Student maths skills worksheet

Name ..... **Class** ..... **Date** .....

Density calculations

Aims

In this sheet, you will work through two worked examples designed to allow you to improve your maths skills. The focus is on solving algebraic equations, by substituting numbers into the equation and rearranging if needed. The algebraic equation is the formula for density.

Learning outcomes

After completing this activity, you should be able to:

- determine the volume of rectangular shapes
- convert between g and kg
- convert between litres, millilitres and cm^3
- apply the relationship between density, mass, and volume
- substitute numerical values into algebraic equations using appropriate units
- solve algebraic equations.

Worked examples

1 A student pours out 1 litre of a liquid and finds its mass is 0.7 kg. Calculate the density of the liquid.

Step 1: Write down what you know

Volume = 1 litre, Mass = 0.7 kg, density = ?

Step 2: Convert your units (either into g and cm^3 or kg and m^3)

Volume = 1 litre = 1000 ml (1 litre = 1000 ml)

Volume = 1000 cm^3 (1 ml = 1 cm^3)

Mass = 0.7 kg = 700 g (1 kg = 1000 g)

Step 3: Write the numbers into the equation and calculate

$$\text{Density } (g/cm^3) = \frac{\text{mass (g)}}{\text{volume } (cm^3)} = \frac{700}{1000} = 0.7\ g/cm^3$$

Student maths skills worksheet

Name ..... **Class** ..... **Date** .....

2 A block of wood has a density of 0.8 g/cm^3. The block measures 30 cm × 10 cm × 10 cm. Calculate the mass of the block of wood in kg.

Step 1: Write down what you know

Density = 0.8 g/cm^3, length = 30 cm, depth = 10 cm, height = 10 cm, mass = ?

Step 2: Convert your units (either into g and cm^3 or kg and m^3)

Not needed but you do need to find volume in this question.

Step 3: Calculate the volume

Volume = 30 × 10 × 10 = 3000 cm^3 (volume = length × depth × height)

Step 4: Write the numbers into the equation

$$\text{Density } (\text{g/cm}^3) = \frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}}$$

$$0.8 = \frac{\text{mass}}{3000}$$

This time the question wants you to calculate the mass. Mass is not the subject of the formula.

Step 5: Rearrange the equation so that mass is the subject of the formula

Multiply both sides of the equation by 3000

0.8 × 3000 = mass

2400 g = mass

Mass in kg = 2.4 kg (1 kg = 1000 g)

Questions

1 Convert the following to cm^3

a 100 ml

..... (*1 mark*)

b 2 litres

..... (*1 mark*)

Student maths skills worksheet

Name ..... **Class** ..... **Date** .....

2 A tennis ball has a volume of 150 cm^3 and mass of 58 g. Calculate the density of the tennis ball. State the units.

.....

..... (*3 marks*)

3 An ice cube has the dimensions 3 cm × 2 cm × 2 cm. The mass of the ice cube is 10.8 g. Calculate the density of ice.

.....

.....

..... (*3 marks*)

4 A miner finds a sample of rock and is convinced it contains gold. He looks up the density of gold and discovers gold has a density of 19 g/cm^3, whilst 'fool's gold' has a density of 5 g/cm^3. The mass of his sample is 5.5 kg and the volume of water displaced by it is 300 cm^3.

a Calculate the density of the sample in g/cm^3.

.....

..... (*2 marks*)

b Discuss whether you think the miner had found gold or fool's gold. Explain your answer.

.....

..... (*2 marks*)

5 Molten iron has a density of 7.0 g/cm^3. In its solid state, iron has a density of 8.0 g/cm^3.

a Calculate the volume of 10 kg of molten iron.

.....

..... (*3 marks*)

b Calculate the volume of 10 kg of solid iron.

.....

..... (*3 marks*)

Student maths skills worksheet

Name ..... **Class** ..... **Date** .....

c Molten iron fills a mould, which has a volume of 200 cm^3. Calculate the volume when the iron cools and solidifies.

