Density calculations and units

Name: _____ Class: _____ Date: _____

Start here

0-5 minutes

Today: Calculate density, mass and volume, convert units and justify a comparison.

You need: Pen, a different-coloured pen and a calculator.

Work from memory. Write in this booklet and show your working. If unsure, make your best attempt.

1. A test sample has a mass of 0.180 kg. Convert its mass to grams.

Working:

Mass = g

2. A cuboid measures 2 cm × 3 cm × 4 cm. Calculate its volume in cm³.

Working:

Volume = cm³

3. Samples A and B each occupy 10 cm³. A has mass 20 g and B has mass 30 g. Which sample has the greater density? Explain without doing a calculation.

Stop for check 1. Wait for your teacher before moving on.

Try again A

Only if your teacher asks. Use the first 2 reading minutes, then continue on page 2.

Help: Use the equation and units table on page 2. For equal volumes, compare the masses. Volume of a cuboid uses all three dimensions.

(a) Convert 0.075 kg to grams. (b) Find the volume of a 5 cm × 2 cm × 1 cm cuboid. (c) Two samples occupy the same volume. State which is denser: a 15 g sample or a 25 g sample. Give a reason.

When your teacher says, turn to page 2.

Read the method and model

5-15 minutes

Density means mass per unit volume. A larger or heavier object does not automatically have a greater density. Choose the equation for the quantity you need.

Find…	Equation and consistent units
Density, ρ (rho)	ρ = m ÷ V. Use g and cm³ for g/cm³; kg and m³ for kg/m³.
Mass, m	m = ρ × V. A density in kg/m³ needs volume in m³ to give mass in kg.
Volume, V	V = m ÷ ρ. A mass in g and density in g/cm³ give volume in cm³.

Convert volume as a cube

Convert…	What to do
g to kg / kg to g	Divide by 1000 / multiply by 1000.
cm³ to m³	Divide by 1 000 000. 1 cm³ = (0.01 m)³ = 0.000001 m³.
g/cm³ to kg/m³	Multiply by 1000: 1 g/cm³ = 0.001 kg ÷ 0.000001 m³ = 1000 kg/m³.

Worked model - the revision-note cuboid

A 54 g metal cuboid measures 3 cm × 2 cm × 1 cm. Calculate its density in kg/m³.

Volume = 3 × 2 × 1 = 6 cm³. Density = 54 ÷ 6 = 9 g/cm³. Convert: 9 × 1000 = 9000 kg/m³. Check using SI units: mass = 0.054 kg; volume = 0.000006 m³; density = 0.054 ÷ 0.000006 = 9000 kg/m³.

Same material, different size

At the same temperature, cutting a uniform material changes mass and volume in the same proportion. Their ratio, and therefore density, stays the same. For a cuboid, volume = length × width × height.

Adapted from PhysicsUK: Density and Particle Arrangement, “Convert volume as a cube”, section 2. Optional online reading.

Turn to page 3 for question 4.

Choose and show why

15-20 minutes, then begin practice

4. A plastic sample has density 2.4 g/cm³. Which value is the same density in kg/m³? Choose a letter. Show how 2.4 g and 1 cm³ convert before you divide.

A. 2.4 kg/m³

B. 2400 kg/m³

C. 0.0024 kg/m³

D. 2 400 000 kg/m³

2.4 g = kg

1 cm³ = m³

Working and chosen letter:

Stop for check 2. Wait for your teacher before moving on.

Try again B

Only if your teacher asks. Complete this instead of questions 9-10, then answer questions 5-8.

Help: Use “Convert volume as a cube” on page 2. Convert the numerator (mass) and denominator (volume). A cubic centimetre becomes a millionth of a cubic metre.

Convert 1.6 g/cm³ to kg/m³. Show the conversion of 1.6 g and of 1 cm³ before you divide.

Practice - start at 20 minutes

A salvage workshop checks metal parts and a cooling liquid. Questions 5-10 each refer to a separate sample.

5. A technician compares the mass per unit volume of two metal samples. Name this physical quantity.

6. A sample has mass 54.0 g and volume 20.0 cm³. Calculate its density in g/cm³.

Working:

Density = g/cm³

7. A replacement insert has density 2.70 g/cm³ and volume 35.0 cm³. Calculate its mass.

Equation and working:

Mass = g

Continue with questions 8-11 on page 4.

Choose the units and equation

20-33 minutes

8. A sample has mass 121.5 g and density 2.70 g/cm³. Calculate its volume.

Equation and working:

Volume = cm³

9. A small part occupies 6.0 cm³. Convert its volume to m³.

Working:

Volume = m³

10. A sample has density 2.70 g/cm³. Convert this to kg/m³. Show the mass and volume conversions.

2.70 g = kg; 1 cm³ = m³

Working:

Density = kg/m³

Pause for an independent check - about 30 minutes

11. A moulded part has density 1200 kg/m³ and volume 25 cm³. Calculate its mass in kg. Show the volume conversion and state the equation you use.

