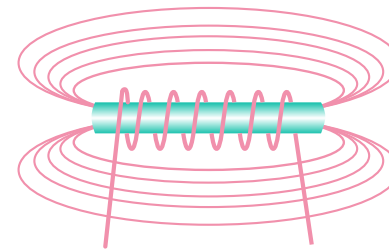


Build Your Own Electromagnet

Stuff you need:

- 9-volt battery
- Insulated copper wire with ends stripped
- Large iron nail
- Small paper clips or staples



What to do:

Wrap the copper wire tightly around the nail and touch the ends of the wire to the battery. Always wrap the wire in the same direction. Try to pick up the staples.

What's the deal?

The battery is a source of electrons, and the electrons flow through the wire. Electrons behave like little magnets, and when they flow through a wire, they create a magnetic field.

Measure the Speed of Light

Stuff you need:

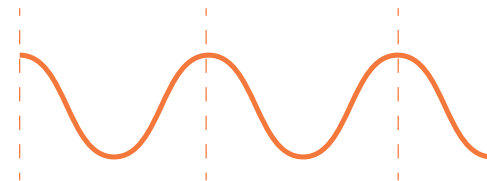
- Microwave-safe dish (bigger is better)
- Mini-marshmallows
- Ruler
- Calculator
- Microwave (OK, not a Dollar Store purchase, but you probably have one)

What to do:

Put a layer of marshmallows on dish. If your microwave has a rotating platform, remove it. Microwave marshmallows for 10 seconds. Marshmallows should be just partially melted (if not, adjust time). Measure distance (in cm) between melted and non-melted marshmallows. This is half the wavelength of a microwave. Look for sticker on microwave that tells its frequency (in Hertz, or Hz). Most are approx. 2,450 MHz (MHz = 10^6 Hz). Calculate speed of light with this equation. Speed of Light = $2 \times$ (distance between melted spots) \times (frequency of microwave). The actual speed of light is 3×10^{10} cm/s. Compare: how closely did your measurements come?

What's the deal?

The oven creates a standing wave. The peaks of the wave heat faster to melt the marshmallows first. You're measuring half the wavelength of the microwave light.



Cartesian Ketchup

Stuff you need:

- Empty 2-litre pop bottle
- Ketchup packet
- Water



What to do:

Find a ketchup packet that floats (but barely). Most are like this. Fill the bottle $\frac{3}{4}$ full with water. Push the unopened ketchup packet through the mouth of the bottle. Tightly screw on the cap. Squeeze the bottle (hard!) and watch your ketchup submarine dive. Bonus points for getting it to stop halfway to the bottom.

What's the deal?

You've created a Cartesian diver. Objects float because of density. Density is mass divided by volume. The ketchup packet floats because a bit of air in it is less dense than water. By squeezing, that air pocket gets smaller, making the ketchup packet more dense than water. You get the bonus points when the density of water and ketchup are equal.

Measure the Diameter of the Sun

Stuff you need:

- A sheet of cardboard (letter size is ok)
- A sheet of white paper
- A piece of aluminum foil (3x3 cm)
- Tape
- Scissors
- Ruler



What to do:

Cut a 2x2cm square in the centre of cardboard. Tape a foil “window” over it and poke a small hole in the middle of the foil. Hold cardboard so sunlight passes through the pinhole onto the white paper behind it (try to make the space between the cardboard and paper as big as possible).

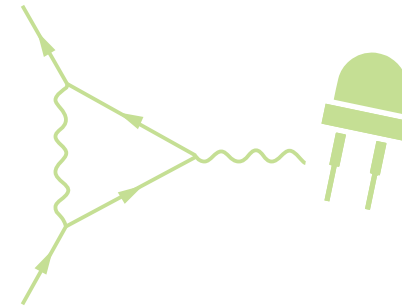
Measure the diameter of the sunlight on the paper (call this X). Measure the distance of between the paper and the pinhole (call this Y). To calculate the Sun’s diameter, you need the number 149,600,000 (kilometres between Earth and the Sun).