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..... (*2 marks*)

6 A fish tank with mass 1.0 kg is placed on a shelf. The dimensions are 37 cm × 15 cm × 28 cm. The shelf can hold a mass of 16 kg and the density of the water inside it is 1.0 g/cm^3.

a Calculate the maximum volume of water the fish tank can contain.

..... (*1 mark*)

b Determine whether the shelf is strong enough for the fish tank when it is full of water. Explain your answer

.....

.....

..... (*3 marks*)

7 A hollow plastic ball has volume of 250 cm^3 and a mass of 150 g. To float, the ball must have a density less than 1.0 g/cm^3.

a Calculate the density of the ball.

..... (*1 mark*)

b The ball is floating in water, but it has a small hole and is slowly filling with water. Calculate how much water will flow into it before it sinks.

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..... (*3 marks*)

Student maths skills worksheet

Name ..... **Class** ..... **Date** .....

Velocity and acceleration graphs

Aims

This is an activity to ensure you display confident maths skills. In this activity you will interpret distance–time and velocity–time graphs. You will calculate velocity, acceleration, and distance travelled. The first section provides a step-by-step worked example. Then it will be time for you to have a go yourself. There is a series of questions for you to practise and the first ones will be similar to the worked solution.

Learning outcomes

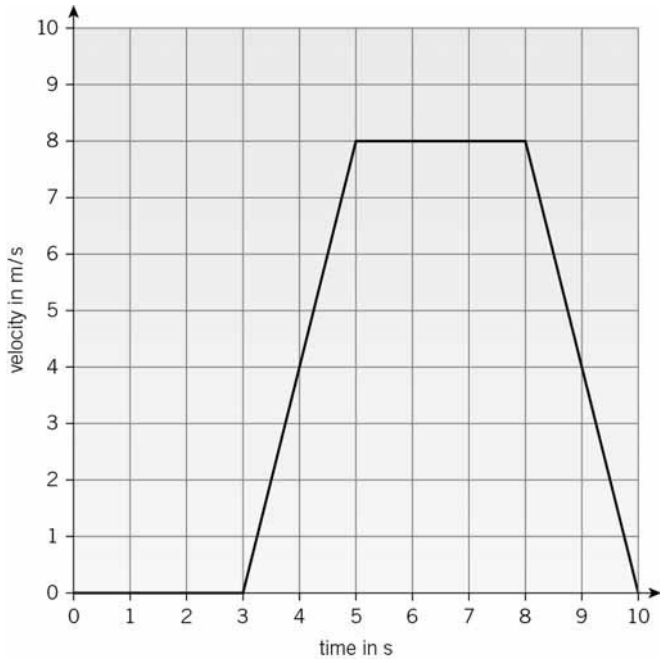
After completing this worksheet, you should be able to:

- interpret distance–time and velocity–time graphs to work out if an object is accelerating, decelerating, or moving at a constant velocity
- calculate the acceleration of an object by determining the gradient of the velocity–time graph
- calculate the area under a velocity–time graph to determine the distance travelled
- HT only – calculate unknowns using the equation $v^2 - u^2 = 2as$.

Student maths skills worksheet

Name ..... **Class** ..... **Date** .....

Worked example



Look at the velocity–time graph above for a fish's journey.

i Calculate the velocity of the fish in the first 3 seconds.

ii Calculate the acceleration of the fish between 3 and 5 seconds.

iii What is the velocity of the fish between 5 and 8 seconds?

iv How far did the fish travel between 0–10 seconds?

i It is apparent from the graph that the fish has zero velocity in the first 3 seconds, that is, it is stationary. $v = 0$ m/s.

ii To calculate the acceleration of the fish between 3 and 5 seconds it is necessary to determine the gradient of line. In other words, the change in velocity divided by the time taken. In this case: $a = \frac{8}{2} = 4$ m/s^2.

iii Look at the graph. You will see it is at constant velocity (shown by the horizontal line). So the velocity of the fish between 5 and 8 seconds is 8 m/s.

iv To work out how far the fish travelled between 0 and 10 seconds you need to know the area under graph. Divide the trapezium into 2 triangles (3–5 s and 8–10 s) and a rectangle from 5–8 seconds.

