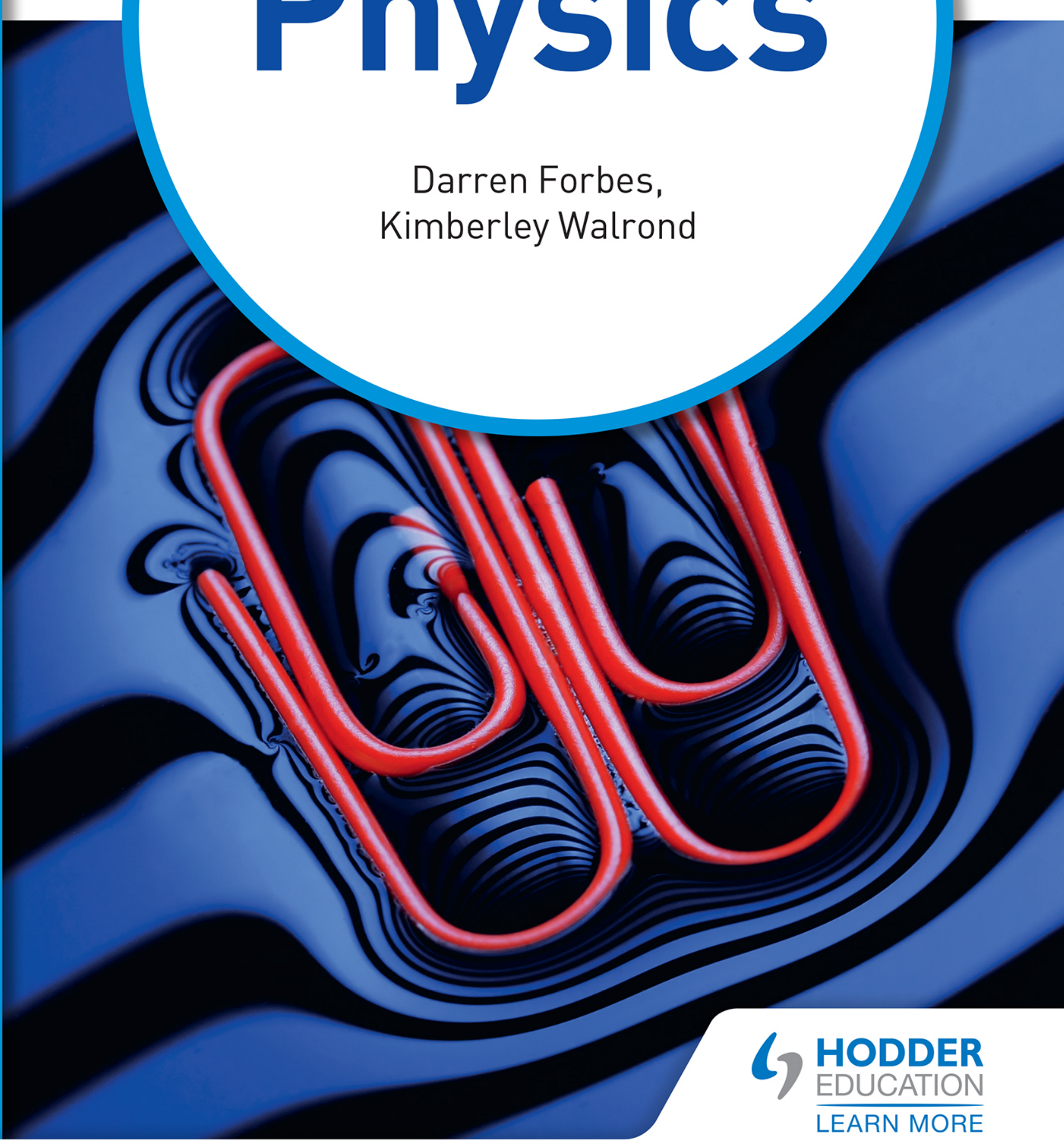
PRACTICE MAKES PERMANENT

350+ questions

AQA GCSE Physics

Darren Forbes,
Kimberley Walrond



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Introduction

Practice Makes Permanent is a series that advocates the benefits of answering lots and lots of questions. The more you practise, the more likely you are to remember key concepts; practice does make permanent. The aim is to provide you with a strong base of knowledge that you can automatically recall and apply when approaching more difficult ideas and contexts.

This book is designed to be a versatile resource that can be used in class, as homework, or as a revision tool. The questions may be used in assessments, as extra practice, or as part of a SLOP (i.e. Shed Loads of Practice) teaching approach.

How to use this book

This book is suitable for the AQA GCSE Physics course, both at Higher and Foundation levels. It covers all the content that you will be expected to know for the final examination.

The content is arranged topic-by-topic in the order of the AQA specification, so areas can be practised as needed. Within each topic there are:

- **Quick questions** – short questions designed to introduce the topic.
- **Exam-style questions** – questions that replicate the types, wording and structure of real exam questions, but highly-targeted to each specification point.
- **Topic reviews** – sections of exam-style questions that test content from across the entirety of each topic more synoptically.

These topic questions are tagged with the following:

p64	page references for the accompanying Hodder Education Student Book: AQA GCSE 9–1 Physics, 9781471851377. This can be revisited before or after attempting the questions in a topic.
4.1.1.1	the AQA specification reference, which can be used if you want to practise specific areas.
H	indicates Higher-only content.
MS 3b	indicates where questions test Maths skills.
QWC	indicates where answers will also be marked on the quality of written communication.
WS 4.1	indicates where questions require you to work scientifically.
AT 1	indicates where questions ask you to use practical knowledge of apparatus and techniques.
RP 1	indicates where questions test understanding of required practicals.

At the end of the book there is a full set of **practice exam papers**. These have been carefully assembled to resemble typical AQA question papers in terms of coverage, marks and skills tested. We have also constructed each one to represent the typical range of demand in the GCSE Physics specification as closely as possible.

Full worked **answers** are included at the end of the book for quick reference, with awarded marks indicated where appropriate.

Equation sheet

(final velocity)^2 – (initial velocity)^2 = 2 × acceleration × distance	$v^2 - u^2 = 2as$
elastic potential energy = 0.5 × spring constant × (extension)^2	$E_e = \frac{1}{2} ke^2$
change in thermal energy = mass × specific heat capacity × temperature change	$\Delta E = mc\Delta\theta$
period = $\frac{1}{\text{frequency}}$	
magnification = $\frac{\text{image height}}{\text{object height}}$	
thermal energy for a change of state = mass × specific latent heat	$E = mL$
For gases: pressure × volume = constant	pV = constant

Higher-only equations

pressure due to a column of liquid = height of column × density of liquid × gravitational field strength (g)	$p = h\rho g$
force = $\frac{\text{change in momentum}}{\text{time taken}}$	$F = \frac{m\Delta v}{\Delta t}$
force on a conductor (at right angles to a magnetic field) carrying a current = magnetic flux density × current × length	$F = BI\ell$
$\frac{\text{potential difference across primary coil}}{\text{potential difference across secondary coil}} = \frac{\text{number of turns in primary coil}}{\text{number of turns in secondary coil}}$	$\frac{V_p}{V_s} = \frac{n_p}{n_s}$
potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil	$V_p I_p = V_s I_s$

1 Energy

Energy changes in a system

Quick questions

p2 | 4.1.1.1 | WS4.1

1 What does the term 'system' mean in physics?

p3 | 4.1.1.1 | WS4.1

2 Describe how to increase the energy in:

- the kinetic energy store of a car
- the thermal energy store of a potato.

p2 | 4.1.1.1

3 What are the energy changes in energy stores when a candle is used to heat a beaker of water?

p64 | 4.1.1.2 | MS3b,3c | WS4.1-4.3

4 Write down the correct SI unit for each of these quantities used in energy calculations.

mass	distance (or extension)	energy
speed (or velocity)	gravitational field strength	spring constant

p5 | 4.1.1.2 | MS3b,3c

5 Write down the equation that can be used to find the amount of energy in a kinetic store.

p5 | 4.1.1.2 | MS3b,3c

6 Calculate the kinetic energy for cars A and B shown in **Figure 1**.

Figure 1

p5 | 4.1.1.2 | MS3b,3c

7 A large spring used in the suspension system of a lorry has a spring constant of 200 kN/m. Calculate the elastic potential energy stored in the spring when it is compressed by 4.0 cm.

p12 | 4.1.1.3 | WS4.1

8 Some materials are more difficult to heat than others because they have higher specific heat capacities. Give the definition of specific heat capacity.

p12 | 4.1.1.3 | MS3b,3c

9 A bottle of cold water is taken out of a refrigerator and is left in a warm room. The bottle contains 0.25 kg of water and warms from 5 °C to 20 °C. The specific heat capacity of water is 4200 J/kg °C.

Use the equation

change in thermal energy = mass × specific heat capacity × temperature change

to calculate the change in the thermal energy store of the bottle of water.

p10 4.1.1.4 WS4.1 **10** Define the term 'power' in terms of energy transferred.

p10 4.1.1.4 MS3b,3c **11** The engine driving a fairground ride provides 42 kJ in one minute. What is the power rating of the engine?

p10 4.1.1.4 MS3b,3c **12** A weightlifter can lift a weight of 1700 N to a height of 2.0 m by doing 3400 J of work in 2.2 s. Calculate the effective power of the weightlifter during the lift.

p10 4.1.1.4 MS3b,3c **13** How much energy is transferred by an electric motor with a power rating of 250 W if it operates for one hour?

p10 4.1.1.4 MS3b,3c **14** Calculate the time it will take for a heating element with a power rating of 75 W to transfer 3.6 kJ of energy.

Exam-style questions

15 A motorcycle and rider have a mass of 300 kg and are travelling at 4.0 m/s.

p5 4.1.1.2 MS3b, 3c,3d **15–1** Calculate the kinetic energy stored by the motorcycle and rider. *[3]*

p5 4.1.1.2 **15–2** What would happen to the amount of energy in the kinetic store if the speed of the motorcycle doubled? *[1]*

p2 4.1.1.1 WS4.1 **15–3** The motorcycle leaves a motorway and travels up a slope to a junction. The motorcycle slows down without braking.

Describe the energy changes that take place while the motorcycle is slowing down. *[2]*

Total: 6

16 The equation used to calculate the amount of energy stored in a stretched spring is:

elastic potential energy = 0.5 × spring constant × $(\text{extension})^2$

p5 4.1.1.2 WS4.1 **16–1** Define the 'extension of a spring'. *[1]*

p5 4.1.1.2 **16–2** A spring with a high spring constant and a spring with a low spring constant are stretched by the same length.

Compare the amount of energy stored by the two springs. *[1]*

p5 4.1.1.2 MS3a, 3c,3d **16–3** The spring used in a suspension system for a car has a spring constant of 5000 N/m and is compressed by 5.0 cm.

Calculate the energy stored in the spring. *[2]*

p2 4.1.1.1 WS4.1 **16–4** The spring is repeatedly compressed and stretched as the car travels.

