10.2: Weight

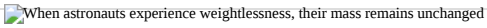

Figure 3.1.1

Astronauts in training often fly in the KC-135 training aircraft to experience near-weightlessness. Three Japan Aerospace Exploration Agency astronauts—Akihiko Hoshide, Satoshi Furukawa, and Naoko Yamazaki—are shown here during such an exercise. Though they experience near-weightlessness, we can see that their mass has not changed. What is the relationship between mass and weight?

Mass and Weight

The **mass** of an object is defined as the amount of matter in the object. The amount of mass an object has does not change; a moon rock that has been returned to Earth has the same mass on the Earth's surface as it had on the moon. The amount of mass in an object is measured by comparing the object to known masses on an instrument called a balance.

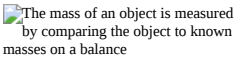

Figure 3.1.2

Using the balance shown here, the object would be placed in one pan and known masses would be placed in the other pan until the pans were exactly balanced. When balanced, the mass of the object would be equal to the sum of the known masses in the other pan. A balance will work in any location; whether on the moon or on Earth, the moon rock mentioned earlier will have the same mass.

The **weight** of an object is the force pulling the object downward. On Earth, this would be the gravitational force of the Earth on the object. On the moon, this would be the gravitational force of the moon on the object. The gravitational force of the moon is one-sixth the magnitude of the gravitational force of the Earth; the weight of the moon rock on the moon will be one-sixth the weight of the moon rock on the Earth's surface.

The gravitational force is derived from Newton's Second Law, $F=ma$, where F is the force of gravity in Newtons, m is the mass of the object in kilograms, and a is the acceleration due to gravity on Earth, 9.81 m/s^2 . When the formula is used specifically to solve for the weight of an object, it appears as $W=mg$. Weight is always measured in force units Newtons, m is the mass of the object in kilograms, and g is the gravitational strength, or the acceleration due to gravity, of the planet in N/kg or m/s^2 (g_{Earth} = 9.81 m/s^2).

Gain access to an Astronaut Training Chamber in the simulation below and observe how the mass of an object on various planets stays the same but its weight (or force due to gravity) differs. Try to use the graph to derive the strength of the gravitational field on the moon, Mars and even Saturn's moon, Dione!

Examples

Example 3.1.1

What is the weight of an object sitting on the Earth's surface if the mass of the object is 43.7 kg?

Solution

$W=mg=(43.7\text{ kg})(9.81\text{ m/s}^2)=429\text{ N}$

Example 3.1.2

What is the mass of an object whose weight sitting on the Earth is 2570 N?

Solution

$m=W/g=(2570\text{ N})(/9.81\text{ m/s}^2)=262\text{ kg}$

Summary

- The mass of an object is measured in kilograms and is defined as the amount of matter in an object.
- Mass is determined by comparing an object to known masses on a balance.
- The weight of an object on the Earth is defined as the force acting on the object by the Earth's gravity.

- Weight is measured by a calibrated spring scale.
- The formula relating mass and weight is W=mg.

Review

1. The mass of an object on the Earth is 100 kg.
    1. What is the weight of the object on the Earth?
    2. What is the mass of the object on the moon?
    3. Assuming the acceleration due to gravity on the moon is exactly one-sixth of the acceleration due to gravity on Earth, what is the weight of the object on the moon?
2. A man standing on the Earth can exert the same force with his legs as when he is standing on the moon. We know that the mass of the man is the same on the Earth and the moon. We also know that F=ma is true on both the Earth and the moon. Will the man be able to jump higher on the moon than the Earth? Why or why not?

Explore More

Use the resource below to answer the questions that follow.

1. What is the difference between mass and weight?

Additional Resources

Study Guide: Newton's Laws Study Guide

Real World Application: The Weight of Gold

PLIX: Play, Learn, Interact, eXplore: The Weight of Gold

Videos: