However, the force (or weight) that they feel will vary with a linear dependence on mass. Specifically, this will be accomplished by dropping items of different size and shape and having the students predict which will hit first. With few exceptions, all the items will be relatively aerodynamic and should experience little resistance from drag so they should hit the ground at the same time if they are dropped from the same height at the same time with the same initial velocity. Furthermore, we will show the students the difference between weight and mass and explain that gravity is the factor that separates the two. This experiment also offers the opportunity to reinforce proper application of the scientific method, in terms of methodology, data collection, and analysis.

Materials:

- Golf balls
- Ping-Pong balls
- Cotton balls
- Paper (flat sheets and crumpled sheets)
- Misc. other items that can be dropped without damaging them
  -We used foam dice of two different sizes and small numbered balls from a Bingo set

*The specific items don't really matter. You want a total of eight items for each group. We recommend you have enough material for the class to broken into groups of at least 3, but no more than 4 students. As long as they can drop the objects, they will serve the purpose. The paper is important because the flat sheet will encounter drag and thus will fall at a different rate. It is good to have at least one item that will fall slower so that the reason for the different rate can be explained.

Initial Introduction:

If you have not done so already, review Newton's 3 laws of motion:
1. An object at rest tends to stay at rest unless acted upon by an outside force. An object in motion tends to stay in motion unless acted upon by an outside force.
2. F=ma Force equals mass multiplied by acceleration
3. For every action, there is an equal and opposite reaction.

You should also review the scientific method if they are not already familiar with it by this point. Explain to the students that gravity is a force that attracts objects to the center of the earth. Present the experiment as an investigation of how gravity affects objects with different size, shape, and mass. Don't tell them much about gravity or how it works beyond this basic definition. Let them discover it for themselves through the course of this experiment.

Procedure:

Round 1:

1. Form the students into groups of 3-4 students.
2. Write the problem statement on the board:
   Something along the lines of: How does gravity effect objects with different size, shape, and mass?
3. Leave space for a hypothesis, but don't let them form one yet, because it is not at this point an educated guess, it is just a guess.
4. List out the method/procedure:
   -Put the 8 objects into 4 groups of two (the teacher should probably decide in advance how they will be grouped)
   -Drop the items as pairs and record which item hit first.
      -Repeat 5 times for each pair (explain the need for reproducibility in experiments)

Step back and let them run with it. Keep things from getting out of hand, but try to let them figure out how to do the experiment in a reliable, reproducible manner. Some students will throw the items up (or down) rather than just dropping them. Some groups will have two different students dropping the items (so you know they won't be released at the same time or height). Almost no one will bother to make sure they are really at the same height before dropping. Let them do what they will though at this point. Make sure they record the data.

5. Have the students discuss their results within the group, and come up with explanations as to why they saw the results they did.
6. Discuss as a class the results from all the different groups. There will undoubtedly be a wide range in answers and hopefully the students will catch on that experimental error is the reason for this. Make sure they understand the problem is not with gravity. In the course of the discussion, try to ask how the experiment can be improved or if anyone noticed why their results may have differed from another group's. By the end of this time, make sure they understand the need to drop the ball at the same time, at the same height, with no initial velocity (up or down). Also discuss ways to insure this actually happens. Also discuss how they should be determining which item hits first. Have a student get

down on the ground for a better angle instead of trying to figure out which one hit first by looking down on the objects. **Do not tell them yet that all the objects should be hitting at the same time if they do the test properly.**

Round 2:

7.   Have them repeat the experiment, but this time have them make a hypothesis. The first round of experimentation allows them to make an educated guess. They should phrase it in terms of, "I think bigger, heavier objects will fall faster." Or "Gravity is stronger for bigger objects." Accept whatever they want to hypothesize, but ask for an explanation of why they think something will happen. Make sure it is not just a blind guess and that this is based on what they saw in their early experiments.

8.   Collect the data and discuss once again. Hopefully, this time they will get more consistent results. Also, many of the students should start recognizing that the items are hitting the ground at the same time, (except for the crumpled paper vs. the flat paper).

Round 3 (optional):

9.   If desired, you could at this point allow them to mix and match items and text the idea that all the items should hit at the same time unless they are opposed by another force (such as drag). They can repeat the experiment again and convince themselves that all objects regardless of mass experience the same acceleration due to gravity.

Summary & Discussion:

In the end, the students should all understand that gravity will affect all objects equally in terms of acceleration, but that the force will be different for each object as it hits the ground. They should see that there is also a need to be careful in the way that one conducts their experiment if they hope to have reliable results. Remind them of how their results changed from round 1 to round 2 by using more careful experimental procedures. The concept of drag should be discussed as an opposing force to gravity that will sometimes make objects fall slower. You could discuss parachutes in this context. **Most importantly though**, don't let them walk away without understanding that gravity is acting on objects with some defined mass to give them weight. That while different objects have different weight, they are still experiencing the same relative acceleration due to gravity and so they should all fall at the same rate provided they start falling under identical conditions. However, if a cotton ball falls on your head, it will have a much different feeling than if it is a golf ball. It might not be a bad idea to make sure they don't test that theory ☺.