Explain why the spring becomes hot. *[2]*

Total: 6

p6 4.1.1.2 **17–1** Write the equation which can be used to calculate the amount of gravitational potential energy stored in a system. *[1]*

p6 4.1.1.2 MS3a, 3c,3d **17–2** An astronaut in training climbs a ladder on a landing module while on Earth. The total mass of the astronaut and their suit is 120 kg. He climbs a vertical distance of 2.3 m.

The gravitational field strength near the Earth's surface is 9.8 N/kg.

Calculate the change in gravitational potential energy of the astronaut as he climbs the ladder. *[2]*

p6 | 4.1.1.2 | MS3a, 3c,3d

17–3 The gravitational field strength on the Moon is 1.6 N/kg. The astronaut again climbs the ladder to a vertical height of 2.3 m to get back into the landing module after exploring the Moon's surface.

Calculate the change in gravitational potential energy as the astronaut climbs the ladder. *[2]*

p7 | 4.1.1.2 | MS3b

17–4 The astronaut falls from the top of the ladder.

Compare the speed at which the astronaut will hit the ground on the Moon to the speed at which they would hit the ground on Earth. Show working to explain your answer. *[3]*

Total: 8

18 A toy rocket launcher uses a compressed spring to launch a small plastic rocket of mass 0.15 kg vertically.

The spring has a spring constant of 50 N/m and is compressed by 4.0 cm.

p2 | 4.1.1.1 | WS4.1

18–1 Describe the energy changes from when the rocket is launched until it reaches its maximum height. *[2]*

p6 | 4.1.1.2 | MS3a,3c

18–2 Calculate how much energy is stored elastically in the spring when it is fully compressed. *[2]*

p6 | 4.1.1.2

18–3 Write down the amount of energy stored kinetically by the rocket just after it has been launched. *[1]*

p6 | 4.1.1.2

18–4 Explain your answer to question 18–3. *[1]*

p6 | 4.1.1.2 | MS3a-d

18–5 Calculate the maximum speed at which the rocket will leave the launcher. *[4]*

p6 | 4.1.1.2 | MS3a-d

18–6 Calculate the maximum possible height the rocket can reach. *[3]*

Total: 13

19 A group of students tested the principle of conservation of energy by allowing toy cars to roll down a ramp, as shown in **Figure 2**. The mass of each car was 0.12 kg and the gravitational field strength was 9.8 N/kg.

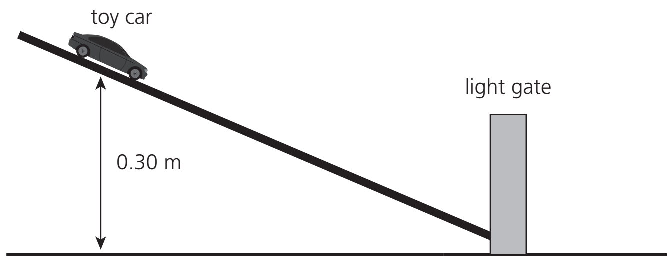


Figure 2

Each car was released from a vertical height of 0.30 m and rolled freely down the ramp until it passed through a light gate at the bottom of the ramp which measured its speed. The students repeated this several times and found that the average speed was 2.31 m/s.

p2 | 4.1.1.1

19–1 Describe the energy changes as the car travels down the ramp. *[2]*

p6 4.1.1.2 MS3a, 3b,3d **19–2** Calculate the gravitational potential energy of the car before it is released. *[2]*

p6 4.1.1.2 **19–3** State the maximum kinetic energy of the car as it passes through the light gate. *[1]*

p7 4.1.1.2 MS3a-d **19–4** Calculate the maximum speed at which the car can be travelling as it passes through the light gate. *[4]*

p7 4.1.1.2 MS3a-d **19–5** Suggest why the speed that the students measured was less than the speed you calculated in question 19–4. *[1]*

Total: 10

p12 4.1.1.3 **20** Some students are attempting to find the specific heat capacity of copper.

- The students warm a small copper block with a mass of 0.10 kg in a water bath until its temperature reaches 80 °C.
- They place the block into a well-insulated beaker containing 0.20 kg of water.
- The metal block cools down as it heats up the water.
- The students gently stir the water until the block and water reach the same temperature.
- The students measured the initial and final temperature of the water.

The initial temperature of the water was 25.0 °C.

The final temperature of water was 27.3 °C.

The specific heat capacity of water is 4200 J/kg °C.

change in thermal energy = mass × specific heat capacity × temperature change

MS3a, 3b,3d RP1 **20–1** Calculate the energy transferred to the water using the equation above. *[3]*

MS3a, 3c,3d **20–2** Calculate the decrease in temperature of the copper block. *[1]*

20–3 Write down the thermal energy change for the block of copper. *[1]*

MS3a-d **20–4** Calculate the specific heat capacity of copper. *[3]*

20–5 Explain why the beaker of water needed to be well insulated in the experiment. *[1]*

Total: 9

p10 4.1.1.4 **21** **Table 1** shows the results of an experiment to determine the power of some motors. The electric motors are used to lift different weights through different heights. The time taken to do this is recorded.

Motor	Weight lifted in N	Height lifted through in m	Time taken in s
A	45	3.0	21
B	35	2.7	14
C	104	1.4	32

Table 1

21–1 Identify which motor has done the most work during the experiment. *[1]*

21–2 Compare the power of each motor. State which was the most powerful motor. *[4]*

MS3a, 3c,3d **21–3** A fourth motor is tested. The motor has a power rating of 12 W.

Calculate the amount of work that this additional motor can do in 15 seconds. *[2]*

Total: 7

Conservation and dissipation of energy

Quick questions

p15 4.1.2.1 WS4.1 **1** What is the principle of conservation of energy?

p18 4.1.2.2 **2** Explain the difference between an efficient energy transfer and an inefficient energy transfer.

p19 4.1.2.2 **3** A microwave oven is used to heat a baked potato. The oven transfers 2.0 kJ of energy but the potato only gains 1.8 kJ.

How much energy is wasted? Explain where the wasted energy goes.

p18 4.1.2.2 **4** There are two equations which are used to calculate the efficiency of a system. The first is shown here. Write the other equation.

$$\text{efficiency} = \frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$$

p18 4.1.2.2 WS4.1 **5** Explain why it is not possible for the efficiency of a device to be greater than 1.

p19 4.1.2.2 MS3c,3d **6** Determine the efficiency of a lamp that has a power rating of 75 W but only produces 55 W of useful energy.

p20 4.1.2.1 WS1.4 **7** Describe how the efficiency of a mechanical motor can be improved.

p20 4.1.2.2 MS3b,3c **8** A bouncy ball of mass 54 g is dropped from a height of 1.00 m onto a hard surface. The ball bounces back up to a height of 0.93 m. Calculate the efficiency of the bounce.

p20 4.1.2.2 MS3b,3c **9** Use the efficiency relationships to complete **Table 2**.

Device	**Power input in W**	**Useful power output in W**	**Power wasted in W**	**Efficiency**
Loudspeaker	1.4	0.40		
LED light	4.0		1.0	
Fluorescent light	9.0		8.0	
Electric drill motor		1200		0.80

Table 2

Exam-style questions

10 The motor used in a lift is supplied with 25 kJ of energy. It does 22 kJ of useful work.

p19 4.1.2.2 MS3a, 3c,3d **10–1** Calculate the energy wasted by the motor. *[1]*

p19 4.1.2.2 MS3a, 3c,3d

10–2 Calculate the efficiency of the motor. [2]

p15 4.1.2.1

10–3 Describe where the wasted energy goes. [1]

p15 4.1.2.1

10–4 The two common ways of improving efficiency are lubrication and using thermal insulation. Suggest whether these methods would improve the efficiency of the lift motor. Explain your answer. [4]

Total: 7

11 A lamp is designed to produce infra-red radiation to heat a surface. The manufacturer states that the lamp has an efficiency of 0.94. It is provided with energy at a rate of 110 W.

p19 4.1.2.2 MS3a-d

11–1 Calculate the energy usefully transferred by the lamp per second. [2]

p15 4.1.2.1

11–2 Suggest how energy might be wasted by this device. [1]

p18 4.1.2.2 MS4.1

11–3 A student claims that the lamp might be considered to have an efficiency of 1.

Suggest why this claim might be considered to be true. [2]

p18 4.1.2.2

11–4 Explain why the efficiency of the lamp cannot be greater than 1. [1]

Total: 6

p17 4.1.2.1 RP2

12 A group of students conducted an experiment to test the effectiveness of a material as a thermal insulator. They investigated how effective different numbers of layers of expanded polystyrene sheets were at keeping water warm. The equipment they had available included a kettle, measuring cylinders, beakers, stopwatches, thermometers, elastic bands and thin sheets of expanded polystyrene.

AT1 QWC

12–1 Describe how the students could use this equipment to determine how the number of layers affects the effectiveness of the insulation provided. [6]

12–2 Name the independent variable in this experiment. [1]

12–3 Write down **two** other factors that the students should control to make this experiment a valid test. [2]

AT2

12–4 Describe how the students could reduce energy losses due to evaporation in this experiment. [1]

12–5 **Table 3** shows the results of the students' experiment. Explain what the results show about the effectiveness of polystyrene layers. [2]

Time in s	No layers of polystyrene	One layer of polystyrene	Two layers of polystyrene	Three layers of polystyrene
	Temperature in °C			
0	90	90	90	90
60	83	84	86	86
120	77	79	81	82
180	72	74	76	77
240	68	71	73	74
300	65	70	72	73

Table 3

Total: 12

p17 4.1.2.1 RP2

13 A group of students are testing which materials are the best insulators. They insulate a beaker containing 50 cm^3 of hot water using a single layer of a range of materials and measure the temperature change after 5 minutes. Each container has only one layer of insulating material.

The results are shown in **Table 4**.

	Temperature in °C			
	No insulation	**Cardboard**	**Polystyrene**	**Cotton wool**
Start	85	83	86	85
End	64	65	70	72

Table 4

MS3a, 3c,3d

13–1 Calculate the change in temperature for the four different containers. *[2]*

13–2 Name the material that was the best thermal insulator. *[1]*

13–3 Suggest **two** ways in which the students could improve the accuracy of the results. *[2]*

Total: 5

National and global energy reserves

Quick questions

p21 4.1.3 WS4.1

1 Explain what is meant by a non-renewable energy resource. List as many examples of this type of resource as you can.

p22 4.1.3 WS4.1

2 Explain what is meant by a renewable energy resource. List some examples.

p22 4.1.3

3 Is uranium a renewable or non-renewable resource?

p22 4.1.3

4 Explain why the waste produced in a nuclear power station is dangerous.

p24 4.1.3

5 Give **two** advantages and **two** disadvantages of using hydroelectric dams to generate electricity.

Exam-style questions

p21–2 4.1.3

6–1 Copy and complete **Table 5** to show some suggestions of how different non-renewable fuels are used as energy sources. *[3]*

Fuel	**Application**
	To power a motorcycle
	In a central heating system used to heat a house
Coal	

Table 5

WS4.1

Some energy resources are said to be reliable while others are unreliable.

6–2 Explain what 'reliable' means in this context. *[1]*

6–3 State an example of a reliable energy resource and explain why it is considered to be reliable. *[2]*

6–4 State an example of an unreliable energy resource and explain why it is considered to be unreliable. *[2]*

Total: 8

p22 4.1.3

7 The graph in **Figure 3** shows the energy demand in the UK over a period of one day. The lines show the typical demand for a day in winter and a day in summer.

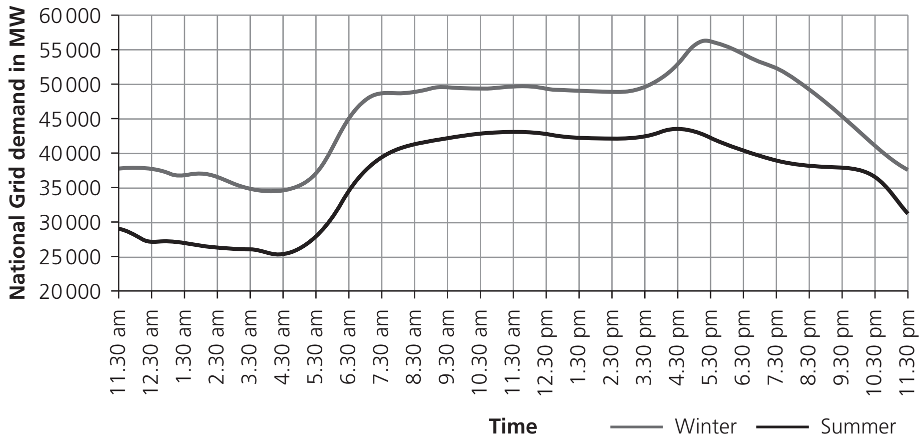


Figure 3

7–1 Explain why there is a difference between the demand during a day in summer and a day in winter. *[1]*

7–2 Suggest why the demand increases significantly between the hours of 5:30 am and 7:30 am. *[2]*

7–3 Suggest why there is a peak at around 5:30 pm. *[2]*

Total: 5

p21 4.1.3

8 Most cars use either petrol or diesel fuel which are extracted from crude oil. Some cars have been adapted to use biofuels which contain ethanol. This is produced by plant crops.

8–1 Explain why biofuels, such as ethanol, are sometimes described as 'carbon neutral'. *[2]*

8–2 Explain why the use of ethanol fuels has a smaller impact on climate change than using crude oil-based ones. *[2]*

WS1.4 8–3 Some people are concerned that an increase in the use of ethanol-based fuels will have an impact on food security and may also increase deforestation.

Suggest how this could happen. *[3]*

Total: 7

p22 4.1.3

9 The use of electric cars to replace fuel-burning cars is expected to increase rapidly over the next decade.

WS4.1 9–1 Describe how energy is stored in an electric car. *[1]*

9–2 Suggest how the use of electric cars may reduce pollution in cities. *[2]*

WS1.4 9–3 Predict the effect that the increase in electric cars will have on the need for new power stations in the UK. Give a reason for your answer. *[2]*

Total: 5

4.1.3 p23 QWC

10 The government want to build a new nuclear power station on the coast of the UK. Explain why some local residents might object to the construction while others support it. In your explanation you should mention scientific, economic and social considerations. [6]

Total: 6

Energy topic review

p12&18 4.1.1.2

1 A gas boiler is used to heat 50 kg of water from 25 °C to 34 °C. It transfers 2.5 MJ of energy when burning the gas. The specific heat capacity of water is 4200 J/kg °C.

MS3a, 3c,3d

1–1 Calculate the increase in the thermal energy store of the water. [3]

1–2 Calculate the efficiency of the gas boiler. [2]

1–3 Describe what happens to the energy that is not used to heat the water. [1]

Total: 6

p5&18 4.1.1.2 MS3a, 3c,3d

2 A model electric scooter of mass 42 kg accelerates from rest to a speed of 3.0 m/s in 4.5 s. The scooter is powered by a single electric motor with a power rating of 75 W.

2–1 Calculate the increase in the kinetic energy store of the scooter. [3]

2–2 Calculate the energy transferred by the motor during the 4.5 s. [2]

2–3 Calculate the efficiency of the electric motor. [2]

Total: 7

3 An experimental micro drone of mass 0.25 kg lifts off from the floor and reaches a height of 0.40 m. While doing this, the electric motor transfers 4.4 J of energy to the motor from the battery. Assume g = 9.8 m/s.

p6 4.1.1.2 MS3a, 3c,3d

3–1 Calculate the gain in gravitational potential energy of the micro drone. [3]

p18 4.1.2.2 MS3a, 3c,3d

3–2 Calculate the efficiency of the motor. [2]

p2 4.1.1.1

3–3 The motor fails and the drone falls back to the ground. Describe the energy transfers which take place during the fall. [2]

p6 4.1.1.2

3–4 Write down the change in kinetic energy as the drone falls. [1]

p7 4.1.1.2 MS3a-d

3–5 Calculate the speed at which the drone hits the floor. [4]

Total: 12

4 The remote island of Caprona uses various sources of renewable energy to produce electricity. During periods of low electricity demand, an electric pump in a hydroelectric storage system lifts 1000 kg of water through a vertical height of 50 m each second. To do this, the pump operates with a power of 600 kW.

p6 | 4.1.2 | MS3a, 3c,3d

4–1 Calculate the gain in gravitational potential energy per second of the water. Assume g = 9.8 m/s. *[2]*

p18 | 4.1.2.2 | MS3a, 3c,3d

4–2 Calculate the efficiency of the energy transfer. *[2]*

p15 | 4.1.2.2

4–3 Describe what has happened to the energy wasted by the motor. *[2]*

p6 | 4.1.2 | MS3a, 3c,3d

4–4 When there is a high demand for electricity the water is released and passed through a set of turbines. The water falls through a vertical height of 50 m and passes through the turbines at a rate of 5000 kg/s.

Calculate the maximum theoretical power output from the turbines. *[2]*

p18 | 4.1.2.2 | MS3a-d

4–5 The actual efficiency of the turbines and generators is 0.75.

Calculate the energy output per second from the system. *[2]*

Total: 10

5 A spring in a pinball machine is used to launch a ball of mass 80 g. The spring has a spring constant of 100 N/m and is compressed by 8.0 cm before launching the ball.

Specific heat capacity of the ball = 460 J/kg °C.

p5 | 4.1.2 | MS3a, 3c,3d

5–1 Calculate the elastic potential energy stored in the spring. *[2]*

p5 | 4.1.2

5–2 When the spring is released the ball is accelerated into the pinball machine.

State the maximum kinetic energy of the ball when it is launched. *[1]*

p7 | 4.1.2 | MS3a-d

5–3 Calculate the maximum speed of the ball as it is launched. *[3]*

p12 | 4.1.3

5–4 During the game, the ball is hit by flippers and its temperature increases. The thermal energy stored by the ball increases by 94 J.

Explain why the temperature of the ball increases. *[1]*

p12 | 4.1.3 | MS3a-d

5–5 Calculate the increase in temperature of the ball. *[3]*

Total: 10

6 The villagers of a remote Scottish island want to build wind turbines to generate their electricity. The economy of the island depends on tourism and its apple crop.

p24 | 4.1.3 | WS4.1 QWC

6–1 Discuss the advantages and disadvantages of using wind turbines in a remote location. *[6]*

p18 | 4.1.2.2 | MS3a, 3c,3d

6–2 A small scale model of a wind turbine is constructed to test its efficiency. The model produces an electricity output of 0.50 kW when the measured kinetic energy of the wind driving it is 6.00 kW.

Calculate the efficiency of the model wind turbine. *[2]*

Total: 8

2 Electricity

Current, potential difference and resistance

Quick questions

p38 4.2.1.1 WS4.1 **1** Draw and label the symbols for these components used in electrical circuits.

switch	diode	cell	LED	battery
LDR	lamp	resistor (fixed)	fuse	thermistor

p40–1 4.2.1.1 WS4.1 **2** Draw the symbols for the following three components, and describe what they are used for.

ammeter	voltmeter	variable resistor

p39 4.2.1.2 WS4.1 **3** What is an electric current? Describe what causes electric charges to move in a circuit.

p39 4.2.1.2 WS4.1 **4** Write the equation that links charge, current and time.

p39 4.2.1.2 MS3a **5** What can be said about the size of the current at any point in a single closed loop of a circuit?

p39 4.2.1.2 MS3b,3c **6** How much charge is transferred by a current of 3.2 A over a period of 30 s?

p39 4.2.1.2 MS3b,3c **7** Calculate how long it will take for a current of 620 mA to transfer a charge of 1.5 C.

p39 4.2.1.2 MS3b,3c **8** A typical lightning strike transfers a charge of 20 C in 0.42 ms. Calculate the size of the current in the lightning strike.

p40 4.2.1.2 MS1b, 3b,3c **9** The charge on a single electron is 1.6×10^{-19} C. Determine how many electrons need to pass a point in a wire each second to produce a current of 48 mA.

p39–41 4.2.1.3 WS4.1 **10** **Table 1** shows some quantities used in electrical calculations. Copy and complete the table.

Quantity	**Symbol used in equations**	**SI unit**	**Symbol for unit**
charge	Q	coulomb	C
electric current			A
potential difference			
resistance	R		

Table 1

MS3b,3c **11** Write the equation that links current, resistance and potential difference.

MS3b,3c **12** Calculate the potential difference needed to cause a current of 2.5 A through a resistance of 82 Ω.

MS3b,3c **13** What size current would a potential difference of 60 V cause in a resistor of 1.2 kΩ?

Exam-style questions

p41–2 4.2.1.3

14 An engineer is attempting to find the resistance of a fixed value resistor. She measures the current and potential difference three times while the circuit is operating. In between each test the engineer switched off the current. **Table 2** shows her results.

Potential difference in volts	1.75	1.73	1.73
Current in amperes	0.70	0.69	0.71

Table 2

WS1.2 **14–1** Draw a circuit which could be used to take these measurements. *[4]*

MS3a, 3c,3d **14–2** Use the data in the table to calculate the resistance of the resistor. *[3]*

14–3 The engineer then left the current on for five minutes. She measured the resistance to be 3.28 Ω.

Suggest a reason why this resistance measurement is significantly different from the original measurement. *[2]*

Total: 9

RP3 **15** A group of students were investigating how the resistance of a wire varies with its length. They set up a circuit as shown in **Figure 1** and obtained the results shown in **Table 3**.

