Minds•On Physics Activity

FF•11

Distinguishing Mass and Weight

Purpose and Expected Outcome

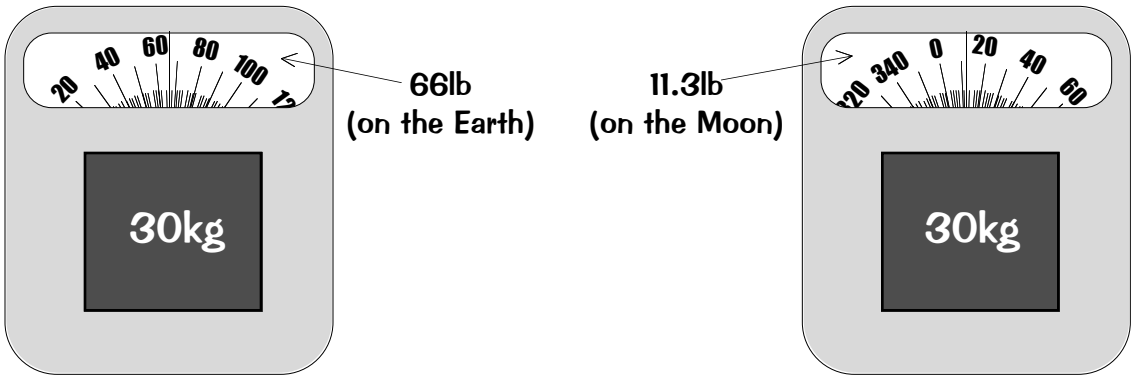
In this activity, you will explore the effect that the gravitational force has on objects near the surface of the Moon. As a result of this activity, you will understand better the need for the distinction between *mass* and *weight*.

Prior Experience / Knowledge Needed

To benefit from this activity you should be comfortable with the concepts of *force*, *weight*, and *mass*. You should recall the expression for the weight near the surface of the Earth, $F_g = mg$. In addition you should know that the local gravitational constant on the Moon is different than that on the Earth, as described below.

g ON THE MOON

When a 30kg mass is placed on a scale on the Earth, it reads about 66lb or about 295N. This means that the local gravitational constant on the Earth is about 2.2lb/kg, or about 9.8N/kg. When the same 30kg mass is placed on a scale on the Moon, it reads only about 11.3lb or about 50N, which means that the local gravitational constant on the Moon is about 0.38lb/kg, or about 1.67N/kg.



Explanation of Activity

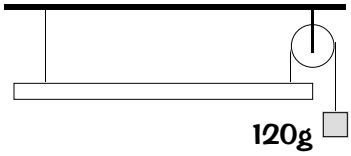
There are two parts in this activity.

PART A: Doing Physics on the Moon

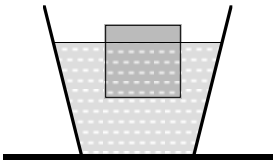
In each of the situations below, you are asked to consider how a phenomenon would look if it happened on the Moon. Be prepared to explain your answers.

A1. A 3kg mass is hung from a spring having an elastic constant of 10N/cm. How far would the spring stretch on the Moon?

A2. On the Earth, the arrangement on the right is balanced by a hanging mass of 120g. What hanging mass would be needed to balance this arrangement on the Moon?

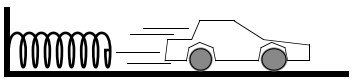


A3. On the Earth, a certain object floats in water with $^3/_4$ of its volume submerged. What fraction of its volume would be submerged in water on the Moon?



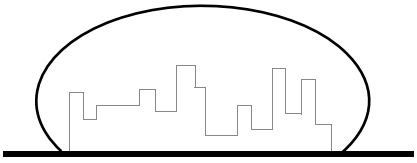
A4. A certain box slides to a stop in 3 seconds on the Earth. Using the same arrangement and the same initial velocity, how long would it take for the box to slide to a stop on the Moon?

A5. A toy car is launched by a spring and seen to travel at 2m/s. If the same set-up is taken to the Moon, what would be the speed of the car after being launched?



