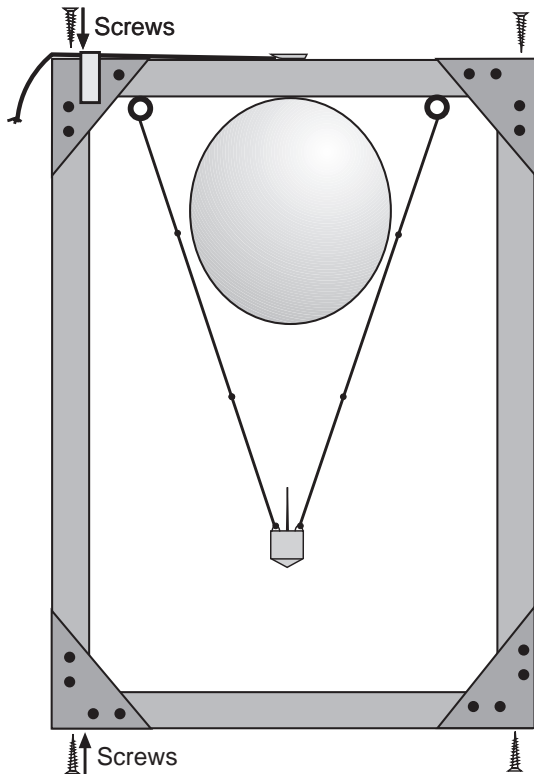


# Falling Weight Apparatus



## MATERIALS AND TOOLS

### MATERIALS NEEDED:

- 2 pieces of wood 16x2x1 in.
- 2 pieces of wood 10x2x1 in.
- 4 wood screws (#8 or #10 by 2 in.)
- 8 corner brace triangles from 1/4 in. plywood
- Glue
- 2 screw eyes
- 4-6 rubber bands
- 1 6-oz fishing sinker or several lighter sinkers taped together
- Long sewing needle
- Small round balloons (4 in.)
- String
- Drill, 1/2 in. bit, and bit for piloting holes for wood screws
- Screwdriver
- Pillow or chair cushion
- (Optional - Make a second frame with string supporting the sinker.)

## Construction:

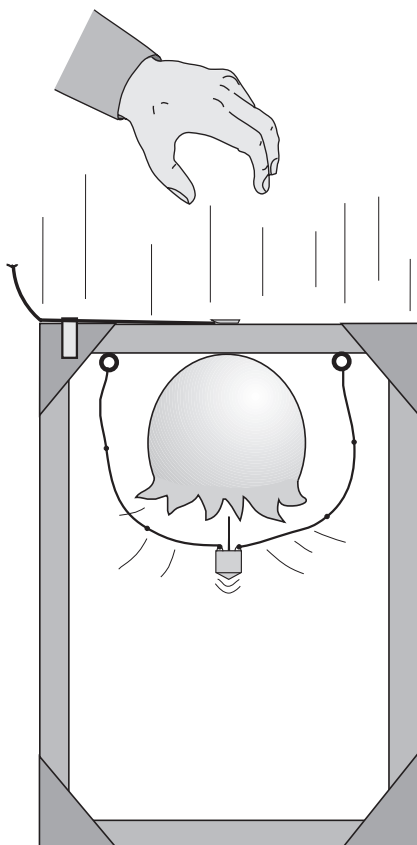
1. Assemble the rectangular supporting frame as shown in the diagram. Be sure to drill pilot holes for the screws and glue the frame pieces before screwing them together. Brace the front and back of each corner with small triangles of plywood. Glue and nail them in place.
2. Drill a 1/2 inch-diameter hole through the center of the top of the frame. Be sure the hole is free of splinters.
3. Twist the two screw eyes into the underside of the top of the frame as shown in the diagram. (Before doing so, check to see that the metal gap at the eye is wide enough to slip a rubber band over it. If not, use pliers to spread the gap slightly.)
4. Join three rubber bands together and then loop one end through the metal loop of the fishing sinker.
5. Follow the same procedure with the other three rubber bands. The fishing weight should hang downward like a swing, near the bottom of the frame as shown in the illustration. If the weight hangs near the top, the rubber bands are too strong. Replace them with thinner rubber bands. If the weight touches the bottom, remove some of the rubber bands.
6. Attach the needle to the weight, with the point upward. There are several ways of doing this depending upon the design of the weight. If the weight has a loop for attaching it to fishing line, hold the needle next to the loop with tape or low-temperature hot glue. Another way of attaching the needle is to drill a small hole on top of the weight to hold the needle.

## Use:

Inflate the balloon and tie off the nozzle with a short length of string. Thread the string through the hole and pull the balloon nozzle through. Pull the string snugly and tape it to the top of the frame.

## Demonstration:

1. Place a pillow or cushion on the floor. Hold the frame above the pillow or cushion at shoulder level.
2. Ask the students to predict what will happen when the entire frame is dropped.
3. Drop the entire unit onto the cushion. The balloon will pop almost immediately after release.



## Explanation:

When stationary, the lead fishing weight stretches the rubber bands so the weight hangs near the bottom of the frame. When the frame is dropped, the whole apparatus goes into freefall. The microgravity produced by the fall removes the force the fishing weight is exerting on the rubber bands. Since the stretched rubber bands have no force to counteract their tension, they pull the weight—with the needle—up toward the balloon, causing it to pop. (In fact, the sinker's acceleration toward the balloon will initially be zero due to the energy released as the rubber bands relax to their normal, unstretched length.) If a second frame, with string instead of rubber bands supporting the weight, is used for comparison, the needle will not puncture the balloon as the device falls because the strings will not rebound like the rubber bands did.

In tests of this device using a television camera and videotape machine as a timer (see extensions), the balloon was found to pop in about 4 frames which is equal to fourthirtieths of a second or 0.13 seconds. Using the formula for a falling body (see below), it was determined that the frame dropped only about 8 centimeters before the balloon popped. This was the same as the distance between the balloon and the needle before the drop.

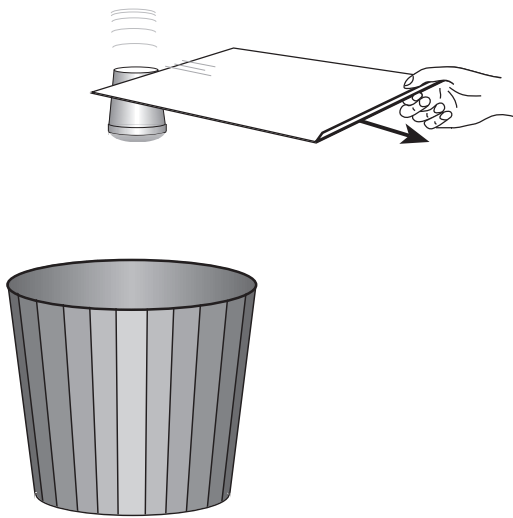
$$d = \frac{1}{2} at^2$$

$$d = \frac{1}{2} \times 9.8 \text{ m/s}^2 \times (0.13\text{s})^2 = 0.08\text{m}$$

$d$  is the distance of the fall in meters  
 $a$  is the acceleration of gravity in meters per second squared  
 $t$  is the time in seconds



# Falling Water



## MATERIALS AND TOOLS

Plastic drinking cup  
Cookie sheet (with at least one edge without a rim)  
Catch basin (large pail, waste basket)  
Water  
Chair or stepladder (optional)  
Towels  
Television camera, videotape recorder, and monitor (optional)

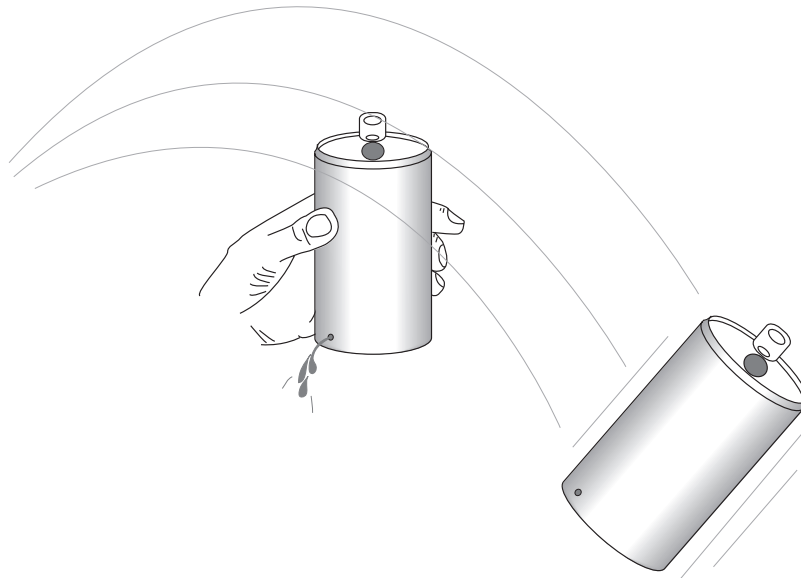
## Procedure:

1. Place the catch basin in the center of an open area in the classroom.
2. Fill the cup with water.
3. Place the cookie sheet over the opening of the cup. Press the cup tight to the sheet while inverting the sheet and cup.
4. Hold the cookie sheet and cup high above the catch basin. You may wish to stand on a sturdy table or climb on a stepladder to raise the cup higher.
5. While holding the cookie sheet level, slowly slide the cup off the edge of the cookie sheet and observe what happens.
6. Refill the cup with water and invert it on the cookie sheet.
7. Quickly pull the cookie sheet straight out from under the cup and observe the fall of the cup and water.
8. (Optional) Videotape the cup drop and play back the tape frame-to-frame to observe what happens to the water.

## Explanation:

Air pressure and surface tension keep the water from seeping around the cup's edges while it is inverted on the cookie sheet. If the cup were slowly pushed over the edge of the sheet, the water would pour out. However, when the sheet is quickly pulled out from under the filled cup, the cup and water both fall at the same time. Since they are both accelerated downward by gravity an equal amount, the cup and water fall together. The water remains in the cup but the lower surface of the water bulges. Surface tension tends to draw liquids into spherical shapes. When liquids are at rest, gravity overcomes surface tension, causing drops to spread out. In freefall, gravity's effects are greatly reduced and surface tension begins to draw the water in the cup into a sphere.

# Can Throw



## Procedure:

1. Punch a small hole with a nail near the bottom of an empty soft drink can.
2. Close the hole with your thumb and fill the can with water.
3. While holding the can over a catch basin, remove your thumb to show that the water falls out of the can.
4. Close the hole again and stand back about 2 meters from the basin. Toss the can through the air to the basin, being careful not to rotate the can in flight.
5. Observe the can as it falls through the air.
6. (Optional) Videotape the can toss and play back the toss frame-to-frame to observe the hole of the can.

## Explanation:

When the can is stationary, water easily pours out of the small hole and falls to the catch basin. However, when the can is tossed, gravity's effects on the can and its contents are greatly reduced. The water remains in the can through the entire fall including the upward portion. This is the same effect that occurs on aircraft flying in parabolic arcs.

### MATERIALS AND TOOLS

Empty aluminum soft drink can  
Sharp nail  
Catch basin  
Water  
Towels  
Television camera, videotape recorder, and monitor (optional)