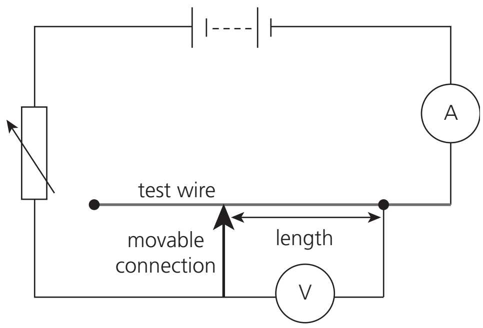


Figure 1

Length in cm	Resistance in Ω
20	4.12
25	5.14
30	6.19
35	7.20
40	8.24

Table 3

WS2.2 **15–1** Name the dependent variable in this investigation. *[1]*

WS2.2 **15–2** Name the independent variable. *[1]*

WS2.2 **15–3** Name **one** control variable. *[1]*

WS2.2 **15–4** Describe an experimental method which would allow the students to collect the data shown in the results table. *[4]*

WS3.1,3.2 MS4a,4c **15–5** Plot a graph of Resistance (y-axis) against Length of the wire (x-axis). *[3]*

WS3.2 **15–6** Explain what the graph shows about the relationship between the length of the wire and its resistance. *[2]*

WS3.2 **15–7** The students then tested a wire which had a greater resistance per centimetre than the original wire.

Compare the expected graph of Resistance against Length for this new wire with the graph you plotted in question 15–5. Describe any similarities and differences. *[2]*

Total: 14

p43 4.2.1.4

16 **Figure 2** shows the current–potential difference (*I–V*) characteristics for a filament lamp.

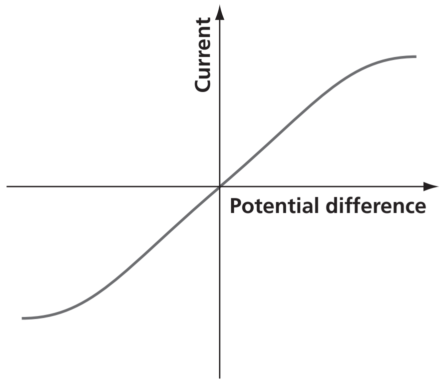


Figure 2

RP4 WS4.1 **16–1** Draw a circuit which could be used to collect the data needed to produce this graph. *[4]*

RP4 WS4.1 **16–2** Explain what this graph shows about the resistance of the filament lamp as the current through it increases. Explain the reason for this change. *[4]*

MS3a, 3c,3d **16–3** When the potential difference across the lamp is 2.5 V the current through it is 0.35 A.

Calculate the resistance of the lamp when the current through it is 0.35 A. *[1]*

16–4 Conductors can be described as being ohmic or non-ohmic.

Sketch the *I–V* characteristics of an ohmic conductor. *[2]*

WS4.1 **16–5** Give an example of an ohmic conductor. *[1]*

Total: 12

p44 4.2.1.4

17 A group of students investigated how the resistance of a thermistor is related to its temperature. They used the circuit shown in **Figure 3**. Their results are shown in **Table 4**.

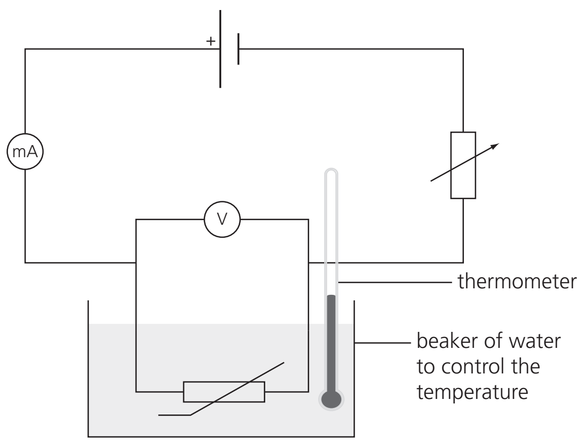


Figure 3

Temperature in °C	Resistance in Ω
10	1650
20	1300
34	1000
50	750
70	500
100	200

Table 4

WS2.3 AT1 **17–1** Name the instrument used to measure the temperature. Give the precision of the instrument. *[2]*

MS4a,4c WS3.2 **17–2** Plot a graph showing the relationship between the resistance of the thermistor and its temperature using the data from the table. Draw a line of best fit on your graph. *[4]*

WS3.1 **17–3** Describe the relationship between the resistance of the thermistor and its temperature. *[2]*

MS4a WS3.1 **17–4** Use the graph to determine the resistance of the thermistor when its temperature is 60 °C. *[1]*

17–5 Suggest a reason why the students did not continue to increase the temperature beyond 100 °C. *[1]*

Total: 10

p43 4.2.1.4

18 **Figure 4** shows the current and potential difference characteristics for a diode.

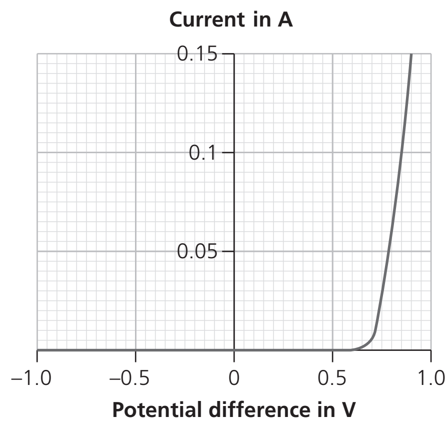


Figure 4

WS3.2 **18–1** Is the diode an ohmic or non-ohmic conductor. Explain your answer. *[2]*

MS4a **18–2** At what potential difference does the diode begin to conduct? *[1]*

MS3a, 3c,3d **18–3** Describe the resistance of the diode and the current through it when there is a potential difference of –0.5 V acting across it. *[2]*

4.2.1.3 MS4a,3a, 3c,3d **18–4** Use the graph to determine the resistance of the diode when there is a current of 0.1 A through it. *[4]*

Total: 9

19 A student constructs a circuit containing a diode, a resistor and a lamp as shown in **Figure 5**.

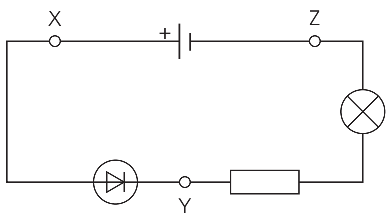


Figure 5

The cell provides a potential difference of 1.5 V and the current at point X in the circuit is 250 mA.

p43 4.2.1.4 **19–1** Write down the size of the current at point Z in the circuit. *[1]*

p43 4.2.1.4 MS3a, 3c,3d **19–2** Calculate the total resistance of the circuit. *[2]*

p39 4.2.1.2 MS3a-d **19–3** The circuit is left to operate for 25 seconds.

Calculate the amount of charge which passes through the resistor in this time. *[2]*

p39 4.2.1.2 MS3a, 3c,3d **19–4** The charge on a single electron is 1.6×10^{-19} C.

Calculate the number of electrons which pass through the diode in the 25 seconds. *[2]*

p43 4.2.1.4 **19–5** The student then reversed the direction of the diode in the circuit.

Describe what happens to the size of the current in the circuit. Explain your answer. *[2]*

Total: 9

Series and parallel circuits

Quick questions

p46 4.2.2 WS4.1 **1** Sketch a circuit showing a battery powering two lamps connected in series.

p47 4.2.2 WS4.1 **2** Sketch a circuit showing a battery powering two lamps connected in parallel.

p46–7 4.2.2 WS4.1 **3** The following set of rules applies to the components in a series circuit (S), parallel circuit (P) or both (B). Write the correct letter next to each of the statements. The first one has been done for you.

Letter	Statement
S	The current is the same through all of the components.
	The current through the components is smaller than the current from the power supply.
	There are no branches in the circuit.
	The total potential difference of the power supply is shared between the components.
	There are branches where the current can travel different routes.
	The total resistance is the sum of the individual resistances of the components.
	The total resistance is less than the largest individual resistance of the components.
	The total power output is the same as the power output of the individual components.

p47 4.2.2 WS4.1 MS1c, 3b-d **4** Determine the total resistance between points X and Y for the combination of resistors shown in **Figure 6**.

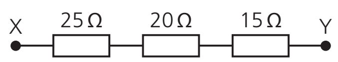


Figure 6

p41&47 4.2.2 MS3b-d **5** Determine the current that would pass through the resistors in **Figure 6**, if they were connected to a 6.0 V power supply.

Exam-style questions

p44 &47 | 4.2.1.& 4.2.2

6 **Figure 7** shows a light dependent resistor connected in series with a resistor.

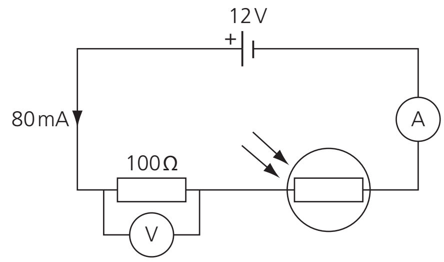


Figure 7

MS3a, 3c,3d

6–1 Calculate the total resistance of the circuit. *[3]*

MS3a, 3c,3d

6–2 Calculate the resistance of the LDR at the current light settings. *[2]*

6–3 Describe what happens to the resistance and current in the circuit when the light level increases. *[3]*

Total: 8

7 **Figure 8** shows a circuit which is used to test the operation of small light bulbs. A bulb with resistance 20 Ω is placed in the circuit and the switch is closed. If the bulb is operating correctly it will light up.

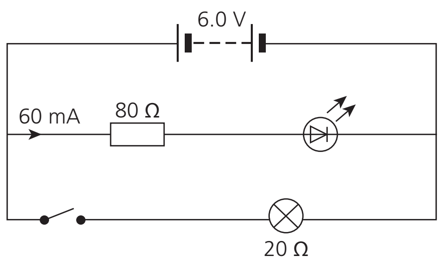


Figure 8

p41 &48 | 4.2.1.& 4.2.2 | MS3b-d

7–1 Calculate the current through the bulb. *[2]*

p41 &48 | 4.2.1.& 4.2.2 | MS3a

7–2 The current through the branch of the circuit containing the fixed resistor and light emitting diode is 60 mA.

Calculate the total resistance of the branch of the circuit containing the fixed resistor and the light emitting diode. *[2]*

p41 &48 | 4.2.1.& 4.2.2 | MS3a, 3c,3d

7–3 Calculate the resistance of the diode. *[2]*

p47 | 4.2.2

7–4 Suggest the purpose of the upper branch of the circuit. *[1]*

Total: 7

8 A student builds a simple dimmer switch to control a light by constructing the circuit shown in **Figure 9**. The variable resistor has a resistance of between 20 Ω and 60 Ω.