Now do the math: $(X+Y) \times (149,600,000) = \text{Diameter of the Sun!}$

Photon Energy

Stuff you need:

- Glow-in-the-dark stickers or decals
- Blue LED light
- Red LED light



What to do:

Shine the LEDs on the stickers, starting with the low-frequency colour (red). What do you observe? Now try the higher frequency colour (blue). What is different, if anything?

What's the deal?

The energy of light is determined by its frequency. Red light has a low frequency and energy in comparison to blue light. Red light does not have enough energy to make the stickers glow, but blue light does. The link between colour and frequency was discovered in the early 1900s and helped launch quantum physics.

Standing Waves

Stuff you need:

- Slinky or long spring
- A friend

What to do:

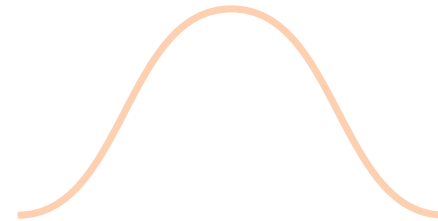
Stretch a coiled spring between two people.

Wiggle one end at a constant rate. Have the second person hold the end steady. The wave will reflect and interfere with the incoming wave.

Try to produce a stable standing wave. Try changing the rate of the wiggling (frequency of vibration).

What's the deal?

Standing waves occur when incoming waves interfere with reflected waves to produce a stable pattern, with points that appear to stand still. These points are called nodes. Increasing the frequency of the incoming and reflected wave, increases the number of nodes.



Soap-Powered Boat

Stuff you need:

- A Styrofoam tray (the kind meat comes in)
- A cookie sheet full of water
- A bit of liquid dish soap
- A toothpick

What to do:

Cut the Styrofoam into the shape shown, about 4-5 cm in length. Dip the toothpick into the soap, and smear it onto the sides of the notch in the back of the boat. Carefully place the boat on the water in the cookie sheet and watch it go! To do it again, you'll have to start with fresh water.



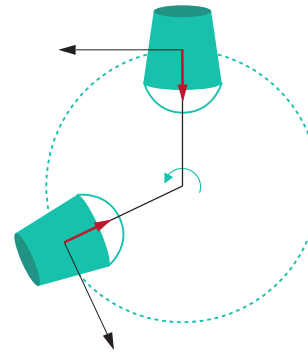
What's the deal?

Soap is a surfactant – it breaks the surface tension of water. When the surface tension breaks, it creates enough force to propel the boat through water.

Centripetal Force

Stuff you need:

- Plastic pail or bucket
- Sturdy rope
- 1 cup of water
- Courage!



What to do:

Attach the rope to the pail and pour in 1 cup of water. Make sure you've chosen a pail that is not too heavy. Hold the rope so the pail dangles around knee-height. Swing the pail in a circle overhead. Swing fast and water will seem to defy gravity!

What's the deal?

Why doesn't the water fall and soak you? The water wants to travel on a straight path as does the bucket, but the tension in the rope keeps them both turning in a circle.

Conservation of Angular Momentum

Stuff you need:

- Two soup cans
- An office chair
- A friend



What to do:

Sit on an office chair with your feet safely away from the ground. Put your arms straight out. Have a friend spin the chair. Draw your arms inward. What happens? Try it again, but this time hold the soup cans in your hands. What happens now?

What's the deal?

This experiment shows conservation of angular momentum. You spin faster when you pull your arms in, like a figure skater. Angular momentum is measured by multiplying how fast an object is spinning by its moment of inertia (how an object's mass is distributed). When your arms are out, there is more mass further away from the axis of rotation, so the moment of inertia is large.

The moment of inertia decreases when you pull in your arms. Newton concluded angular momentum should stay constant, so the rate of spinning must compensate for the change in inertia.

Bend Water

Stuff you need:

- A nylon comb
- A faucet with running water



What to do:

Turn on the faucet so that a very small stream of water is running. Run the comb through your hair several times. Now, slowly bring the comb closer to the running water, around 10 cm below the faucet. What happens when the comb gets close to the stream of water?

What's the deal?

Static electricity is the build-up of an electrical charge in an object. By running the comb through your hair, electrons are collecting on the comb, giving it a negative charge. Water, on the other hand, is more positively charged. Thanks to their opposite charges, the comb and the water will attract each other – but only the water can move by itself.