**Density**

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**Subject:** Physics **Week**:

**Grade:** Nine **Time**: 2 hrs.

**Number of Sessions**

1. 40 minutes

1 - 80 minutes

**Topic:** Density

**Link to Vision 2030**

Goal 1: Jamaicans are empowered to achieve their fullest potential (Vision 2030). This lesson seeks to achieve this goal by enhancing third-form students' problem-solving and critical-thinking skills.

**General Objectives**

* Understand how density affects real-world phenomena and applications

**Lesson Objective(s)**

* Define density and explain its relationship to mass and volume
* Calculate density using the formula D = M / V
* Compare and contrast the densities of different objects and liquids

**Key Skills:**

* Communication,
* collaboration,
* critical thinking,
* problem-solving,
* analytical reasoning

**Materials Needed**

- Various objects of different sizes and materials (e.g., wood blocks, metal cubes, plastic toys, glass marbles, styrofoam balls)

- Graduated cylinders (100 mL and 250 mL)

- Beakers (250 mL and 500 mL)

- Water

- Vegetable oil

- Corn syrup

- Rubbing alcohol

- Salt

- Sugar

- Electronic balance (0.1 g precision)

- Calculators

- Worksheets

- Large clear container (2 L or larger) for demonstrations

- Eggs

- Food coloring

- Ice cubes

- Hot plate (for teacher use only)

- Safety goggles

**Procedure**

**Engage**

* Students will participate in an activity called “Sink or Float,” where they will place a small wooden block, a plastic toy, a metal marble, and a table tennis ball into a container of water. The teacher will encourage the students to make predictions before carrying out this activity.

The teacher will encourage a class discussion around the following number

* + What do you think determines whether an object sinks or floats?
  + Have you ever seen a large, heavy ship float? How do you think that's possible?

**Explore**

* Students will conduct an experiment to measure the mass and determine the volume of various objects (such as a metal bolt and a rubber ball), and then calculate their density.

**Explain**

* Students will discuss how density relates to the "Sink or Float" activity:

Objects with a density lower than water (1 g/cm³) will float

Objects with a density higher than water will sink

* The teacher will define density - define density as the mass per unit volume of a substance.

Introduce the formula: Density (D) = Mass (M) / Volume (V)

Explain units: g/cm³ or kg/m³

Note that 1 cm³ = 1 mL for water

* The teacher will explain how density is reflected in liquids. To help with the explanation, the teacher will build a density tower.

**Demonstration: Density Tower**

* + Create a density tower using liquids of different densities:

Honey (1.4 g/cm³)

Dish soap (1.06 g/cm³)

Water (1.00 g/cm³)

Vegetable oil (0.92 g/cm³)

Rubbing alcohol (0.79 g/cm³)

**Elaborate**

* Students will use their knowledge of density to guess the objects. Students will be divided into groups with mystery items (e.g., different metal cubes, plastic shapes) and will be asked to determine their densities.
* The teacher will prompt a class discussion based on the following questions:

• How might understanding density be useful in real-life situations? (e.g., designing ships, hot air balloons, or understanding ocean currents?)

• Can you think of examples where changing density is important? (e.g., fish using swim bladders, lava lamps, weather patterns?)

**Evaluate**

* Students will answer the following questions.

1. What is the formula for density?
2. If an object has a mass of 30g and a volume of 10cm³, what is its density?
3. Will an object with a density of 0.8 g/cm³ sink or float in water? Why?
4. How can you change the density of a liquid?
5. A cube of unknown material has a mass of 13.5g and an edge length of 2cm. Calculate its density and suggest what material it might be.