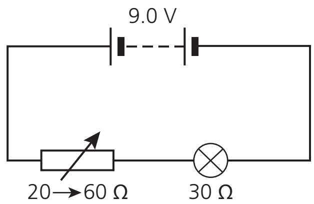


Figure 9

p46 | 4.2.1.2& 4.2.2

8–1 Describe what happens to the brightness of the lamp as the resistance of the variable resistor is gradually increased from 20 Ω to 60 Ω. Explain your answer. *[3]*

p47 | 4.2.1.2& 4.2.2 | MS3a, 3c,3d

8–2 Calculate the maximum resistance of the whole circuit. *[2]*

p41 &47 | 4.2.1.2& 4.2.2 | MS3a-d

8–3 Calculate the maximum current which can pass through the lamp. *[5]*

Total: 10

Domestic uses and safety

Quick questions

p50 | 4.2.3.1 | WS4.1

1 Electrical devices in homes are connected to the mains supply.

- What is the frequency of the UK mains supply?
- What is the potential difference (voltage) of the UK supply?

p51 | 4.2.3.2 | WS4.1

2 **Figure 10** shows an open three-pin plug. Write down the labels for A–F, choosing from the list below.

live wire	earth wire	neutral wire	cable grip	fuse	cable

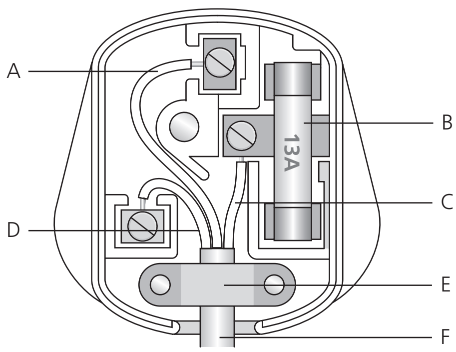


Figure 10

p51 | 4.2.3.2 | WS4.1

3 In a three-pin plug, what colour are the following wires?

earth	live	neutral

p38 | 4.2.3.2 | WS4.1

4 Explain the purpose of a fuse in a plug. Describe how the fuse operates.

p52 | 4.2.3.2 | WS4.1

5 Many mains powered devices are connected to the Earth by an earth wire. Explain the purpose of an earth wire. Describe how it works.

Exam-style questions

p51 | 4.2.3.1& 4.2.3.2

6 **Figure 11** is a representation of an electric cooker connected to a mains alternating current (a.c.) circuit. The graph shows the changes in potential difference for the live wire.

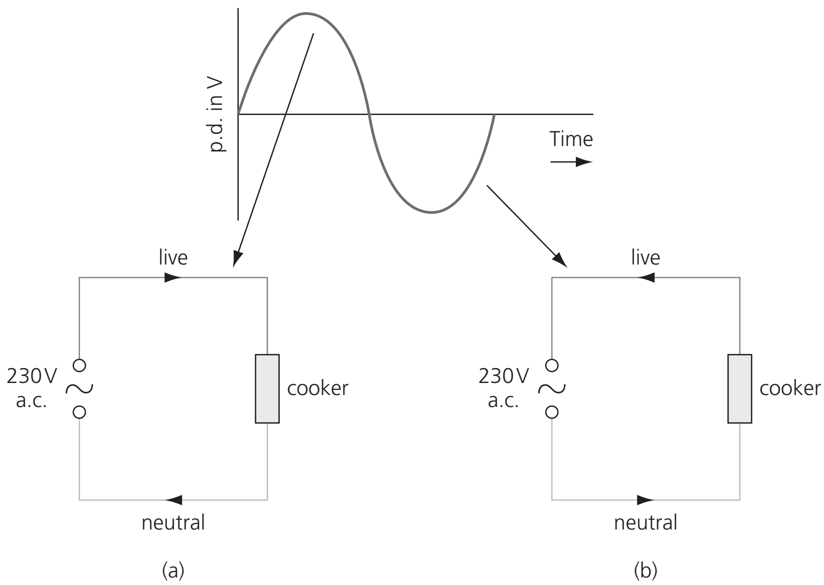


Figure 11

6–1 Compare an a.c. electricity supply with a direct current (d.c.) supply. Describe any similarities and any differences. *[4]*

WS4.1 MS4a

6–2 Describe how the potential difference of the live wire changes over time. *[2]*

MS4a

6–3 Describe how the potential difference of the neutral wire changes over time. *[1]*

MS4a

6–4 Describe how energy is provided to the cooker by the a.c. supply. *[2]*

Total: 9

Energy transfers

Quick questions

p53 | 4.3.4.1 | MS3a

1 Write the equation that links electrical power, potential difference and current.

p53 | 4.3.4.1 | MS3a, 3c,3d

2 Calculate the power rating of an electrical device which has a current of 4.5 A when there is a potential difference of 12 V across it.

p53 | 4.3.4.1 | WS4.1

3 A simple circuit consists of a battery and a resistor. Describe what happens to the power output of the circuit if:

- the resistance is doubled
- the current in the circuit is doubled.

p53 | 4.2.4.2

4 What factors will increase the total amount of energy delivered by an electrical device? Select all the correct answers from the options below.

The time the device operates for	The power rating of the device	Powering the device by mains electricity instead of a battery

p53 | 4.2.4.2 | MS3a, 3c,3d

5 Copy and complete **Table 5** showing power, current, potential difference and resistance in a circuit.

Power in W	Current in A	Potential difference in V	Resistance in Ω
	1.5	12	2.83
24		6.0	1.50
	3.0		5.0
120		250	520

Table 5

p53 | 4.2.4.2 | MS3a, 3c,3d

6 A circuit transfers a charge of 0.40 C across a potential difference of 1.5 V. How much energy has been transferred?

p54–5 | 4.2.4.3 | WS4.1

7 There are a range of voltages used in the National Grid and electrical wiring in homes. Explain why:

- very high voltages are used in the National Grid
- lower voltages (230 V) are used within homes.

p55 | 4.2.4.3 | WS4.1

8 Describe the purpose of transformers in the National Grid.

p55 | 4.2.4.3 | WS1.4

9 **Figure 12** shows a simplified diagram of parts of the National Grid.

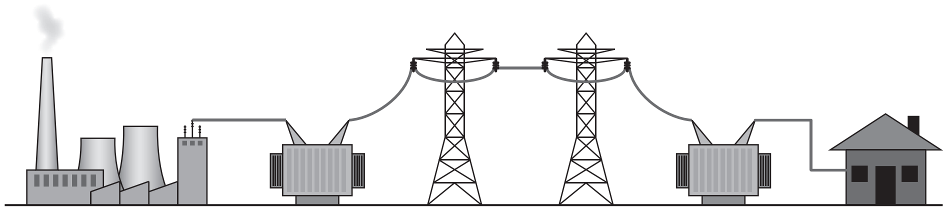


Figure 12

- Copy and label **Figure 12** using the following words.

pylon	step-down transformer	power station	transmission cable	step-up transformer	house

- Circle and label the parts of your copy of **Figure 12** where the voltage is:
  - very high (250 000 V).
  - high (2500 V).
  - low (230 V).

Exam-style questions

p53 | 4.2.4.1& 4.2.4.2

10 An electric kettle is used to heat water in the UK. The kettle operates at 230 V a.c. and takes a current of 4.5 A.

MS3a, 3c,3d

10–1 Calculate the power rating of the kettle. *[2]*

MS3a, 3c,3d

10–2 Calculate the resistance of the heating element in the kettle. *[3]*

10–3 The kettle is to be used to heat water as part of an experiment in a school laboratory. Four identical kettles are connected to an extension cord.

Explain why four kettles should not be connected in this way. Predict what is likely to happen. *[3]*

10–4 In the USA the mains voltage is 110 V a.c. A standard kettle takes longer to boil than the same kettle in the UK.

Suggest why the kettle in the USA takes longer to boil water. *[2]*

Total: 10

p53 4.2.4.2

11 A battery pack is used to charge a gaming device. The battery pack operates at a potential difference of 5.0 V and can provide 25 kJ of energy with a current of 0.5 A.

MS3a, 3c,3d

11–1 Show that the amount of charge the battery pack transfers when it recharges the gaming device is 5000 C. *[3]*

MS3a-d

11–2 Calculate how long it will take the device to transfer this amount of charge. *[3]*

MS3a, 3c,3d

11–3 Calculate the power output of the battery pack. *[3]*

MS3a, 3c,3d

11–4 Calculate the resistance of the circuit recharging the gaming device. *[3]*

Total: 12

12 The National Grid connects power stations to local substations through a series of transformers and cables.

p55 4.2.4.3 WS1.4, 4.1 QWC

12–1 Describe the structure of the National Grid and explain why transferring energy using high voltages and low currents is much more efficient than using high currents and low voltages. You may use a diagram and example calculations to assist your explanation. *[6]*

p53 4.2.4.2 MS3a-d

12–2 A length of cable in a local power transmission system runs for several kilometres. The cable has a resistance of 5.0 Ω and the power loss due to heating in the cable is 25 W.

Calculate the current in the cable. *[3]*

p53 4.2.4.2

12–3 Describe what would happen to the power loss due to heating if the current in the cable doubled. Explain your answer. *[2]*

Total: 11

Static electricity

Quick questions

p56 4.2.5.1 WS4.1

1 Copy and complete the following sentences about charged objects:

Two objects with a positive charge will __________ each other.

Two objects with a negative charge will __________ each other.

An object with a positive charge and an object with a __________ charge will attract each other.

p57 4.2.5.2 WS4.1

2 Choose all the **correct** statements about an electric field from the options below.

A charged object will create an electric field around itself.	The strength of an electric field becomes greater the further away from a charged particle it gets.	The direction of a field is the direction of the force acting on a negative particle placed in the field.	The greater the charge on the object the stronger its electric field will be.

p57 4.2.5.2 WS4.1

3 In **Figure 13**, sphere A is charged positively and sphere B is charged negatively. Point C is a small positive test charge placed near each of the spheres. Copy **Figure 13** and draw:

- field lines to show the shape of the field around the balls
- a line to show the direction of the force acting on the small test charge C.

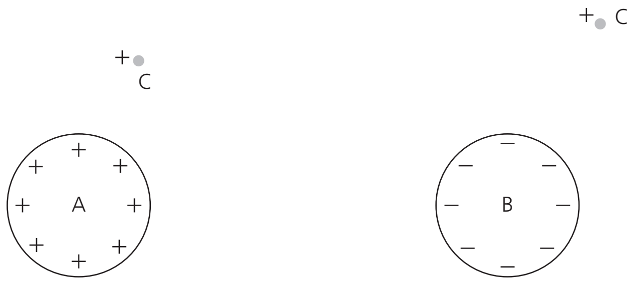


Figure 13

Exam-style questions

p56 4.2.5.1

4 A cloth can be used to electrically charge a *Perspex*® ruler (**Figure 14**).

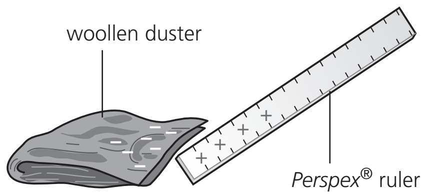


Figure 14

WS4.1 **4–1** Describe how to charge a *Perspex*® ruler using a cloth. *[1]*

WS4.1 **4–2** During charging, the *Perspex*® ruler becomes positively charged. Explain why this happens using the idea of electrons. *[3]*

4–3 During a demonstration, a teacher charges up a metal dome with a positive charge. The teacher forgets to discharge the dome and reaches out to touch it. There is a spark between the dome and the teacher's finger.

Describe the reason for this observation. *[2]*

4–4 Explain why the spark only happened when the teacher's finger was close to the dome. *[2]*

Total: 8

p57 4.2.5.2

5 In a laboratory, two metal spheres are placed next to each other. The domes have equal but opposite electric charges.

5–1 Give the direction of the force between the two spheres. *[1]*

WS4.1 **5–2** The size of the charges on the spheres are gradually increased.

