Jar Races **Primary Audience: 3rd – 10th Grade**

Description: Gain a better understanding of how friction, inertia, and mass affect objects.

Keywords: Friction, inertia, mass, velocity

Concepts:

- The amount of momentum that an object has depends on two physical quantities: the mass and the velocity of the moving object. The heavier the overall weight of the car and passenger is, the more momentum and force it will have.

Materials:

- For Demonstration:
  - 2 Identical Clear Jars with Screw on/off Lids
  - Three Ring Binders
  - Water or other substances you would like to fill the jars with such as sand, syrup, etc.

Instructions:
(Set the three ring binders on flat surface. Fill one jar with water, and leave one empty.)

Imagine that you're riding a roller coaster...let's say it's the Gemini at Cedar Point. You've begun the climb to the top of the first hill…it's a big one! Clink! Clink! Clink! As you reach the top you look over to see your friends in the train next to you. In your train…it's just you. The chain releases the two trains and you begin your first descent.

Both trains accelerate down the hill, but your train lacks the mass of your friends' train. Which train will reach the bottom faster? (Take a few hypotheses.) Why?

Now imagine that these two jars are those trains. One is filled with water…that is your friends' train. The other jar is empty…that is your train. Which will reach the bottom of this ramp first? Any thoughts? *(Take a few hypotheses.)*

Let's see who's correct. *(Start the jars at the top of the "ramp" the binder forms and release them.)* Watch what happens.

Draw some conclusions; retest the experiment using different materials in the jars.

Possible Interactive Questions:

- Ask the participants to make a hypothesis as to which jar will reach the bottom of the ramp first. Why?
- If we change the amount of fluid, would that alter our results? What if we changed the liquid from water to oil or from a liquid to a solid?
- How does friction and mass affect such rides as roller coasters? Explain some factors that can change the distance or direction of the train during the ride.

What's Going On?

At first, the water-filled jar moves down the ramp faster than the empty one. This happens because its weight is evenly distributed throughout its volume, thanks to the water inside it. The empty jar's weight is its entire glass exterior; therefore, it doesn't roll quite as fast. But as the jars begin rolling on the flat surface, the greater weight of the full jar causes friction between the jar and the floor as well as internal friction between the water and the inside of the jar. The full jar slows down, allowing the lighter, empty jar to take the lead. You can take the experiment one step further by timing the jars and recording the times and comparing which substance caused the jar to roll the slowest, fastest. Why?

Further Exploration:

1. Place a large, sealed jar full of pickles (with pickle juice) at the center of a turntable. Rotate the table back and forth with your hands at various speeds. Observe what happens, or doesn't happen, to the pickles inside the jar. Pickles at rest tend to stay at rest. Now rotate the table steadily in one direction until the pickles start to rotate along with the jar and the table. Once the pickles are in motion, reach out and grab the pickle jar with both hands and pick it off the table. Observe the motion of the pickles. Pickles in motion tend to stay in motion.
2. Take two eggs, one hard-boiled and one raw, and place them on a table. Have two students spin them at exactly the same time. Which stops first? The raw egg stops spinning before the hard-boiled egg. Try the experiment again to see if the results are the same. What possible explanations could there be?

Relevant Ohio Science Content Standards:

- Physical Sciences 3-5: Describe the forces that directly affect objects and their motion.
    - 3.2: Describe an objects motion by tracing and measuring its position over time.
- Physical Sciences 9-10: Explain the movement of objects by applying Newton's three laws of motion.

- 9.22: Demonstrate that any object does not accelerate (remains at rest or maintains a constant speed and direction of motion) unless an unbalanced (net) force acts on it.
- 9.23: Explain the change in motion (acceleration) of an object. Demonstrate that the acceleration is proportional to the net force acting on the object and inversely proportional to the mass of the object. (F net=ma. Note that weight is the gravitational force on a mass.)
- 9.25: Demonstrate the ways in which frictional forces constrain the motion of objects (e.g., a car traveling around a curve, a block on an inclined plane, a person running, an airplane in flight).