APPENDIX E
GRAVITY

OBJECTIVES

The students

- Develop a concept map and definition of the term *gravity*.
- Invent a way to compare the energy of falling objects.
- Discover that speed (height) and mass determine the energy in falling objects.

CLIMATE EDUCATION FRAMEWORK

- 3-5Systems.B.8 Earth is shaped like a huge ball. Things on or near the Earth are pulled towards Earth's center by gravity.

BACKGROUND

In this activity the students come up with a definition of gravity. ***Gravity*** is the force (or pull) exerted on objects created by the Earth's gigantic mass. Earth's gravity attracts objects (including the moon) toward its center without touching them. It even exerts this force through other objects such as a book on a table. The students investigate the effects of gravity in terms of the energy of motion. They invent ways of comparing the energy of motion produced by falling objects.

The students invent different ways to compare the energy of motion. Several suggestions are shown in the Figure. Control the invention by the supplies you provide. Small stones or balls can be used as falling objects.

The mechanical energy, or energy of motion, of an object is determined by the mass of an object and its speed. When an object such as a stone falls, it gains speed as it gets closer and closer to the floor or ground. The higher it was when it was dropped, the greater its speed when it hits and the greater the energy it delivers to whatever it hits. Examples are numerous. Massive stones falling off a truck can mash cars while small pebbles dropping off the same truck will simply bounce away. However, a fast-moving pebble can break a windshield.

Generalizations

Three generalizations flow out of this activity. The first is that gravity causes things to fall toward the center of the Earth. The second is that the faster a falling object moves, the greater the energy it has. The second is that of two objects falling at the same speed the one with the greater mass will have the greater energy.

Real and Ideal Worlds

There are some subtleties in this observation that need to be recognized. In the ideal world of a vacuum a sheet of paper and a ball made of the same of amount paper will fall to the ground at the same speed when dropped from the same height. In the real world students will find that the crumpled sheet of paper will fall faster than an uncrumpled sheet. Air resistance makes the difference. In fact, in air objects dropped from great height reach a certain speed beyond which they can go no faster. This is called **terminal velocity.** These exceptions aside, the generalization about mass and speed to produce increased energy in falling objects will flow out of this inquiry.

SOME SUGGESTED MATERIALS

Marbles (different sizes)
Base ball and a tennis ball
Golf ball and a ping-pong ball
Rulers and meter sticks
Tuna cans
Large cans of sand
Water
Platform spring scales
Small stones
Styrofoam
Wood blocks
Modeling clay
Pencil
Plastic bowls

PROCEDURES

1. **Develop a concept map of the term *gravity* with the class.**
   Include such ideas as
   - Gravity is a *force* or the pull of the Earth on objects.
   - Gravity causes things to fall.
     ✔ Ask for examples.
   - Things fall toward the Earth
     ✔ They actually fall toward the Earth's *center*.
     ✔ A globe could be used to illustrate this.
   - Gravity is caused by the Earth's mass.
     ✔ If this idea does not emerge, include it as a question to be investigated.

2. **Help the students establish that a falling object has energy of motion and can make other things move.**
   Use a game format. Ask how they could show that a falling ball moves
   - Another ball.
   - A mound of sand.
   - A stick in the sand.
   - A teeter-totter.
   - Water.

3. **Have the students invent a way to measure the energy of two falling stones or balls of different masses but similar sizes. Have them drop the two objects from the same height.**
   Assist the invention with probing questions such as
   - If a tennis ball and a baseball of the same size were dropped from the same height, would they have the same energy?
   - Which will make something move more?
   - How can you measure the difference in movement?
     ✔ Anything that will move on being hit will work—a pool of water, a pile of salt or dry sand, another ball, and so forth.

4. **Have the students explore what seems to determine how much energy objects have when they fall from the same height.**
   Ask such questions as
   - Did the falling objects of different mass have the same energy when they fell from the same height?
     ✔ Get agreement that the more massive object had the greater energy. It made something else move more.
   - How could you make falling objects of different mass have the same energy?
     ✔ Get at the idea that the objects might move faster or slower.
   - What seems to determine the energy in the fallen object?
     ✔ Get agreement that mass seems to be important.
     ✔ Accept speed and volume if the *students* suggest these properties.

5. **Have the students explore what happens to the amount of energy from the same falling object when it is dropped from different heights.**
   Ask such questions as
   - What happens to the energy as you change height.
     ✔ Get agreement that as one increases the height of the drop, the amount of energy in the object increases.
   - What happens to the speed of the object as it is dropped from ever higher positions?
     ✔ Work toward the idea that as its height increases, its speed increases.