**Reflection:**

Students will write a reflection on one new thing they learned about density **and** one question they still have about density

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**Differentiation Strategies**

**For Slower Learners:**

- Provide step-by-step instructions for calculations

- Use visual aids to represent density concepts (e.g., Lego bricks to show mass/volume relationships)

- Allow extra time for hands-on activities

- Pair with peer mentors for support

- Offer simplified worksheets with partially completed calculations

**For Fast Learners:**

- Offer more complex density problems (e.g., calculating density of irregular shapes)

- Challenge them to design their own density experiments

- Encourage research on real-world applications of density (e.g., how density affects climate and ocean currents)

- Introduce the concept of specific gravity and its relationship to density

**Homework**

Ask students to:

1. Find three examples of how density is important in everyday life and explain each briefly.

2. Design a simple experiment to demonstrate one of these examples.

3. Calculate the density of three household objects and explain whether they would sink or float in water.

**Content**

Density is a fundamental property of matter that helps us understand how different substances interact with each other and their environment.

**What is Density?**

Density is defined as the mass of a substance per unit volume. In other words, it's a measure of how much matter is packed into a given space. The formula for density is:

Density (ρ) = Mass (m) / Volume (V)

Where:

- ρ (rho) is the Greek letter commonly used to represent density

- m is mass, typically measured in grams (g) or kilograms (kg)

- V is volume, typically measured in cubic centimetres (cm³) or cubic metres (m³)

The standard unit for density is kilograms per cubic metre (kg/m³), but it's often expressed in grams per cubic centimetre (g/cm³) for smaller objects.

**Calculating Density**

To calculate density, you need to know two things:

1. The mass of the object

2. The volume of the object

**Example 1:**

A cube of aluminium has a mass of 27 grams and a volume of 10 cm³. Calculate its density.

Solution:

Density = Mass / Volume

         = 27 g / 10 cm³

         = 2.7 g/cm³

Therefore, the density of aluminium is 2.7 g/cm³.

**Measuring Mass and Volume**

**Measuring Mass**

Mass is typically measured using a balance. In school laboratories, you might use:

- Triple beam balance

- Electronic balance

Always ensure the balance is zeroed before placing your object on it.

**Measuring Volume**

The method for measuring volume depends on the state and shape of the substance:

1. For regular solids (cubes, spheres, cylinders):

   - Use mathematical formulas to calculate volume based on measurements.

2. For irregular solids:

   - Use the displacement method:

     a. Fill a graduated cylinder with water

     b. Record the initial volume

     c. Submerge the object

     d. Record the new volume

     e. Subtract the initial volume from the new volume

3. For liquids:

   - Use a graduated cylinder or pipette to measure the volume directly

**Example 2:**

An irregular rock has a mass of 56 grams. When placed in a graduated cylinder, it raises the water level from 50 mL to 72 mL. Calculate its density.

Solution:

Mass = 56 g

Volume displaced = 72 mL - 50 mL = 22 mL (note: 1 mL = 1 cm³)

Density = Mass / Volume

        = 56 g / 22 cm³

        = 2.55 g/cm³

**Density of Different States of Matter**

**Solids**

Solids generally have the highest densities due to their tightly packed particles.

Example: Iron has a density of about 7.87 g/cm³

**Liquids**

Liquids have particles that can move around each other, resulting in lower densities than most solids.

Example: Water has a density of 1 g/cm³ at 4°C

**Gases**

Gases have the lowest densities due to their particles being spread far apart.

Example: Air at sea level has a density of about 0.0013 g/cm³

1. Temperature: Generally, as temperature increases, density decreases (with some exceptions like water between 0°C and 4°C).

2. Pressure: Increasing pressure typically increases density, especially noticeable in gases.

3. Composition: The type of atoms or molecules in a substance determines its density.

**Applications of Density**

1. Buoyancy: Objects float when their density is less than the fluid they're in.

   Example: A ship floats because its average density (including the air inside) is less than water's density.

2. Hot Air Balloons: They rise because heated air is less dense than the surrounding cooler air.

3. Density Towers: Liquids of different densities can be layered on top of each other.

   Example: In a density tower, you might see (from bottom to top): honey, dish soap, water, vegetable oil, and rubbing alcohol.

**Reference**

Jones, M., Fellowes-Freeman, D., & Smyth, M. (2020). Cambridge Lower Secondary Science Learner’s Book 9 (2nd ed.). Cambridge University Press.