11-14 Density

Prerequisites:

Students should have already completed the **Forces** and the **Weight** sheets

The Main Points

- **Density** allows us to compare how heavy (or how difficult to move) different materials are.
- Both weight and 'difficulty to move' (inertia) are determined by the object's **mass**: so we want to compare the mass of the **same volume** of different materials.
- The density is the mass (in grams or kilograms) of a fixed volume - usually a cubic centimetre or cubic metre.
    - Density in g/cm^3 = Mass in g / Volume in cm^3
    - Density in kg/m^3 = Mass in kg / Volume in m^3
    - In symbols $\rho=m/V$ where ρ (rho) is the symbol for density
    - $1cm^3 = (0.01m)^3 = 0.000\ 001\ m^3$
    - so $1\ g/cm^3 = 0.001\ kg / 0.000\ 001\ m^3 = 1000\ kg/m^3$
    - Water has a density very close to $1000\ kg/m^3 = 1\ g/cm^3$
- For a rectangular block, we work out the volume by multiplying the width, depth and height of the block.
- A solid object will sink in a liquid if it is denser than the liquid. It will float if it is less dense than the liquid.
- A helium balloon rises in air because helium is less dense than air.
- For liquids, the volume is often measured in millilitres (mL), where $1mL = 1cm^3$.

Teacher Quarter Briefing

- Introduction: https://youtu.be/OkAlrS85BuQ
- Practice:https://isaacphysics.org/gameboards#itsp_teach_density
- Review: https://youtu.be/WN-ljSgK6SY
- If you want to go further: https://isaacphysics.org/gameboards#step_up_phys_30_b1

Class Question Notes

The worksheet can be printed either in full, or in cloze text form (where the red text is missing, and students can complete these blank spaces after class discussion). The online version of the notes requires the appropriate text to be dragged to the right place in the sentences.

Shallow learning gradient online assignment - q1,2,4,5,6,7,8,9,10,11
Steeper learning gradient online assignment - q2,3,4,5,6,8,10,12,13

1. The first two questions address the misconception 'Iron is heavier than wood'. In this question, the student thinks of objects like an iron nail and a wooden table, where the wooden object is heavier. So big wooden things can be heavier than small iron things, so it is not always true that 'wood is heavier'.
2. In this question, the student corrects the statement 'Iron is heavier than wood' to include ideas of density with and without using the word 'dense'.
3. Here the student uses their awareness of common materials to put five materials in order of increasing density. They should know that a helium balloon floats in air, so helium will be less dense than air. They should also know that wood floats, whereas steel does not. The gases (air and helium) are much less dense than solids or liquids, which enables the student to get the order right.
4. After a definition of density, this question leads students to calculate densities with scaffolding.
5. Students calculate densities from masses and volumes without scaffolding.
6. Here the student works out densities of liquids where the volume has been given in millilitres. The student needs to remember that 750mL, for example, is the same as 750cm^3. The notes in the question remind the student of this.
7. Students calculate masses from densities and volumes with scaffolding
8. Here, the student calculates masses from densities and volumes without scaffolding.
9. Students calculate volumes from densities and masses with scaffolding.
10. Here, the student calculates volumes from masses and densities without scaffolding.
11. The student completes word equations with mass, density and volume three times, with a different subject each time.
12. The student repeats Question 8, now working in symbols.
13. In this question, the student works out the cost of a gold bar. They do this in stages. Firstly, they multiply the dimensions 15cm x 8cm x 6cm = 720cm^3 to get the volume. They then multiply this by the density (19g/cm3) to get the mass (13 680g, but the student may round to 2sf or 3sf if they want to). Finally, they multiply this by the cost (£50/gram) to get the value of the bar.

Homework Question Notes

These questions have a very similar form to the questions in the class task, so students can refer back to their earlier answers to help

Shallow learning gradient online assignment - q1,2,4,5,6,7,8,10
Steeper learning gradient online assignment - q2,3,4,7,9,10,11,12

1. The first two questions address the misconceptions caused by students confusing density with weight. In this question students tick whether statements are sometimes true (iron is heavier than air), always true (iron is denser than air) or false (air is denser than iron).
2. Here students fill in the blanks to write an explanation of why we need density to help us compare materials.
3. Here the student uses their awareness of common materials to put five materials in order of increasing density. They should know that ice floats, whereas iron and gold do not. They should also be aware that gold is denser than iron.
4. This is a scaffolded question where students calculate density from mass and volume.
5. This is a scaffolded question where students calculate mass from volume and density.
6. This is a scaffolded question where students calculate volume from mass and density.
7. In this question, the students fill in a table with the symbols and units for mass, volume and density.
8. The student completes word equations with mass, density and volume three times, with a different subject each time.
9. The student repeats Question 8, now working in symbols.
10. Students use their understanding (and/or the formula) to work out masses, densities and volumes.
11. Students calculate the density of ice, compare this with the density of water, and answer whether an ice cube will float in water, and whether all ice will float in water (or only small pieces of ice).
12. In this question, students work out the mass (in kg) of the water in a swimming pool. They work in stages
    a. Working out the volume of $1m^3$ = 100cm x 100cm x 100cm = 1000 000 cm^3.
    b. Using a density for water of $1g/cm^3$, working out the mass of $1m^3$ of water = 1000 000g.
    c. Writing this mass in kg: 1000kg.
    d. Working out the volume of the swimming pool 50m x 10m x 1.25m = 625 m^3.
    e. Using (c) and (d) to get the mass of the water: 1000 x 625 = 625 000 kg.

Extension questions from ‘Step Up to GCSE Physics’:
https://isaacphysics.org/gameboards#step_up_phys_30_b1