

Physics on the Playground

Jungle-Gym Drop Teacher's Guide

We will examine objects of different shapes, sizes, and masses.

You might need to help you students pick out some appropriate objects: Some suggestions:

assorted balls, paper, pens and pencils, rocks, feathers, balloon, water balloon (messy, but fun), coins, anything not too heavy, awkward, or breakable.

The Theory: (to be explained only after the experiments)

In a vacuum (like on the surface of the Moon) objects you drop would fall with the same acceleration. On Earth, this is usually true for objects dropped from small distances, but on some objects air resistance is important. Paper and feathers have very little mass and have high surface area, making air resistance important. Also, your students might ask about hot air balloons. Because they contain hot air, the air inside them is less dense than the surrounding air, and their buoyancy keeps them up. You can explain this to your students by saying that the balloon is supported by the air around the balloon.

Before the playground

First: Make your own hypotheses about what controls how objects will move when dropped.

Here, the students can work in small groups, or individually. If you will be using the [experiment report form](#) with your students, give the students a chance to read it after they have suggested their own experiments but before they begin the experiments.

3) What would be different about our experiment on the Moon? Why might our results change if we dropped things on the Moon?

Since the Moon has no atmosphere **all objects** will fall with the same acceleration, and they will never reach terminal speed (the speed at which air resistance prevents an object from continuing to accelerate as it falls). The acceleration will be lower of course, because of the Moon's smaller mass and lower gravity.

On the playground

Materials: objects to drop, a kitchen scale, clip boards with paper (or notebooks), stop watches, and a tape measure

First: Ask if the students have experiment ideas. They may suggest just what I have in mind. If not, they can try their own experiments in addition to the ones I have suggested here.

First weigh your objects and determine which are heaviest (more mass) and which are lightest (less mass). Have your students climb the jungle-gym two at a time to drop their objects. By dropping two objects at a time, the students will get a subjective view of how fast objects fall. Also, to provide a more objective measurement, have the students measure the distance between each object and the ground before they drop it. Try to drop all of the objects from the same height the first time through, then have them vary the distance from the ground that some objects are dropped. While some students are dropping their objects, others should time them with a stop watch. Chances are, because the distance objects fall will be so short, the subjective measurements of which hit the ground first will be just as good as the objective ones. Single measurements could therefore be **VERY** misleading.

The problem of timing:

Taking more than one measurement should help this problem. Students may well see slightly different numbers on their stop watches from what their classmates see. Using at least three stop watches at a time or repeating a drop at least three times is recommended to help show that results in science need not be (and often aren't) identical. This might be a good time to talk about the concept of uncertainty and error in science. Errors in measurements are the norm in science and happen in part because people and equipment can never be perfect. Uncertainty can be thought of as how trustworthy the measurements are. If after several drops of a ball from the same height the students all have times within one second of one another, then the measurements are believable to a second or two. The problem is, because of the short distances involved, most objects will only take a second or two (at most) to fall. For this experiment, then, the stop watches just won't be any better than the eye. They may still be valuable to help illustrate the idea of scientific error.

You might try asking your students what would make the experiment better for making measurements.

Additional Materials: pie pans and a can of shaving cream

Momentum: How long it takes a ball to fall is bad enough to measure in this experiment, measuring the momentum an object hits the ground with presents a particularly hard problem. I have come up with what I believe will be a fun (and messy) solution.

Students should select only a few objects for this experiment. For each object, fill or refill a pie pan with shaving cream (try to keep the amounts fairly consistent). After a practice drop to determine the best location of the "target" let the students drop their objects two at a time (into different pie pans, of course) into the target. They might miss a time or two, but they'll likely hit it after that. To prevent a mess on the playground and to be

environmentally aware, try putting an old washable blanket under the "target area". The bigger the splash, the more momentum the object hit the shaving cream with.

After the Playground:

Before you leave the playground or the next class, ask the students about how their hypotheses held up. Would they change any of their answers to the questions in the before the playground section? Did they learn anything new? If the experiments didn't work well, discuss what should have happened, and have the students come up with reasons why it didn't. Discuss the student responses, and add your own suggestions if necessary.

For older students (who understand square roots), you may wish to have them do some calculations in addition to the experiment report using the equation:

$$\text{Time to fall} = [(2 \times (\text{distance})) / (\text{the acceleration due to gravity})]^{1/2}$$

to determine the times it should have taken their objects to fall in the absence of air resistance. The acceleration due to gravity at the surface of the Earth is about 9.8 m/s^2 (10 m/s^2 is close enough). Make sure that the students use the proper units (meters and seconds) in the above equation.

Another equation students can use (even if they don't know how to do square roots) is:

$$\text{impact speed} = \text{the acceleration due to gravity} \times \text{time to fall}$$

which will allow the students to determine the momentum of each object (once again in the absence of air resistance which will slow an object down as it falls). Remember, the momentum of an object is defined as:

$$\text{momentum} = \text{mass of object} \times \text{speed of object}$$

and the important speed in this experiment is the impact speed. Suggestion: have the students compare the momentum of different objects dropped different distances.