Area under rectangle $= 3 \times 8 = 24$ m

Area under the two triangles (they are identical) $= 2 \times (\frac{1}{2} \times 2 \times 8) = 16$ m

Total area $= 24 + 16 = 40$ m.

Student maths skills worksheet

Name ..... **Class** ..... **Date** .....

Questions

1 **a** A car travels 1800 m in 60 seconds. What is its speed?

.....

..... (*2 marks*)

b The car travelled at a constant speed throughout its journey. How far will this car travel in 300 seconds?

.....

..... (*2 marks*)

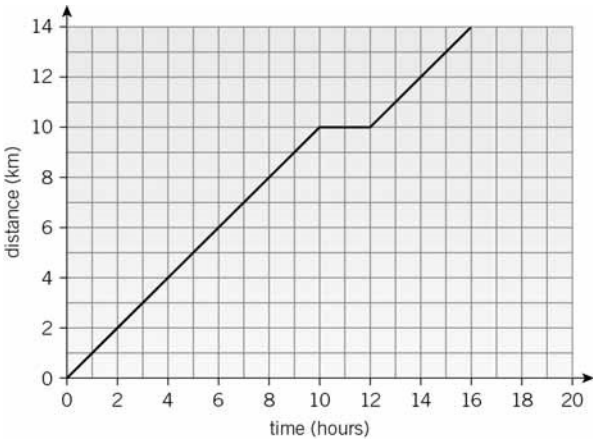
c If we plotted this journey on a distance–time graph, sketch the expected graph.

(*1 mark*)

d If we plotted this journey as a velocity–time graph, sketch the expected graph.

(*1 mark*)

2 Look at the graph.



Student maths skills worksheet

Name ..... **Class** ..... **Date** .....

a Describe the journey shown in as much detail as you can.

.....

..... (*3 marks*)

b What is the velocity at 6 hours?

.....

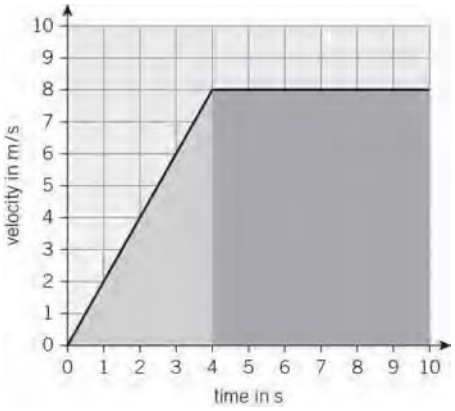
..... (*1 mark*)

c What is the overall distance of the journey?

.....

..... (*1 mark*)

3 Look at the graph.



a Describe the journey shown in as much detail as you can.

.....

..... (*2 marks*)

b What is the velocity at 6 seconds?

..... (*1 mark*)

c What is the acceleration between 0 and 4 seconds?

.....

..... (*2 marks*)

Student maths skills worksheet

Name ..... **Class** ..... **Date** .....

d What is the overall distance of the journey?

.....

.....

..... (*2 marks*)

HT questions

4 **a** A lorry travels 3600 m on a test track accelerating constantly at 3 m/s^2 from standstill. What is its final velocity (to 3 sig fig)?

.....

.....

..... (*2 marks*)

b A car accelerates with a constant acceleration of 5 m/s^2 from 3 m/s to 30 m/s. How far does it travel?

.....

.....

..... (*2 marks*)

5 A ball is thrown vertically upwards and reaches a height of 28.8 m. Ignore air resistance and take acceleration due to gravity as 10 m/s^2. Note that the ball comes to rest momentarily at the peak of its flight path.

Find the initial upwards velocity.

.....

