Mass & Weight: What's the Difference?

Many people think that there is no difference between the terms "weight" and "mass." But there is! Mass is related to the amount of matter (or "stuff") in an object, regardless of how much space the object takes up. As long as you do not add or take away any matter from an object, its mass stays the same, even at different locations. If you take an object to the Moon or Mars, it will have the same mass that it had on Earth.

But what about its weight? Would an object weigh the same on the Moon or Mars as it does on Earth? As you found out in your investigation, the answer is "no." The weight of an object changes from planet to planet. Weight even changes from one place on a planet (such as a mountaintop, where you might weigh less) to another (such as the bottom of a deep valley, where you might weigh more).

Measuring Mass and Weight

Weight is a measure of the force of gravity on an object. (A force is a push or pull on or by an object.) We use a spring scale to measure the strength of the gravitational pull on the mass of an object. Objects with the same mass have the same weight. An object with more mass has a stronger gravitational force pulling on it than an object with less mass. The spring scale is pulled down farther, showing that the object weighs more. In the metric system, weight is measured in newtons.

Mass is measured in kilograms and grams in the metric system. To find the mass of an object, we use a balance. When equal amounts of matter are placed on opposite sides of a beam balance, for example, the pull of gravity is the same on both sides, and the beam balances. If the mass of an object were measured with a balance on Earth, and then with the same balance on the Moon, the results would be identical. The amount of "stuff" in the object hasn't changed.

Mass and Weight on the Eight Planets

An object with mass attracts any other object with mass. The strength of that attraction depends on the mass of each object and their distance from each other. This gravitational pull is very small between objects of ordinary size and

Weight is measured using a spring scale.
Mass is measured using a balance.

therefore is hard to measure. The pull between an object with a large amount of mass, such as Earth, and another object, such as a person on the planet's surface, can easily be measured.

Weight on a planet's surface is a measure of the pull of gravity between an object and the planet on which it is located. This force of gravity on an object on a planet's surface depends on the object's mass and the mass of the planet. If the mass of that object is doubled, gravity pulls on it twice as hard. If the mass of the planet is doubled, gravity pulls on the object twice as hard.

The force of gravity also depends on the distance of an object from the center of the planet to its surface. This distance is called the radius of the planet. The farther an object is from the planet's center, the weaker the pull between the planet and the object. This force gets weaker quite rapidly, but there is a pattern to it. If you double the radius of the planet, the weight of the object will be one-fourth as much. If you triple the radius of the planet, the weight will be only one-ninth as much. The force of gravity drops off with the square of the distance between the center of the planet and the object. Each planet in our solar system has a different mass and a different size. This means that the weight of the same object on the surface of each planet will be different. For example, you would weigh less on the Moon than you do on Earth because although the Moon is smaller than Earth, it also has less mass than Earth— and Earth's mass wins out. This means that the Moon exerts less gravitational force at its surface than Earth. Any given object will have the same mass on Earth and on the Moon, but that object's weight on the Moon will be only about 16 percent (one-sixth) of the weight as measured on Earth.

What Would You Weigh on Jupiter?

Jupiter has 318 times more mass than Earth, so you might assume that you would weigh 318 times more on Jupiter than you weigh on Earth. This would be true if Jupiter were the same size as Earth, but the diameter of Jupiter is more than 10 times the diameter of Earth. This means that if you stood on Jupiter, you would actually be farther from the planet's center than you would be if you stood on Earth. This reduces Jupiter's gravitational pull on you to only about 2.36 times (and not 318 times) your weight on Earth.

The number 2.36 is referred to as Jupiter's "gravity factor." The gravity factor is the ratio of each planet's gravity to that on Earth. Earth's gravity factor is 1 and Jupiter's gravity factor is 2.36. By multiplying your Earth weight by a planet's gravity factor, you can determine your weight on that planet. Use the table to find out how much you would weigh on each of the nine planets.