Volume = m³

Equation and substitution:

Mass = kg

Stop for check 3. Wait for your teacher before moving on.

Try again C

Only if your teacher asks. Complete this instead of questions 15-16. Then complete questions 12-14 and 17-21.

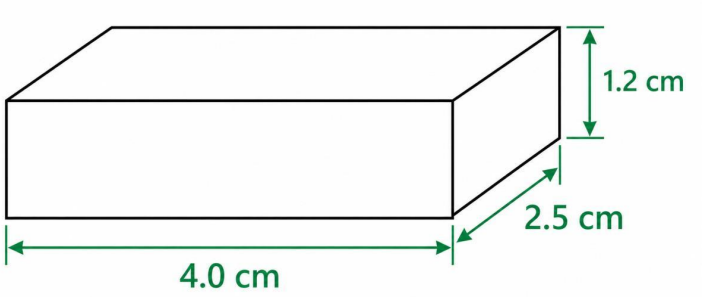
Help: For mass, use m = density × volume. The density is in kg/m³, so convert the volume to m³ before multiplying. Use the cubic conversion row on page 2.

A component has density 1500 kg/m³ and volume 40 cm³. Calculate its mass in kg. Write the volume in m³, choose the mass equation and show the substitution.

Continue with the cuboid on page 5.

Compare solid samples

33-45 minutes



Uniform solid cuboid: mass 106.8 g. The drawing is not to scale. Use the labelled dimensions.

Material	Steel	Aluminium	Copper
Supplied density / g/cm³	7.8	2.7	8.9

12. Use the three perpendicular dimensions in the diagram to calculate the cuboid's volume in cm³.

Working:

Volume = cm³

13. Calculate the density of the 106.8 g cuboid in g/cm³.

Working:

Density = g/cm³

14. Use the material table to identify the material most consistent with the cuboid's density. Explain why density alone does not prove its identity.

15. A smaller piece cut from the same cuboid has mass 26.7 g and volume 3.0 cm³. Calculate its density.

Working:

Density = g/cm³

16. The uniform solid cuboid is cut into two equal-volume pieces without losing material. Explain why each piece has the original density.

Continue with the liquid batches on page 6.

Check two liquid batches

Finish practice, then review at 45 minutes

Both batches are at the same temperature. The acceptance range is 1030-1090 kg/m³, including both endpoints. This checks density only.

Batch	Empty cylinder / g	Cylinder + liquid / g	Liquid volume / cm³
A	64.0	140.0	80.0
B	64.0	149.6	80.0

17. Use the liquid table to calculate the mass of liquid in batch A, excluding the cylinder.

Working:

Liquid mass = g

18. Calculate the density of batch A in g/cm³.

Working:

Density = g/cm³

19. Convert the density of batch A to kg/m³.

Conversion and density = kg/m³

20. Use the liquid table to calculate the density of batch B in g/cm³.

Liquid mass and working:

Density = g/cm³

21. Which batch passes the density check? Compare BOTH batches with the inclusive acceptance range 1030-1090 kg/m³.

Check and improve - 45-55 minutes

22. When your teacher gives the practice answers, correct them in a different colour. Choose one correction: write your first answer, the corrected method and why it works. If all answers were correct, explain why a smaller piece of the same uniform material has the same density.

At 55 minutes, cover the earlier pages and turn to page 7.

Show what you can do

55-60 minutes

Work independently. Cover the reading and previous answers. Show working and units.

23. A uniform solid test piece has mass 96 g and volume 12 cm³. (a) Calculate its density in g/cm³ and in kg/m³. (b) It is cut into two equal pieces without losing material or changing temperature. Explain what happens to the density of each piece. Use mass and volume in your reason.

(a) Density working:

Density = g/cm³ = kg/m³

(b) Mass of each half = g; volume = cm³

Density of each half = g/cm³

Reason:

Stop for check 4. Wait for your teacher before moving on.

Write your name on page 1. Hand in the whole booklet, including working and corrections.

Try again D - next lesson

Leave this today. Your usual teacher may ask you to do it next lesson.

Help: Next lesson, revisit the conversion rows and “Same material, different size” on page 2. Then cover the reading before answering.

Next lesson: a uniform sample has mass 72 g and volume 30 cm³. Calculate its density in g/cm³ and kg/m³. One quarter of the sample is cut off without losing material or changing temperature. Explain whether the density of that piece changes.

Hand your booklet to your teacher.