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.....

..... (*6 marks*)

Student maths skills worksheet

Name ..... Class ..... Date .....

Electricity calculations

Aims

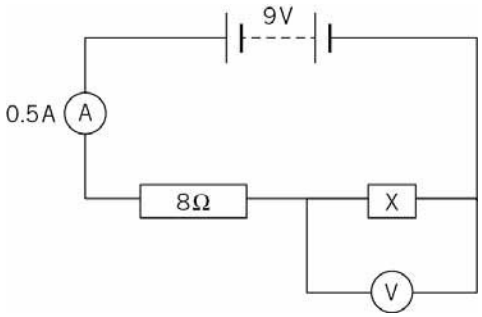
In this worksheet you will learn how to calculate resistance in series and parallel circuits. You will rearrange formulae to find unknowns and calculate resistance, potential difference, and current.

Learning outcomes

After completing this worksheet, you should be able to:

- calculate resistance, potential difference, and current in series circuits, potential difference, and current
- rearrange the equations to find unknowns and calculate potential difference
- recognise that components in parallel always have a lower resistance than in series and be able to explain why.

Worked example



a Calculate the potential difference across the 8 Ω resistor.

b Calculate the voltage over resistor X and its resistance.

Step 1:

a The resistor of 8 Ω has 0.5 A going to it, so use the following equations:

$V = I \times R$

$I = 0.5\ A$

$R = 8\ \Omega$

$V = 0.5 \times 8 = 4\ V$

Student maths skills worksheet

Name ..... **Class** ..... **Date** .....

Step 2:

b There are 9 volts being supplied to the circuit so the potential difference over X is what remains after the 4 volts are used over the 8 Ω component:

9 – 4 = 5 volts are dropped over X

Step 3:

X receives 5 volts and 0.5 amps

$V = I \times R$ so rearranging to give $R = \frac{V}{I}$

$R = \frac{5}{0.5} = 10\ \Omega$

Alternatively, Total $R = \frac{\text{Total } V}{\text{Total } I} = \frac{9}{0.5} = 18$

Total resistance in series $R_{total} = R_1 + R_2$

$R_{total} = 8 + X$

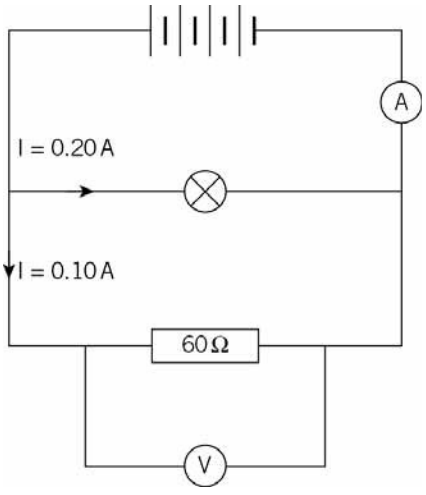
$18 = 8 + X$

$18 - 8 = X$

So resistance over X = 10 Ω

Questions

1 A circuit was set up as shown in the diagram.



Each cell provides a potential difference of 1.5 volts.

a What is the total potential difference provided by the four cells in the circuit?

..... (*1 mark*)

Student maths skills worksheet

Name ..... **Class** ..... **Date** .....

b What potential difference is dropped over the 60 Ω resistor?

..... (*1 mark*)

c What is the current reading on the ammeter A?

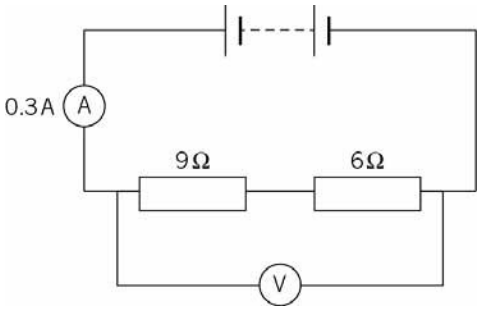
..... (*1 mark*)

d What is the resistance of the bulb?