Table 1 Mass, Radius, and Surface Gravity of Each Planet

Planet	Mass (10^{22} kg)	Radius (km)	Surface Gravity Factor (Earth = 1)
Mercury	33	2439	0.38
Venus	487	6051	0.91
Earth	597	6378	1.00
Mars	64	3396	0.38
Jupiter	189,900	71,492	2.36
Saturn	56,850	60,268	0.92
Uranus	8683	25,559	0.89
Neptune	10,240	24,764	1.12
Pluto	1	1170	0.06
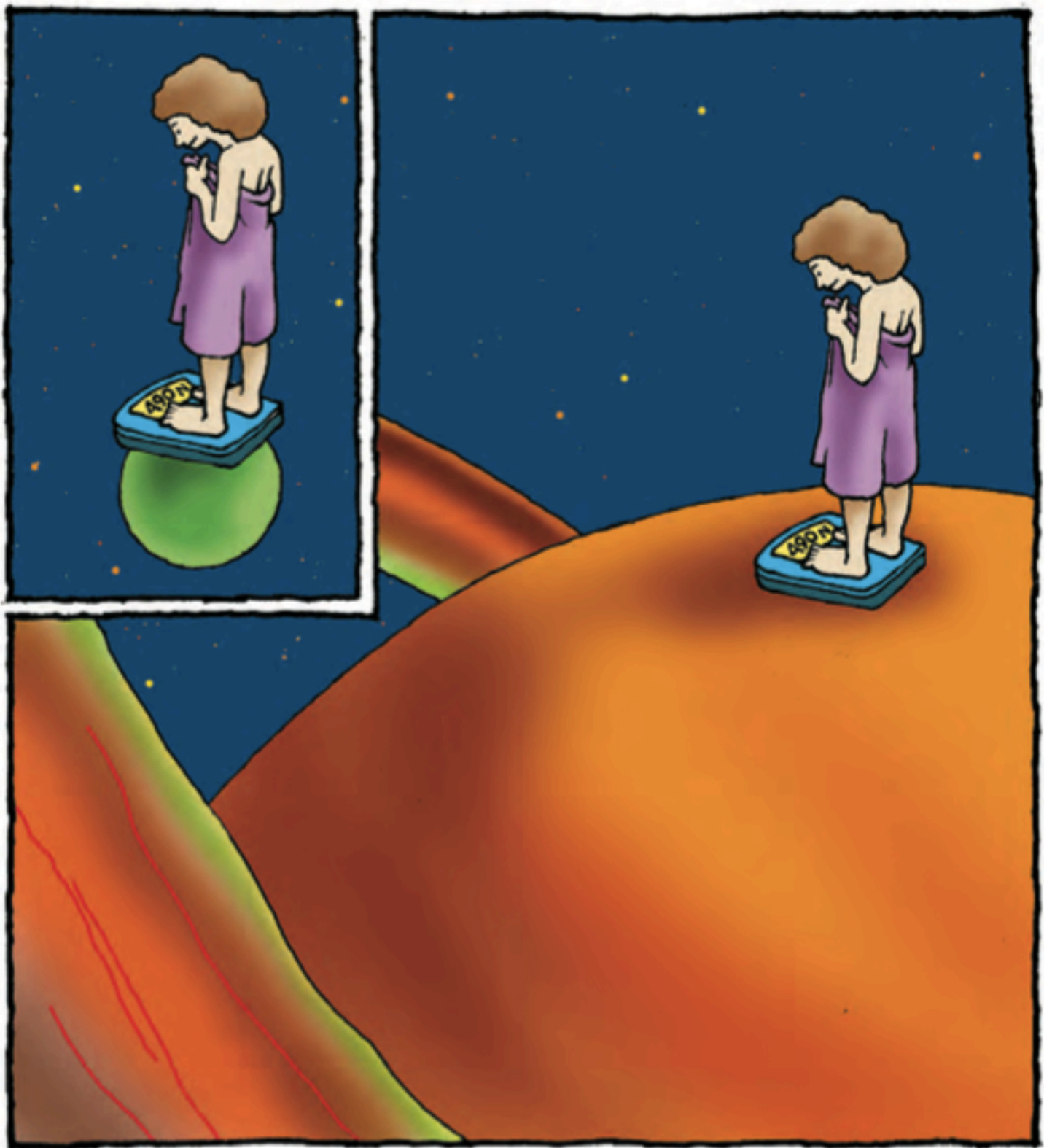
The farther the object is from the center of the planet, the weaker the pull between the planet and the object. This means that your weight on Saturn would be about the same as your weight on Venus, even though Saturn is more massive than Venus.