Name:

Skill Sheet 3-B — Mass vs Weight

What is the difference between mass and weight? Why is it important to know these terms? This skill sheet will help you understand and correctly use mass and weight in problem solving.

mass	Mass is a measure of the amount of matter in an object. Mass is not related to gravity. The mass of an object does not change when it is moved from one place to another in the universe. Mass is commonly measured in grams or kilograms.
weight	Weight is a measure of the gravitational force between two objects. The weight of an object does change when the amount of gravitational force changes, as when an object is moved from Earth to the moon. Weight is commonly measured in newtons or pounds.

1. Why do mass and weight *seem* interchangeable?

People often talk about pounds and kilograms as if they are two units used to measure the same thing. They might say, for example, that a new baby weighs 8 pounds, or 3.63 kilograms. This statement implies that 8 pounds = 3.63 kilograms. This conversion makes sense *as long as* the baby stays on the surface of Earth.

On Earth's surface, the force of gravity acting on one kilogram is 2.22 pounds. So, if an object has a mass of 3.63 kilograms, the force of gravity acting on that mass *on Earth* will be:

$$3.63\text{ kg} \times \frac{2.22\text{ pounds}}{\text{kg}} = 8.06\text{ pounds}$$

On the moon's surface, however, the force of gravity acting on one kilogram is about 0.370 pounds. The same newborn baby, if she traveled to the moon, would still have a mass of 3.63 kilograms, but her weight would be just 1.34 pounds.

1. What is the weight (in pounds) of a 7.0-kilogram bowling ball on Earth's surface?

2. What is the weight of a 7.0-kilogram bowling ball on the surface of the moon?

3. What is the mass of a 7.0-kilogram bowling ball on the surface of the moon?

2. What does it mean when we say that weight is a force?

In everyday language, we think of weight as a measure of "how heavy" something is. A 25-pound toddler, for example, is a lot heavier to carry around than an 8-pound newborn.

Force, on the other hand, is defined as a push, pull, or any action that has the ability to change motion. So what does pushing or pulling have to do with weight?

To understand why we say that weight is a force, it helps to look at the scales used to measure weight. Grocery stores often have scales in the produce section. To use the scale, you put your produce (a bunch of bananas, for example) in a basket hanging from a spring. The force of gravity acting on the bananas *pulls* on the spring, causing it to stretch. The dial at the top measures how much the spring stretches. The dial shows the amount of pulling force in pounds.

Bathroom scales work much the same way, except that when you stand on the scale, you compress (*push*) the spring instead of pulling on it.

Balances, which are used to measure mass, work differently. A balance is like a see-saw with a pan on each end. In one pan, you put the object to be measured. In the opposite pan you put objects whose masses are known. When the two pans are balanced, you know the two sides have equal mass.

1. Describe what would happen to the spring in a bathroom scale if you were on the moon when you stepped on it. How is this different from stepping on the scale on Earth?

2. Would a balance function correctly on the moon? Why or why not?

3. What is free fall?

If you were to jump off of a 10-meter diving board with a scale attached to your feet, what would the scale read?

Until you hit the water, the scale would read zero pounds, even though you are very definitely still under the influence of gravity. It's just that you and the scale are falling at the same time, so there is nothing for your feet to push against.

A similar situation occurs when a space shuttle orbits the earth. The space shuttle is not so far away from Earth as to escape Earth's gravity. To understand what is happening, think about throwing a baseball. The baseball curves toward Earth due to the influence of gravity. Now think about throwing the baseball a little farther, and a little farther. What would happen if you could throw the baseball so hard that it kept falling *around* Earth? Then it would be like a space shuttle in orbit. The astronauts and everything inside the space shuttle seem to be weightless because they are in constant free fall.

4. Try this!

Take a bathroom scale into an elevator. Step on the scale.

1. What happens to the reading on the scale as the elevator begins to move upward?

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2. What happens to the reading on the scale when the elevator stops moving?

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3. What happens to the reading on the scale when the elevator begins to move downward?

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4. Why does your weight appear to change, even though you never left Earth's gravity?

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