.....

..... (*2 marks*)

2



a Calculate the total resistance in this series circuit.

.....

..... (*1 mark*)

b Calculate the potential difference in the circuit.

.....

..... (*1 mark*)

3 The resistance of a 24 W, 12 V filament lamp depends on the current flowing through the lamp. For currents up to 0.8 A, the resistance has a constant value of 2.5 Ω.

Use the equation that relates potential difference to resistance and current to calculate the potential difference across the lamp when a current of 0.8 A flows through the lamp.

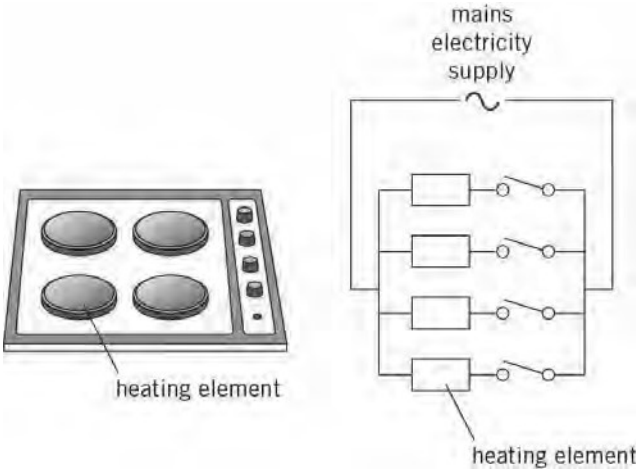
.....

..... (*1 mark*)

Student maths skills worksheet

Name ..... **Class** ..... **Date** .....

4 When all four heating elements are switched on at full power, the hob draws a current of 36 A from the 230 V mains electricity supply.



Calculate the resistance of one heating element when the hob is switched on at full power. Give your answer to 2 significant figures.

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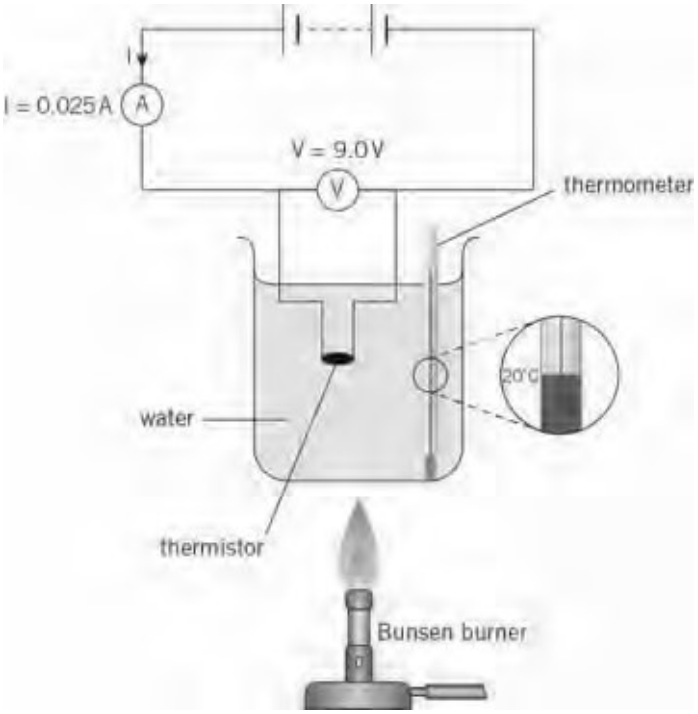
.....

.....

..... (*3 marks*)

5 An experiment to investigate how the resistance of a thermistor varies with temperature is shown below



Student maths skills worksheet

Name ..... **Class** ..... **Date** .....

a What is the resistance of the thermistor shown in this diagram?

.....

.....

..... (*3 marks*)

b As the temperature of the water increases, the resistance of the thermistor decreases. Draw a sketch graph of current vs. temperature for this thermistor. (*2 marks*)