6. **Summarize the activity. Help the students use the concept map and the activities above to write a working definition for the term *gravity*.**
   Ask such questions as
   - What can you say about mass and the energy of moving or falling objects?
     ✔ Get agreement that the greater the mass of similar objects moving at the same speed, the greater the energy.
   - What can you say about the effect of height and energy?
     As the height is increased, the energy is increased.
   - What can you say about the speed of an object and its energy?
     ✔ Get agreement the faster the object goes, the greater the energy.
   - How are height and speed of a falling object related?
     ✔ Get agreement that the longer an object falls, the faster it travels.
   - What seems to cause objects to fall? What is gravity?
   - How does gravity affect the erosion process?

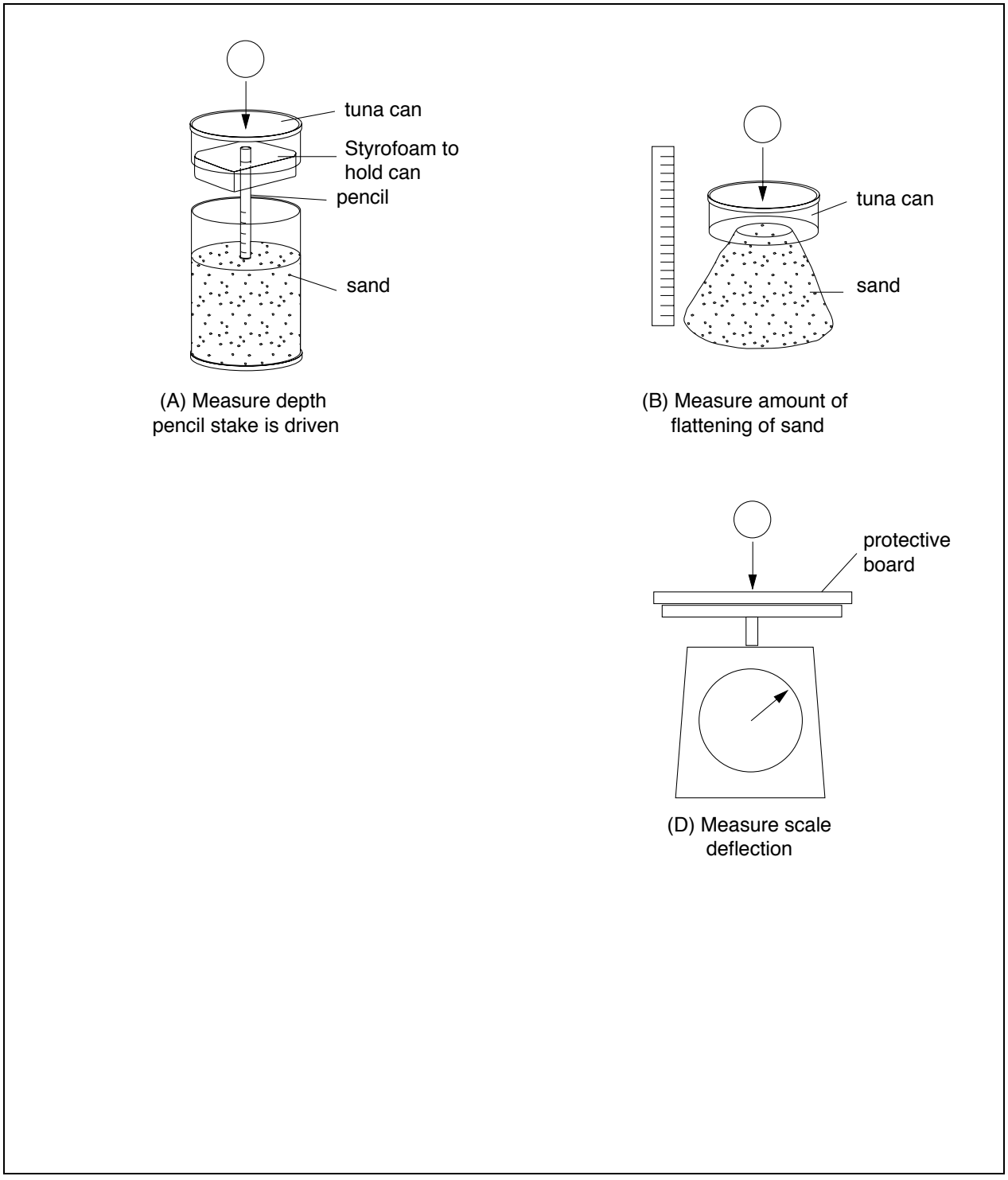

Figure: Devices to measure the relative amount of energy of falling objects