Name:______________________________ Section:______________________ Date:____________

CONCEPTUAL *Physics* | Activity

Free Fall and Weightlessness

Styrofoam Astronauts

Purpose

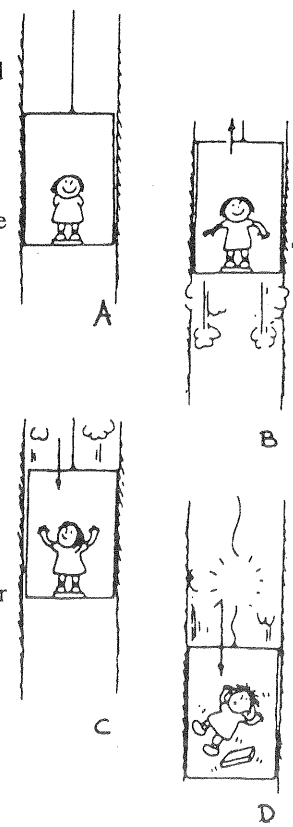
To observe the effects of gravity on objects in free fall.

Equipment and Supplies

2 Styrofoam or paper cups
2 long rubber bands
2 washers or other small masses
masking tape
large paper clip
water

Discussion

It is commonly believed that *since* astronauts aboard an orbiting space vehicle *appear* to be weightless, the pull of gravity upon them is *zero*. This condition is commonly referred to as "zero–*g*". While it is true that they *feel* weightless, gravity *is* acting upon them (Chapter 9 in *Conceptual Physics*). Gravity at space shuttle altitudes is typically about 5% that at Earth's surface.



The key to understanding this condition is realizing that both the astronauts and the space vehicle are in free fall. It is very similar to how you would feel inside an elevator with a snapped cable! The primary difference between the runaway elevator and the space vehicle is that the runaway elevator has no *horizontal velocity* (relative to the Earth's surface) as it falls toward the Earth, so it eventually hits the Earth. The horizontal velocity of the space vehicle ensures that as it falls *toward* the Earth, it also moves *around* the Earth. The combination of motions (tangential and downward) results in it falling without getting closer to the Earth's surface. Both the runaway elevator and the orbiting space vehicle are in free fall.

Procedure

Step 1: Elevators, especially those in tall buildings, are capable of changing the weight you feel or your *apparent* weight. When an elevator first starts to move up or down, your body senses the change in speed. Shortly afterwards, it moves at more or less constant speed until it begins to slow down to a stop. Weigh yourself on a bathroom scale in a motionless elevator. Observe what happens to the reading on the scale (your apparent weight) as the elevator:

A) starts from rest and moves upward.

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B) starts from rest and moves downward.

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C) moves upward at a constant speed.

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D) moves downward at a constant speed.

1. What would the scale reading be if the elevator cable(s) broke?

Step 2: Knot together two rubber bands to make one long rubber band. You may need more than two rubber bands. The bands need to stretch easily enough so the washers produce a noticeable stretch. Knot each end around a small steel washer, and tape the washers to the ends. Poke or bore a small hole about the diameter of a pencil through the bottom of a Styrofoam or paper cup. Fit the rubber bands through the hole from the inside. Use a paper clip to hold the rubber bands in place under the bottom of the cup (see Figure A). Hang the washers over the lip of the cup. The rubber bands should be under enough tension to keep the bands taut but not so much as to flip them into the cup.

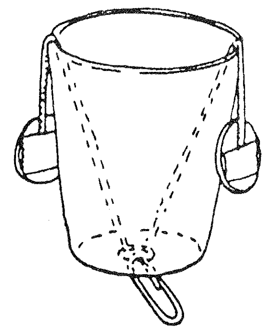

Fig. A

Step 3: Drop the cup from a height of about 2 m.

2. What happens to the washers?

Step 4: Remove the rubber bands from the cup and fill the cup half-full with water, using your finger as a stopper of the hole. Hold the cup directly over a sink or waste basket. Drop the cup into a sink or waste basket. What happens to the water as the cup falls?

Step 5: Repeat Step 3 for a second cup half-filled with water with two holes poked through its sides (Figure B).

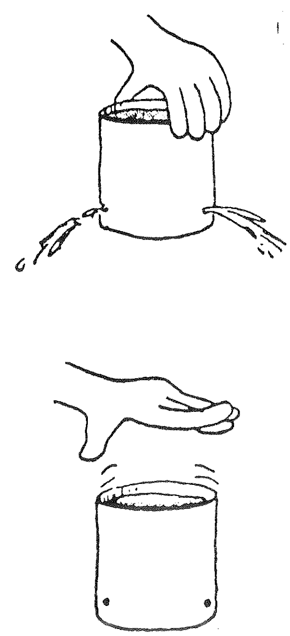

Fig. B

Summing Up

3. Explain why the washers acted as they did in Step 2.

4. Explain why the draining water acted as it did in Steps 4 and 5.