Describe what happens to the size of the force as the charge increases. *[1]*

5–3 Describe what happens to the strength of the electric field between the spheres as the size of the charge increases. *[1]*

WS4.1

5–4 The two spheres are slowly moved closer together. Describe what happens to the strength of the electric field between the spheres as the separation decreases. *[1]*

5–5 Eventually there is a large spark between the two spheres.

Explain what happens to the charges on the spheres due to the spark. *[3]*

Total: 7

Electricity topic review

1 A 30 Ω resistor is used as heating element to heat some water. The resistor is connected to a battery which provides a potential difference of 12 V. The circuit is switched on for 3 minutes for the water to be heated.

p41 | 4.2.1.2 | MS3a-d

1–1 Calculate the current in the resistor while it is being used to heat the water. *[2]*

p39 | 4.2.4.1 | MS3a-d

1–2 Calculate the amount of charge which passes through the resistor during the three minutes. *[2]*

p53 | 4.2.4.1 | MS3a-d

1–3 Calculate the energy transferred by the resistor during heating. *[2]*

p53 | 4.2.4.1 | MS3a, 3c,3d

1–4 Calculate the power output of the resistor during the heating process. *[2]*

p47 | 4.2.4.1 | WS4.1

1–5 In order to improve the heater a second 30 Ω resistor is added in parallel with the first. Explain why placing a second resistor in parallel would increase the rate of energy transfer by the circuit. *[3]*

Total: 11

2 A single floodlight used in a football stadium lamp has an operating current of 3.0 A and a power rating of 1380 W.

p53 | 4.2.4.1 | MS3a, 3c,3d

2–1 Calculate the resistance of the floodlight. *[3]*

p53 | 4.2.4.1 | MS3a-d

2–2 Calculate the operating potential difference for the floodlight. *[3]*

p53 | 4.2.2 | MS1c

2–3 Twelve of the floodlights are connected in parallel to produce a very bright light source. The lights are all connected to the same power supply. Write down what happens to the total resistance of the circuit. *[1]*

p53 | 4.2.4.1

2–4 Describe the change in the current from the power supply. *[2]*

p53 | 4.2.2

2–5 During a match one of the lamps fails. Predict what will happen to the other lamps. *[2]*

Total: 11

3 An electric car is connected to a charging point in a supermarket car park. The charging point provides an effective current of 24.0 A at a potential difference of 230 V. The car is left to charge for 4.0 hours.

p53 | 4.2.4.1 | MS3a, 3c,3d

3–1 Calculate the power provided by the charging station. *[2]*

p53 | 4.2.4.1 | MS3a, 3c,3d

3–2 Calculate the energy suppled to the car during the charging. *[2]*

p41 | 4.2.1.3 | MS3a, 3c,3d

3–3 The car is driven away. During acceleration, one of the electric motors driving the wheels of the car takes a direct current of 900 A at a potential difference of 96 V.

Determine the resistance of the motor. *[2]*

p43 | 4.2.1.4 | WS4.1

3–4 Explain why the motor becomes hot when the car accelerates. *[4]*

Total: 10

4 A child's toy uses a static electricity effect to make a doll's hair stand on end. The toy uses a small electric current to charge the doll negatively.

p56 | 4.2.5.1

4–1 Name the particles which carry negative electric charge. *[1]*

p56 | 4.2.5.1 | WS4.1

4–2 Explain why the hair on the doll stands on end. *[2]*

p56 | 4.2.5.1 | WS4.1

4–3 A child touches the doll and the hair discharges and falls.

Explain, in terms of particle movement, why the hair falls. *[2]*

p39 | 4.2.1.2 | MS3a, 3c,3d

4–4 The total charge stored by the doll was 2.5 mC. The doll discharges in a time of 0.05 s when it is touched.

Calculate the average current caused by the discharging of the doll. *[3]*

p39 | 4.2.1.2 | WS1.5

4–5 The doll only stores a very small charge and so is considered safe for a child to use.

Explain why the doll would be dangerous if it could be charged to a much larger extent. *[2]*

Total: 10

p41 &42 | 4.2.1.3

5 A student investigated how the length of a wire affected its resistance using the apparatus shown in **Figure 15**.

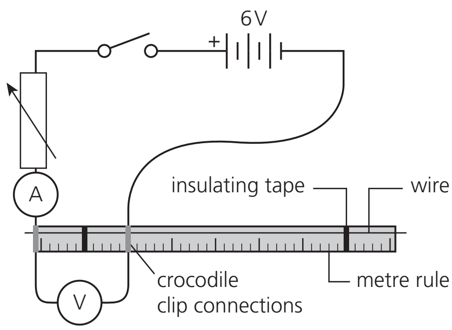


Figure 15

WS2.2 | RP3

5–1 Plan an experiment which would allow the student to investigate the relationship. *[6]*

MS3a, 3c,3d

5–2 During the experiment, the current in 80 cm of wire was found to be 0.75 A when the potential difference across it was 6.0 V.

Calculate the resistance of 80 cm of the wire. *[2]*

WS2.7

5–3 When the student measured the resistance of 10 cm of wire, he found it to be 0.50 Ω. He expected the resistance of 5 cm of wire to be 0.25 Ω but it was significantly higher than that. He observed that the wooden ruler smoked slightly.

Suggest a reason why the resistance of the 5 cm of wire was higher than expected. Explain your answer. *[2]*

Total: 10

3 Particle model

Changes of state and the particle model

Quick questions

p67 | 4.3.1.1 | WS4.1

1 Write a definition of 'density'.

p67 | 4.3.1.1 | WS4.1

2 Write the equation that links density, mass and volume.

p67 | 4.3.1.1 | WS4.1, MS1b, 3a-d

3 Complete **Table 1** which shows the mass, volume and density of some different material samples.

Sample	Mass in kg	Volume in m^3	Density in kg/m^3
A rock	40.00	0.015	
A solid gold crown	1.06		19300
Expanded polystyrene		0.50	15.0

Table 1

p67 | 4.3.1.1 | WS4.1

4 A student measures the diameter of a table tennis ball to be 40 mm.

- Calculate the volume, V, of the ball. ($V = \frac{4}{3}\pi r^3$)

The student measures the mass of the ball to be 2.7 g.

- Calculate the density of the ball. Give your answer in kg/m^3.

p69 | 4.3.1.1 | WS2.3, 4.1, RP5

5 **Figure 1** shows a pair of Vernier callipers which can be used to measure the dimensions of a sample.

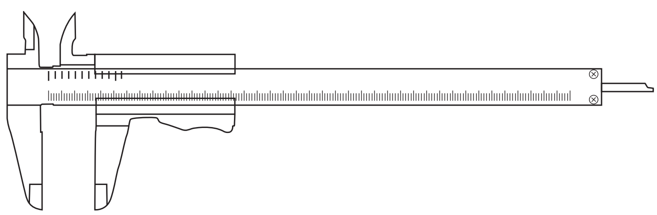


Figure 1

- What is a typical range of measurements you could measure with Vernier callipers?
- What is the typical resolution of a pair of Vernier callipers?

p69 | 4.3.1.1 | WS4.1, RP5

6 A student needs to measure the density of an irregular rock. Write down the apparatus they need.

p71 | 4.3.1.2 | WS4.1

7 Name the following changes of state.

solid → liquid	gas → liquid	liquid → gas	liquid → solid	solid → gas

p70–1 4.3.1.2 WS4.1

8 Which of the following are always conserved when a sample of a solid melts and changes into a liquid? Choose all the correct answers.

The shape of the sample.	The total number of atoms in the sample.	The total mass of the sample.	The thermal energy of the sample.

Exam-style questions

9 **Figure 2** shows the arrangement of particles in a liquid.

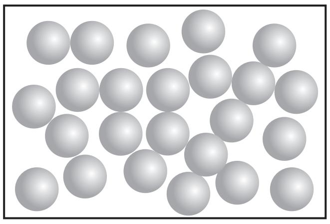


Figure 2

p71 4.3.1.1 WS3.5

9–1 Complete **Figure 2** to show the arrangement of particles in a solid and a gas. *[2]*

p71 4.3.1.1

9–2 Explain how **Figure 2** shows that the density of a gas is less than the density for a liquid. *[3]*

p67 4.3.1.1 MS3a-d

9–3 The density of air at 15° C is 1.225 kg/m^3.

Calculate the mass of air inside a typical room of volume 60.0 m^3. *[2]*

Total: 7

10 A researcher investigated how the density of water changes with temperature. They used a mass of 25.00 g of pure water and measured the volume of the water at different temperatures. Their results are shown in **Table 2**.

p68 4.3.1.1 RP5 AT1 WS2.3

10–1 Name an instrument that could be used to measure the temperature of the water. *[1]*

AT1 WS2.3

10–2 Write down **one** way in which the mass of the water could be measured. *[1]*

AT1 WS2.3

10–3 Give the resolution of the instrument used to measure the volume of the water. *[1]*

AT1 WS2.3

10–4 Explain why it is important to measure the volume of the water to high precision. *[1]*

MS3a, 3c,3d

10–5 Copy and complete **Table 2** to show the density of the water at different temperatures. *[2]*

Temperature in °C	Volume in cm^3	Density in g/cm^3
4.0	25.00	1.000
20.0	25.05	
40.0	25.20	
60.0	25.43	
80.0	25.73	

Table 2

p71 4.3.1.1 **10–6** Describe the relationship between the density of the water and its temperature. *[2]*

p71 4.3.1.1 **10–7** Explain why the density of the water changes as the temperature rises. *[2]*

Total: 8

Internal energy and energy transfers

Quick questions

p72 4.3.2.1 WS4.1 **1** Which **one** of the following is the best definition of internal energy?

The energy of the movement of the particles in a system.	The total kinetic and potential energy of the particles which make up a system.	The energy of an object due to its temperature.

p72 4.3.2.1 **2** Give **four** possible effects of heating a system of particles.

p74 4.3.2.2 WS4.1 **3** Materials are described as having a specific heat capacity. Define 'specific heat capacity'.

p74 4.3.2.2 **4** Name the SI units used to measure specific heat capacity.

p74 4.3.2.2 MS3a, 3c,3d **5** A 0.20 kg sample of silver is heated so that its temperature increases by 50 °C.

The specific heat capacity of silver is 240 J/kg °C.

Calculate the amount of energy transferred. Give the unit with your answer.

p74 4.3.2.2 MS3b-3d **6** Find the missing values from **Table 3** showing energy transfer, specific heat capacity, temperature change and mass.

Material	Mass in kg	Specific heat capacity in J/kg °C	Temperature change in °C	Energy change in J
Sand	4.0	290		46 400
Vegetable oil	0.12		75.0	1800
Glass		840	1.6	1613

Table 3

p75 4.3.2.3 WS4.1 **7** Write down what happens to the temperature of a material during a change of state such as melting.

p75 4.3.2.3 WS4.1 **8** Define 'the specific latent heat of a material'.

p75 4.3.2.3 WS4.1 **9** Name the SI units used to measure specific latent heat.

p76 4.3.2.3 WS4.1 **10** Define 'the latent heat of **fusion**' and 'the latent heat of **vaporisation**' for a substance.

p75 4.3.2.3 MS3a, 3c,3d **11** The specific latent heat for iron is 272 kJ/kg.