[On to Levers](#)

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Jungle-Gym Drop Experiment Report

Who are your experiment partners?

What is the purpose of this experiment?

First, make a list of the objects to be dropped:

Now, fill out the table below:

When you estimate how fast the object fell you may be descriptive and use terms like "very fast, slower than a rock", etc.

Objects Dropped	Distance Dropped	Drop Time (Estimated)	Drop Time (Measured)	Size of "Splash"
Small Rock				

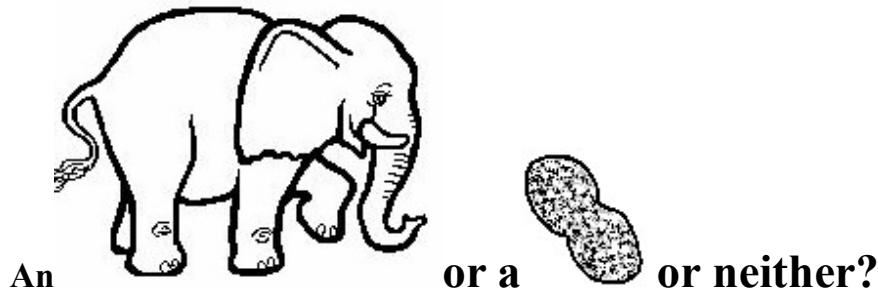
How did your measurements of how fast the objects fell compare to your estimates? (Were you able to use the stop watch to measure how fast every object fell? Did some objects fall too fast measure how fast they fell with the stop watch?)

Which object fell the slowest? How is that object different from the object (or objects) that fell the fastest?

Now that your experiment is over, will you change any of your answers to the questions below?

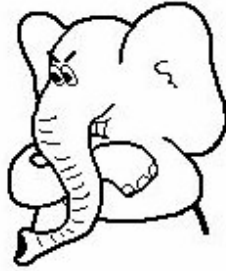
- 1) What makes things fall when you drop them?
- 2) Do heavy objects fall faster, slower, or at the same speed as lighter objects?
- 3) Does it matter how high up you are when you drop an object?

Which would fall faster?



4) Would an elephant fall faster than a peanut? Would an elephant holding a peanut fall faster than an elephant not holding a peanut?

5) If dropped the same distance, which will hit the ground with more **momentum**?



Hey! Don't drop me!

6) Which of your chosen objects will hit the ground with more momentum? Which one with the least momentum?

7) Does the height you drop an object from affect the momentum of object about to hit the ground?

8) How does a kite stay in the air when you fly one?

9) What would be different about our experiment on the Moon? Why might our results change if we dropped things on the Moon?

Finally, write a brief paragraph about what you learned in this experiment.

Playground Physics

Jungle-Gym Drop

Key Words:

distance

force

gravity

hypothesis

mass

momentum

Since the jungle-gym doesn't have any moving parts, our experiments will involve dropping thing from the top of the jungle-gym to find out more about **gravity**.

We will examine objects of different shapes, sizes, and **masses**.

Before the playground

First: Make your own hypotheses about what controls how objects will move when dropped.

Remember, a hypothesis is an educated guess based on your previous experience. Before you make you own hypothesis about each of the following cases, think about what has happened to objects you have dropped in the past. It is perfectly OK to make an incorrect hypothesis...scientists do those all the time? The **only** thing you could do wrong if you make an incorrect hypothesis is if you change your observations to match your hypothesis instead of changing your hypothesis to match your observations. That is cheating and **not** real science.

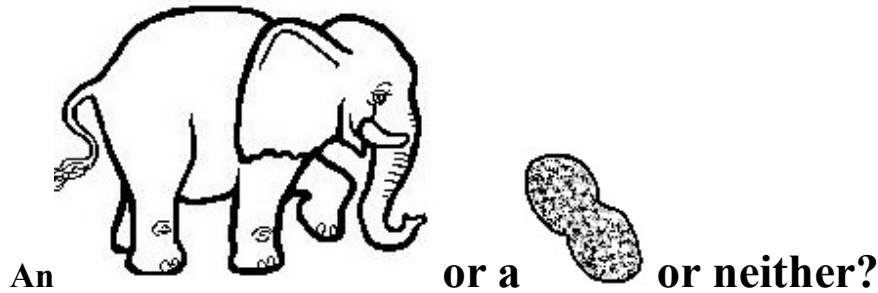
Next: Think about some objects you might have at school or at home that can be used to test how different objects fall when they are dropped. Pick objects that are different sizes, shapes, masses, and are different from one another any other way you might want to examine. Make sure that you have permission to use any object that doesn't belong to you **AND** that the objects you pick won't break.

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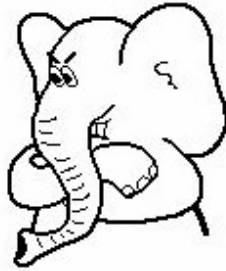
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9) What would be different about our experiment on the Moon? Why might our results change if we dropped things on the Moon?

On the playground

Now comes the fun part! We will actually drop objects and test our hypotheses.

What experiments should we perform?