Lesson Plan

Description

In this lesson, students will learn the difference between mass and weight, and how they interact with gravity, using scientific experimentation.

Learning Outcomes

- Mass and weight mean different things
- Mass is a measure of the amount of matter an object has
- Weight is the amount of force acting on a mass
- Gravity is a force that pushes downwards on objects
- Mass, weight, and gravity interact

Specific Expectations

A3.3 analyse contributions to science and technology from various communities

E2.2 distinguish between the concepts of mass and weight

E2.3 describe the relationship between the force of gravity and the weight of a body

Introduction

What is mass? What is weight? The terms "mass" and "weight" are often used interchangeably, but they mean different things.

Mass is a measure of the amount of matter an object has, or how much "stuff" it is made up of. All things are made up of matter. **Weight** is the amount of force acting on a mass. This force is called gravity!

Gravity is force that pushes downwards and is what keeps us from floating around on Earth. Mass will always stay the same, whereas weight can change depending on the force of gravity. For example, a person standing on the moon weighs less than someone standing on Earth. Why is this? Since there is less gravity on the moon there is less force acting on the mass.

We can calculate weight by using the following formula: **Weight = Mass x Gravity**

You may have heard that Isaac Newton discovered gravity in the 17th century when an apple fell on his head, but this isn't necessarily true. While Newton's work was important, many scholars from different cultures had theorized and thought about gravity long before Newton. In fact, an Islamic scholar named Muhammad Banū Mūsā developed an early form of the Law of Gravitation in the Islamic Golden Age in the 9th century. Newton consulted texts published

by Muslim polymaths (similar to Western philosophers and physicists such as Newton) from this time period before publishing his own work.

Additionally, many others contributed to and improved his theory afterwards. One notable contribution comes from Émilie du Châtelet, a French aristocrat in the 18th century. Émilie conducted experiments to expand on Newton's ideas and made a major discovery about the velocity of gravity. She also translated Newton's original text to French and annotated it to explain his work to others. Émilie was often not credited for her work or published under a man's name, as at the time it was unbecoming for women to be educated. She was a staunch advocate for women's education in addition to her contributions to our understanding of physics.

In this lesson students will learn the difference between mass and weight, and how mass, weight, and gravity interact using hands-on science demonstrations.

Action

Activity 1: Make a Balance

This activity demonstrates the concept of mass.

Materials

- Plastic coat hanger
- String or yarn
- Two paper cups
- Wooden skewer
- Paperclips

Procedure

1. Carefully poke two holes in each cup using the wooden skewer. The holes should be a little below the cup's rim and directly across from each other.
2. Cut two pieces of string about two feet long.
3. Make a cup handle: Use the skewer to push an end of one piece of string through one of the holes in one cup. Tie the end in a knot so it is securely attached to the rim of the cup. Push the other end through the hole on the opposite side of the cup and tie it.
4. Do the same thing with the other cup and piece of string. The loops of string on each cup need to be the same length so that the cups will hang evenly on your scale.
5. Find a place to hang your scale. You need a place where it can hang freely without bumping into anything. Tie a piece of string to the hanger's hook and tie the other end around the whatever you are hanging it from.
6. Now hang the loop of each cup on one of the small clothing hooks on each side of the hanger. The hanger should be balanced, and the cups should hang down at equal levels on each side.

7. Now you can experiment with your balance! What happens if you add an object to the cup on one side but not the other? Can you find an object to put in the other cup that will make the cups balance again?

Now the students have made a balance. Since the paper cups are the same, the hanger balanced evenly because each side had the same mass. If you add objects to your cup, the balance tips because you are changing the mass on one side.

Ask the students why they think the balance tips when they add or remove objects.

Activity 2: Planet Comparison
This activity demonstrates the concept of weight.

Materials
- Planet Comparison Handout

Procedure
Pick an object in the classroom and tell the students that is has a mass of 10 grams. Explain that different planets have different levels of gravity. Give each student a handout and ask them to calculate how much the object weighs on different planets. They will see that with changing gravity, the weight of the object changes.

Activity 3: Falling Experiment
This activity demonstrates the interaction between mass, weight, and gravity.

Materials
- A small ball
- Two sheets of paper

Procedure
1. Hold the ball in one hand and the sheet of paper in the other, with your arms in front of you and the backs of your hands facing up.
2. Ask the students which object they think will hit the ground first.
3. Open both of your hands at the same time and watch the objects fall. Which one reaches the floor first?
4. Crumple one sheet of paper into a ball. Drop the paper ball and the full sheet of paper at the same time. Ask the students what they think will happen, and then what really happens?
5. Now drop the ball and the paper ball at the same time and notice what happens.

In step 1, the ball hit the ground before the sheet of paper.

In step 4, the paper ball also hits the ground before the sheet of paper. They both have the same mass, so why did one hit the ground before the other?

In step 5, the regular ball and paper ball hit the ground at the same time. How is that possible?

Even though it seems like objects with more mass would fall fastest, this isn't always true. Mass and weight do not determine how quickly an object falls; gravity does. All objects fall at the same speed because gravity pulls on them equally, no matter how much they weigh!

That explains why the paper ball and regular ball landed on the floor at the same time, but why didn't the sheet of paper fall as quickly? Objects will only fall at the same speed if no other force is acting on them. The force of air (resistance) was acting on the sheet of paper, pushing against the force of gravity. Since a ball is round, the air couldn't resist as much as on the sheet.

Consolidation/Extension

Birchbark Canoe Activity

In this activity, students can apply the concepts they learned to a real-world application, using the example of the birchbark canoe.

Birchbark canoes were the primary mode of transportation for Indigenous peoples living in the Canadian Shield. Specifically, birchbark canoes were used by the Algonquian peoples, like the Innu, Ojibwe, Wolastoqiyik, and Algonquin. Later, voyageurs used birchbark canoes in the fur trade, as the Europeans noted birchbark canoes were far superior to their own crafts for the navigation of Canadian lakes, rivers, and streams.

Birchbark was smooth, hard, resilient and light, making it an ideal construction material. The skills to make these canoes was passed down through generation of builders. Some birchbark canoes could carry up to 2300 kg of cargo depending on the design.

Students will build their own "birchbark" canoes using tinfoil.

Materials

- Tinfoil
- Tub of water
- Coins/weights

Procedure

1. Provide each student with an approximately 30cm x 30cm piece of tinfoil.
2. Each student will be tasked with building a boat with that sheet of tinfoil that can hold as much weight as possible without sinking.
3. Give the students a set amount of time then come together to test the boats.

4. Place one penny, stone, or weight at a time into the boats. Keep track of how many it holds until it sinks.

Using the example of the canoe, have the students identify what is mass and what is weight in this scenario.

What other forces are acting on the canoe? Why does it float? Discuss how the water (buoyancy) is a force counter-acting gravity in this scenario.

Accommodations/Modifications	Assessment
It is recommended that the lesson be completed in smaller sections to give students the time they need to succeed. Consider pre-fabricating some of the materials in Activity 1, such as having the string pre-cut and holes in the cups.	Teachers can monitor the student work as Assessment *for* Learning. Gather information from the students throughout the activity to gauge their level of understanding.

Additional Resources

The Gravity of Émilie du Châtelet | American Institute of Physics (aip.org)
On the Shoulders of Giants: Inertia from Ibn Sīnā to Newton | American Institute of Physics (aip.org)
Birchbark Canoe | The Canadian Encyclopedia