Calculate the amount of energy required to melt 4.5 kg of iron.

Exam-style questions

12 A small sample of a metal is analysed in a laboratory to determine its properties. The tests carried out include heating the sample until it melts. The material is found to have a melting point of 3033 °C.

p72 4.3.2.1 **12–1** What is the term used to describe the energy stored by the particles within a material due to their kinetic and potential stores? *[1]*

p76 4.3.1.2 **12–2** What happens to the temperature of the metal sample as it changes from a solid to a liquid? *[1]*

p71 4.3.1.1 **12–3** Describe the arrangement of the particles in a solid. *[3]*

Total: 5

p 75 &76 4.3.2.3 **13** A student uses the apparatus in **Figure 3** to measure the latent heat of fusion of ice. She slowly heats a block of ice electrically inside the funnel and collects the resulting water.

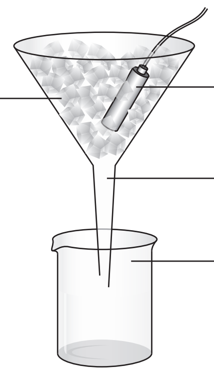


Figure 3

The student measures the energy provided to the ice from the heating element and the mass of ice which has melted.

Energy provided = 34.10 kJ.

Mass of ice melted = 0.106 kg.

WS2.3 **13–1** Name the instrument(s) needed to measure the energy provided to the heating element. *[1]*

13–2 Write down the temperature at which the ice needs to be at the start of this experiment. *[1]*

13–3 Write down the equation that links energy transfer, mass and specific latent heat. *[1]*

MS3a-d **13–4** Use the student's results to determine the specific latent heat of fusion for ice. *[2]*

WS2.7 **13–5** The accepted specific latent heat of fusion for ice is 330 kJ/kg.

Suggest **one** reason why the value calculated in question 13–4 is lower than the accepted value. *[1]*

WS2.7 **13–6** Suggest an improvement to the method which would give a result closer to the accepted value. *[2]*

Total: 8

14 A jewellery maker is making a set of 19 gold rings. Each ring contains a mass of 15 g of gold.

A block of pure gold just large enough to produce the rings is heated from room temperature of 24 °C to the melting point of gold.

The melting point of gold is 1060 °C.

The specific heat capacity of solid gold is 129 J/kg °C.

The specific latent heat of fusion of gold is 63 kJ/kg.

change in thermal energy = mass × specific heat capacity × temperature change

p74 4.3.2.2 MS3a, 3c,3d

14–1 Calculate the energy required to raise the gold block to its melting point. *[4]*

p75 4.3.2.3 MS4.1

14–2 The gold then requires extra energy to change state and melt.

Explain why the gold requires additional energy to melt. *[1]*

p74 4.3.2.3 MS3a, 3c,3d

14–3 energy for a change of state = mass × specific latent heat

Show that the additional energy required to melt the gold is 18.0 kJ. *[3]*

Total: 8

15 An ice cube is placed in a large metal bowl, as shown in **Figure 4**.

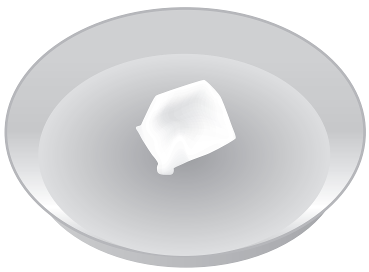


Figure 4

The ice melts and forms a pool of water inside the bowl. The water is at a temperature of 0 °C. The bowl also reaches a temperature of 0 °C just as the ice completes melting.

Mass of ice cube = 0.10 kg.

Mass of bowl = 0.50 kg.

Initial temperature of ice cube = –8 °C.

Initial temperature of bowl = 80 °C.

Specific heat capacity of ice is 2100 J/kg °C.

Specific latent heat of fusion for ice is 330 kJ/kg.

p74 4.3.2.2 MS3a, 3c,3d

15–1 Calculate the energy required to warm the ice to 0 °C. *[3]*

p75 4.3.2.3 MS3a, 3c,3d

15–2 Calculate the energy required to melt the ice. *[3]*

p75 | 4.3.2.2 | MS3a, 3c,3d

15–3 Assume that all of the energy required to heat and melt the ice came from contact with the metal bowl.

Calculate the change in energy of the metal bowl. *[1]*

p74–5 | 4.3.2.2 | MS3a-d

15–4 Show that the specific heat capacity of the metal that the bowl is made from is 867 J/kg °C. *[4]*

p75 | 4.3.2.2 | WS2.7

15–5 The accepted corrected specific heat capacity for the metal used to make the bowl is 900 J/kg °C.

Explain how this shows that the assumption used in question 15–3 was incorrect and why the measured specific heat capacity is lower than the accepted value. *[2]*

Total: 13

Particle model and pressure

Quick questions

p78 | 4.3.3.1

1 Describe the behaviour of the particles in a gas.

p79 | 4.3.3.1

2 Describe what happens to the particles in a gas as its temperature increases.

p79 | 4.3.3.1

3 Describe how a gas causes pressure on the wall of the container it is in. Draw a diagram to help with your explanation.

p79 | 4.3.3.2

4 The relationship pressure × volume = constant for a gas applies only in certain conditions. Write down the conditions under which this applies.

p80 | 4.3.3.2

5 A sample of gas is compressed so that its volume halves. Explain what happens to the pressure of the gas.

p80 | 4.3.3.2

6 A small sample of gas is contained within a sealed syringe. The plunger is pulled outwards and the gas expands to fill the larger volume. Describe what happens to the pressure inside the syringe. Explain your answer.

p81 | 4.3.3.3 | H

7 The temperature of the gas inside a tyre increases when a bicycle pump is used to increase the pressure quickly. Explain why this happens.

When the pressure is increased slowly the temperature does not change as much. Explain why this is.

Exam-style questions

p78–80 | 4.3.3.2

8 A software developer is designing a simulation of the particles in a gas. The software can demonstrate how pressure is caused inside a container and how the pressure changes when the temperature of the gas is increased and the volume of the container is changed.

WS4.1 | QWC

8–1 Describe the behaviour of the particles in a gas. Explain how this causes pressure inside a container. You should include an explanation of the changes in pressure when volume and temperature change. *[6]*

MS3a-d **8–2** The simulation can correctly show how the volume of a trapped sample of gas decreases with pressure, as shown in **Figure 5**.

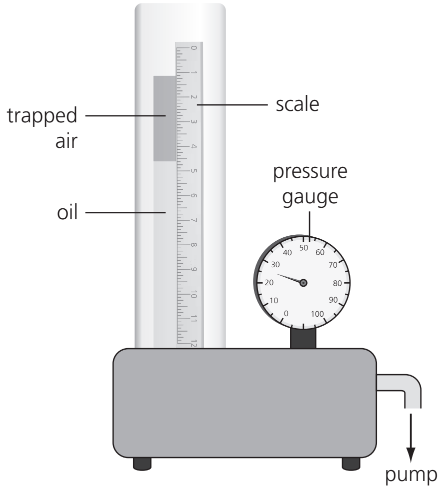


Figure 5

When the pressure gauge shows a pressure of 300 kPa, the volume of the trapped gas is shown to be 20.0 cm^3. What volume of gas should be shown when the pressure gauge reads 500 kPa? *[4]*

Total: 10

9 In an emergency, an astronaut re-pressurises an airlock using the oxygen in cylinders in their spacesuit.

The cylinders in the astronaut's suit contain 0.03 m^3 of oxygen at a pressure of 2.20×10^7 Pa.

The gas is released inside an empty airlock with a volume of 4.00 m^3.

pressure × volume = constant

p78 4.3.3.1 **9–1** Explain why the gas can rapidly fill the airlock. *[2]*

p79 4.3.3.2 MS3a-d **9–2** Calculate the pressure inside the airlock after the oxygen gas has expanded into it. *[4]*

p78 4.3.3.1 MS4.1 **9–3** Describe how the particles of gas cause pressure on the walls of the airlock. *[4]*

Total: 10

Particle model topic review

1 Methanol is an alcohol with many industrial uses. **Table 4** shows some properties of methanol.

Methanol (CH_3OH)	
Warnings **Highly flammable liquid and vapour. Toxic. Causes damage to organs (may cause blindness).**	
Density (at 20.0 °C)	0.792 g/cm^3 (792 kg/m^3)
Melting point	–97.6 °C
Boiling point	64.7 °C
Specific heat capacity (as liquid)	2533 J/kg °C
Latent heat of vaporisation	1110 kJ/kg

Table 4

In a laboratory, a burette is used to measure out a sample of 25.0 cm^3 of pure methanol. The temperature of the methanol is 20.0 °C. The methanol is heated using an electrical heating plate until it reaches its boiling point.

p78 4.3.3.1 WS2.4 **1–1** Suggest a reason why the methanol was not heated with a Bunsen burner. *[1]*

p67 4.3.1.1 MS3a-d **1–2** Calculate the mass of methanol in the sample. *[3]*

p74 4.3.2.2 MS3a, 3c,3d **1–3** Calculate the energy required to heat the sample to boiling point from 20.0 °C. *[4]*

p72 4.3.1.2 **1–4** The methanol continues to be heated after it reaches boiling point and begins to change from a liquid into a gas.

Name the change of state from a liquid to a gas. *[1]*

p72 4.3.1.2 MS4.1 **1–5** Compare the behaviour of the methanol molecules in its liquid form and its gaseous form. *[5]*

Total: 13

2 A truck tyre contains 0.25 m^3 of air with a density of 1.4 kg/m^3.

p67 4.3.1.1 MS3a-d **2–1** Calculate the mass of air in the tyre. *[3]*

p67 4.3.3.2 **2–2** A pump is used to increase the tyre pressure by adding more air so that the tyre now contains 0.40 kg of air. During this process 2.90 kJ of work is done on the gas. The temperature of the gas increases by 7 °C.

Describe what happens to the pressure in the tyre as air is added. *[2]*

p74 4.3.2.2 MS3a-d **2–3** Calculate the specific heat capacity of air using the data above. *[4]*

p74 4.3.2.2 **2–4** Write down **two** assumptions you made in the calculation in question 2–3. *[2]*

Total: 11

4 Atomic structure

Atoms and isotopes

Quick questions

p88 4.4.1.1 WS4.1 **1** Copy and complete **Table 1** showing the properties of the particles which make up an atom.

Component	Relative electric charge	Location	Symbol
proton			
neutron			
electron			

Table 1

p89 4.4.1.2 WS4.1 **2** An atom of plutonium-239 can be represented in this format:

$^{239}_{94}\text{Pu}$

Copy and add the labels: atomic number, mass number, atomic symbol.

p90 4.4.1.2 WS4.1 **3** Carbon-12 and carbon-14 are both isotopes of carbon. Describe the relationship between the numbers of protons, neutrons and electrons for these isotopes.

p90 4.4.1.2 MS3b,3c **4** Copy and complete **Table 2** to show the components of various isotopes.

