



try this activity! by Paul Doherty

Make Einstein's Toy

For his seventy-sixth birthday, Albert Einstein received a simple toy. He enjoyed showing this toy to visitors because it demonstrated a key idea of general relativity, the equivalence principle—the equivalence of gravity and acceleration. Here's how to build a version of that toy.

Materials

- a large, unbreakable cup, about 5 inches tall
- a drill or a thick nail
- 2 paper clips
- 2 rubber bands (the rubber bands should be shorter than the height of the cup when relaxed but they should be able to stretch further than the height of the cup)
- 2 rubber balls, each about an inch in diameter
- 2 wood screws and a screwdriver

Assembly

- Make a hole in the center of the bottom of the cup with a drill or nail.
- Straighten out one of the paper clips, then bend one end into a small hook.
- Stick the hook through the hole into the cup. Hook the rubber bands and pull them slightly through the hole.
- Attach the second paper clip to the rubber bands so they can't go back through the hole.
- Screw a wood screw into each ball, leaving a little space between the ball and the head of the screw.
- Loop a rubber band around each screw, then tighten the screw down.

To do and notice

1. Hold the cup upright with the balls hanging outside the cup.
2. Drop the cup a few feet—but plan to try to catch it.
3. Notice that as soon as you let go of the cup, the rubber bands pull the balls inside.

What's going on?

While you're holding the cup, gravity is pulling down on each ball. At the same time, each stretched rubber band is pulling up on its ball with a force equal to gravity (see Illustration #1 below).

When you release the cup, it goes into free fall: It begins to accelerate downward with the acceleration due to gravity.

The equivalence principle states that an accelerating frame of reference is equivalent to a stationary frame of reference with a gravity force opposite the direction of acceleration. In the freely falling frame of reference of the cup, the gravity force due to the downward acceleration is directed upward and is equal and opposite to the force of the earth's gravity. The result is that, in this frame of reference, the two opposing gravities cancel.

The net force remaining on the balls is that from the stretched rubber bands. The rubber bands contract, pulling the balls into the cup (Illustration #2).

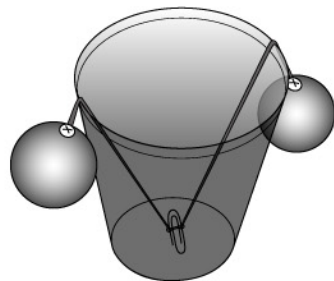


Illustration #1

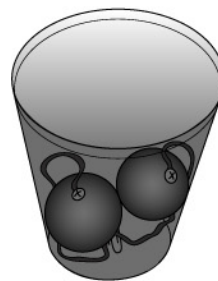


Illustration #2