3M Young Scientist Lab

WHELMERS Student Activity | Grades 3–5

Pie Pan Accelerometer

WHAT YOU NEED:

- Two pieces of string, each approximately 60 inches long
- 20 metal hardware nuts
- Metal pie pan

DESCRIPTION

A metal pie pan demonstrates the acceleration of gravity.

NEXT GENERATION SCIENCE STANDARDS

- **PS2.A: Forces and Motion**
  - Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) (3-PS2-1)
  - The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it.

(Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) (3-PS2-2)

- **PS2.B: Types of Interactions**
  - Objects in contact exert forces on each other. (3-PS2-1)
  - The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5-PS2-1)
- **PS3.A: Definitions of Energy**
  - The faster a given object is moving, the more energy it possesses. (4-PS3-1)
- **PS3.C: Relationship Between Energy and Forces**
  - When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3)

WHAT YOU DO

1. On the first string, use tight knots to attach a metal nut approximately every 15 cm.
2. On the second string, use tight knots to attach the nuts at the following positions: 0 cm, 2 cm, 4 cm, 8 cm, 13 cm, 18 cm, 24 cm, 31 cm, and 40 cm.
3. Hold one string, vertically, over the pie pan. Release the string. Repeat with the other string. When you release each string, the nuts will make a resounding bang as they hit the pan.

Can you determine a difference in the noise pattern created by the two sets of falling nuts? How are they alike? How are they different? Why?

WHAT HAPPENS

The first string has equally spaced hardware nutes. As it falls, you will notice the time between each bang gets shorter and shorter. The second string generates a regular set of bangs, even though the nuts are separated at larger and larger distances. Both strings fall at the same rate. Why do they create different sound patterns? The nuts fall faster and faster, or accelerate!

The constant pull of gravity causes objects to fall toward the earth's center at a rate of 9.8 meters per second per second, or 9.8m/sec². Simply stated, the farther an object falls toward the earth, the faster it goes. It accelerates. The relationship between time (t), distance (d), and the acceleration constant of gravity (g) is represented by the formula $d = \frac{1}{2}(g)(t)^2$. The value of g for the earth's gravitational pull is 9.8 m/sec². This formula was used to determine the positioning of the metal nuts on the second string.

WHERE IN THE WORLD

Accelerometers are all around us. Here are a few examples:

1. Airbags - Accelerometers detect rapid deceleration of a vehicle and the severity of a collision. This triggers the inflation and deployment of the airbag.
2. Smartphones and tablet computers - Accelerometers enable your phone to recognize how you are holding it and the images are rotated upright.
3. Segway - The combination of both an accelerometer and a gyroscope allows the segway to remain upright and balanced while in use.

Can you think of more real-life examples of accelerometers?