A6. On the Earth, a steel ball dropped from a height of 1m has a speed of about $4^1/_2$m/s just before it lands. If the same steel ball is dropped from a height of 1m on the Moon, what would be its speed just before it lands?

A7. Imagine that a city has been built on the Moon, inside a large, pressurized dome so that humans can breathe normally without using a space suit. How does your weight inside this dome on the Moon compare to your weight on the Earth? Explain.



In everyday usage, *mass* and *weight* are often used interchangeably to mean the same thing. In some countries for instance, the standard unit of weight is the "kilo", which is short for "kilogram", while in physics, this is the standard unit of mass ("kg"). The distinction between *mass* and *weight* is not particularly important until we leave the surface of the Earth. On the Moon, for example, the mass of an object is the same as it is on the Earth. In other words, when a net force of 1N is exerted on a 1kg mass, its acceleration is $1m/s^2$ everywhere. However, the weight of an object depends on its location. A 1kg mass weighs 2.2lb on the Earth, but only 0.38lb on the Moon.

PART B: Reasoning with Mass vs. Weight

For each question provide a brief explanation of your answer.

B1. A rock is thrown straight up with an initial speed of 10m/s. Consider the time it takes for the rock to return to the surface. Would this time be larger on the Earth or on the Moon? Explain.

B2. A block starts from rest and slides down a smooth incline. Consider the speed of the block after traveling 1 meter along the incline. Would this speed be larger if the block and incline were on the Earth or on the Moon? Explain.

B3. On the Earth a certain block will slide down a certain rough incline with constant speed once motion is started. If this same block and incline were taken to the Moon and the block were given a tiny push on the incline...

(a) ... would the block move with constant speed as on the Earth? Explain.

(b) ... sketch two strobe diagrams, one showing the position of the block on the incline when the system is on the Earth and another when it is on the Moon. (Use the same time interval for both diagrams.)

B4. A mass m is attached to a string of length L and swung in a vertical circle. The mass is swung so that the speed of the mass at the highest point is v. Consider the tension in the string when the mass is at its highest point. Would this tension be larger if this were done on the Earth or on the Moon? Explain.

B5. Imagine that a city has been built on the Moon, inside a large, pressurized dome so that humans can breathe normally without using a space suit. You are trying to push a car that has stalled on a flat, horizontal highway. Do you think it would be easier or harder to push the car on the Moon than to push it on the Earth? Explain.

Reflection

R1. (a) In part A, how many arrangements produced the same results on the Earth as on the Moon? Which ones? Why do you suppose the results are the same?

(b) In part A, how many arrangements produced different results on the Earth than on the Moon? Which ones? Why do you suppose the results are different?

R2. For which situations in part B did you draw a free-body diagram? Why or why not?

R3. If you have not done so already, draw a free-body diagram for the block in B3 when it is on the Earth and another when it is on the Moon. Are your free-body diagrams consistent with your answer to B3(a)?

R4. (a) Does the Moon exert a gravitational force on you? If so, what is its direction and how does it compare in size with the gravitational force that the Earth exerts on you?

(b) Compare the gravitational force that the Earth exerts on the Moon with the gravitational force that the Moon exerts on the Earth. Explain how you made your comparison.

R5. Consider the gravitational force that a celestial body, such as a planet or a moon, exerts on an object at its surface.

(a) Do you suppose it is possible for a celestial body the size of the Moon to exert a gravitational force on something as strongly as the Earth does? Explain.

(b) Do you suppose it is possible for a celestial body the size of the Earth to exert a gravitational force on something as weakly as the Moon does? Explain.

R6. Imagine that a city has been built on the Moon, inside a large, pressurized dome so that humans can breathe normally without using a space suit. How would riding your bike on the Moon be different than riding it on the Earth? For instance, would the maximum possible accelerations (on the Earth vs. on the Moon) be about the same, or would they be different? Would the distances needed to stop be about the same or different? Would the maximum possible speeds be about the same or different?

R7. Why do you suppose the gravitational constant is smaller on the Moon than on the Earth? What factors do you think determine what the gravitational constant is for a particular celestial object?