DISTINGUISHING MASS AND WEIGHT

Street language and even medical clinics perpetuate the confusion between mass and weight. Because the English measurement system has emphasized weight, and the metric system has emphasized mass, many students mistakenly consider the kilogram to be a unit of weight. Because mass and weight are significantly different concepts, it is necessary to pay special attention to their differences.

Before assigning a reasoning activity to students, the following simple demonstration can be used to illustrate the concept of mass. A 500-g object is placed inside a tennis ball canister with crushed paper holding it at about the longitudinal center of the canister. A 1-kg object is likewise placed in a second canister. The actual masses are not important. But they should differ significantly and the object with the lower mass should be at least 500 g.

A string cradle is constructed to hold one canister by a single cord from a nail driven into the top of a door casing. The canister should hang in the doorway at about hand-height. A second nail holds the second canister 10 or 20 cm away from the first.

Each student, in turn, is directed to stand in the doorway beside the least mass canister and to give it a horizontal thrust that causes it to swing in an approximate 75-degree vertical arc. The student then stops the canister at the original rest position.

The same student repeats the movement with the more massive (1 kg) canister, giving it about the same acceleration. After all have felt the effects of the different masses, students are asked to describe the difference. If any students mention that one canister is heavier, remind them that they did not measure their weight (they did not lift the canisters). You might need to tell them that they felt differences in mass, that is, differences in inertia. They should then be asked to read (or listen to you lecture) concerning the following concepts.

You have just experienced inertia. Inertia is resistance to changes in motion. The inertia of a body standing still makes it difficult to get the body moving. Once the body is moving, inertia makes it difficult to stop the body, or change its speed, or change its direction. One canister has much more inertia than the other and requires more force to put it into motion and also to stop its motion.

The measure of inertia is called mass. The common units of mass are gram, milligram, and kilogram. The mass of 1000 cm$^3$ (or 1 dm$^3$, or 1 liter) of water is 1 kilogram.

A unit of force is the newton (N). One newton is the amount of force needed to increase the speed of a 1-kilogram mass 1 meter per second every second the force acts. If a 1-kg rock is traveling 3 m/s one moment, and 4 m/s a second later, and 5 m/s another second later, a one-newton force must be acting on it.

You exert a force of about one newton when you hold a "D-cell" of a flashlight in your hand. Why do you need to exert a force on the D-cell to keep it from falling? You do because each particle in the universe attracts every other particle. Planet Earth and the D-cell attract each other. This attractive force is called
gravitation. If you don't exert an opposing force on the D-cell, it and Earth will move closer together. We say that the D-cell falls toward Earth.

The measure of gravitational force is weight. We say that the D-cell weighs about 1 newton. But its mass is about 100 grams. Do you understand the difference between mass and weight?

To evaluate your understanding, answer each of the following questions with WEIGHT, or MASS, or BOTH.

1. Which is characteristic of an object itself? ...........................................

2. Which is the result of interactions among two or more objects? ......

3. Which keeps the moon from flying farther from Earth into space? .

4. Which keeps the moon from crashing into Earth? ......................

5. Which keeps water from running out of a bucket standing on a level floor? .................................................................

6. Which keeps water from running out of a bucket swung in a vertical circle while in the upper part of its path ....................

7. Which keeps water from running out of a bucket swinging in a vertical circle while in the lower part of its path? .................

8. Which tends to keep a fast car from turning a "sharp" corner? ......

9. Which starts a motionless car coasting down a hill? ..................

10. Which slows a car while it goes up a hill? .............................

11. Which causes a car to coast part way up a hill? ......................

12. Which changes as an object approaches or leaves a planet or a star? .................................................................

13. Which keeps a pendulum swinging? .................................

14. Which keeps a fast-rolling wheel from falling? ....................

15. Which keeps a spinning top from falling? ..........................

16. Which causes a non-spinning top to fall? ..........................
Discuss the answers with the class after each student has had an opportunity to consider them.

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