Symbol	Element	Atomic number	Mass number	Electrons	Neutrons
$^{23}_{11}\text{Na}$	sodium				
$^{\square}_{82}\text{Pb}$	lead			82	124
$^{208}_{\square}\text{Pb}$	lead		208		
$^{\square}_{\square}\text{Cu}$	copper			29	36

Table 2

p89 4.4.1.1 WS4.1 **5** Identify the type of electrical charge found on an alpha particle and the nucleus of an atom.

p91 4.4.1.3 **6** Describe what happens when an alpha particle passes close to the nucleus of an atom. Explain your answer.

p91 4.4.1.3 WS4.1

7 **Figure 1** represents the 'plum pudding' model of the atom, which was used before the nuclear model was established.

Copy and label **Figure 1**. Describe the properties of the parts of the atom.

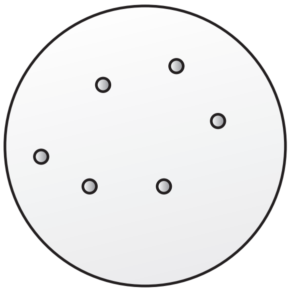


Figure 1

Exam-style questions

p88 4.4.1.2 WS4.1

8–1 Which **two** statements about an atom are true? Choose your answers from the options below. *[2]*

Atoms have no overall electrical charge.	All atoms contain protons, neutrons and electrons.	Atoms have an equal number of protons and electrons.	The number of protons in an atom is equal to the number of neutrons.

p88 4.4.1.1 WS4.3 MS1b

8–2 What is the approximate radius of an atom? Choose your answer from the options below. *[1]*

1×10^{10} m	1×10^{1} m	1×10^{-10} m	1×10^{-6} m	1×10^{-100} m

p88 4.4.1.1

8–3 Describe where the electrons are found in an atom. *[1]*

p88 4.4.1.1

8–4 How much smaller is the radius of the nucleus of an atom compared with the radius of the atom itself? Choose your answer from the options below. *[1]*

1/10th	1/100th	1/1000th	1/10 000th	1/100 000th

Total: 5

p92 4.4.1.3

9 The electrons in atoms can be found in different energy levels.

9–1 Name the scientist who suggested that electrons could be found in different energy levels. *[1]*

WS4.1

9–2 Describe what happens when an electron in an atom absorbs electromagnetic radiation. *[1]*

9–3 Describe what happens when an electron drops down into a lower energy level. *[1]*

9–4 What is formed if the electron gains enough energy to leave the atom? *[1]*

9–5 The nucleus of an atom contains both protons and neutrons.

Name the scientist whose work was responsible for the discovery of the neutron. *[1]*

Total: 5

10 The stable isotopes of chlorine are $^{35}_{17}Cl$ and $^{37}_{17}Cl$. These have identical chemical properties.

p8 4.4.1.2

10–1 Write down the atomic number of chlorine. *[1]*

p90 4.4.1.2 WS4.1

10–2 Define the term 'isotope'. Give **one** similarity and **one** difference between isotopes of an element. *[2]*

p89 4.4.1.2

10–3 A third isotope of chlorine, $^{36}_{17}Cl$, is rare and unstable.

Determine the number of neutrons in an atom of $^{36}_{17}Cl$. *[1]*

p89 4.4.1.2

10–4 Write down the number of electrons in an atom of $^{36}_{17}Cl$. *[1]*

p89 4.4.1.1 WS4.1

10–5 In an experiment an atom of $^{36}_{17}Cl$ is exposed to ultraviolet radiation and a positive ion is formed.

Describe how the positive ion has been formed. *[3]*

Total: 8

p91 4.4.1.3

11 **Figure 2** shows the 'plum pudding' model of the atom widely accepted at the beginning of the twentieth century. This model was soon replaced by the atomic model proposed by Ernest Rutherford based on the alpha particle scattering experiment carried out by his research assistants Geiger and Marsden.

In the 'plum pudding' model, the negatively charged electrons are distributed throughout a region of positive charge.

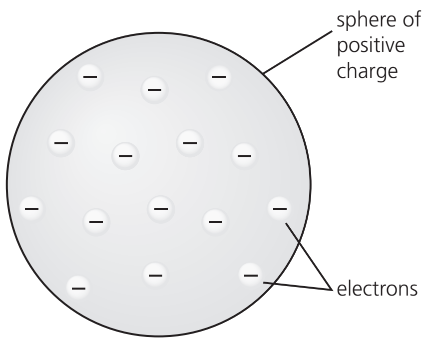


Figure 2

WS4.1

11–1 Describe the location of the electrons and positive charges in the nuclear model. *[2]*

11–2 In the plum pudding model, the positive region occupied the full volume of the atom.

Write down the fraction of the radius of a typical atom that is occupied by the nucleus. *[1]*

WS1.1, 1.2 QWC

11–3 Describe the alpha particle scattering experiment carried out by Geiger and Marsden. Explain how the evidence produced supports the nuclear model of the atom in contrast to the 'plum pudding' model. *[6]*

Total: 9

Atoms and nuclear radiation

Quick questions

p93 4.4.2.1

1 Some nuclei are unstable. What can happen to these nuclei?

p99 4.4.2.1

2 Define 'the activity of a radioactive source'. Give the unit of activity.

p99 4.4.2.1

3 Explain the difference between the count rate of a radioactive source and its activity.

Name a piece of equipment that can be used to measure count rate.

p94 4.4.2.1

4 **Table 3** shows four possible ways for a nucleus to decay. Copy and complete the table to describe the particles emitted and the changes in the nucleus.

Mode of decay	Description of particle emitted	Symbol for particle	Change to the nucleus
	a pair of protons and neutrons	α	
beta decay			
gamma decay			Becomes more stable. Atomic number and mass number unchanged.
neutron decay			

Table 3

p94 4.4.2.2

5 These are the symbols for an alpha particle and a beta particle. Copy and complete them by adding atomic numbers and mass numbers in the correct places.

$^{\square}_{\square}\text{He}$ $\quad$ $^{\square}_{\square}\text{e}$

p94 4.4.2.2

6 Copy and complete the following nuclear decay equations by balancing the mass numbers and atomic numbers.

$$^{230}_{90}\text{Thorium} \rightarrow {}^{\square}_{\square}\text{Radon} + {}^{4}_{2}\square$$

$$^{234}_{\square}\text{Thorium} \rightarrow {}^{\square}_{91}\text{Paladium} + {}^{\square}_{-1}\text{e}$$

p94 4.4.2.2

7 Nickel-60 $\left(^{60}_{28}\text{Ni}\right)$ decays by gamma ray emission. Suggest a reason why a decay equation for this process is not particularly useful.

p98 4.4.2.3 WS4.1

8 Explain what is meant by the phrase 'radioactive decay is a random process'?

p99 4.4.2.3 WS4.1

9 Which of these are possible definitions of the half-life of a radioactive isotope? Choose all possible answers from the options below.

The number of nuclei remaining when half of the sample has decayed.	The time it takes for the number of nuclei of the isotope in a sample to halve.	The time it takes for the count rate (or activity) from a sample to fall to half of its initial value.	The time it takes for the mass of the sample to fall to half of its original value.

p99 4.4.2.3 MS4a

10 **Figure 3** shows the activity of a radioactive sample over time.

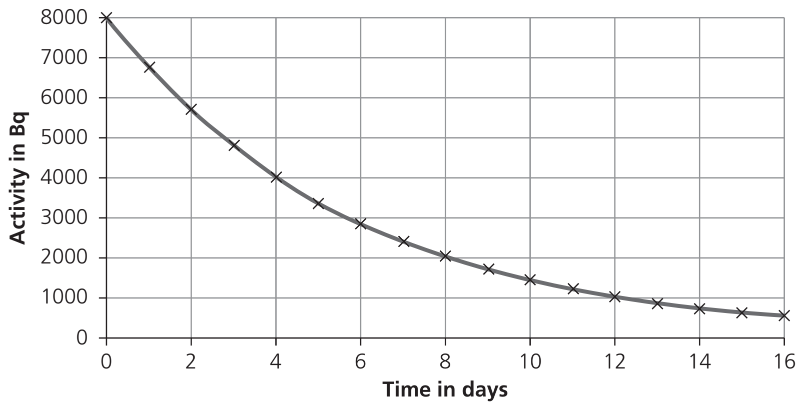


Figure 3

- Use **Figure 3** to determine the activity of the sample after eight days.
- What is the half-life of the sample?
- Describe how you found the half-life using the graph in **Figure 3**.

p105 4.4.2.4 WS4.1

11 Two students are discussing the difference between radioactive contamination and irradiation and they write a series of statements.

Which statements are about irradiation and which are about contamination?

- Can continue to cause damage when you move away from the original source.
- Radioactive material gets inside your body.
- Radiation affects you from outside the body.
- You become radioactive due to it.
- You don't become radioactive.
- It is much more dangerous.
- It can be used to kill bacteria on food.

p218 4.4.2.4 WS1.6

12 Published scientific papers usually go through a process of peer review.

Describe the process of peer review and explain why it is important.

Exam-style questions

p96–7 4.4.2.1

13 **Figure 4** shows a source which is emitting alpha, beta and gamma radiation to the left and to the right.

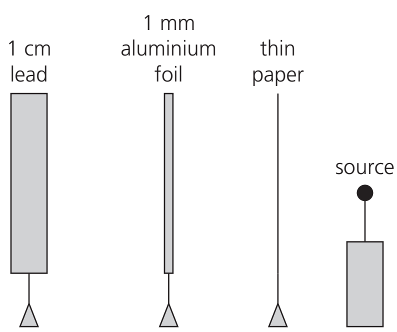


Figure 4

WS3.1 **13–1** Copy and complete **Figure 4** to show:

- how far each type of radiation can travel in air (to the right of the source) [3]
- the penetrating power of each type of radiation (to the left of the source). [3]

13–2 Identify the type of radiation which is the most ionising. [1]

Total: 7

14 A teacher demonstrates the properties of alpha, beta and gamma radiation using a set of small sealed sources.

p102 4.4.2.4 WS1.5, 2.4 **14–1** Describe how the teacher should reduce the students' exposure to the radiation. Explain why these measures are taken. [6]

p94 4.4.2.2 **14–2** One of the sources used by the teacher is americium-241 which decays by alpha particle emission.

Copy and complete the decay equation for americium-241. [3]

$$^{241}_{95}\text{Am} \rightarrow {}^{\square}_{\square}\text{Np} + {}^{\square}_{2}\text{He}$$

p96 4.4.2.1 **14–3** The Geiger counter can only detect emissions from the americium-241 source when it is placed directly in front of the detection tube.

Explain why the detector cannot detect the source when it is placed near the side or a few cm from the front. [2]

Total: 11

p99 4.4.3.1& 4.4.2.3 **15** The half-life of a radioactive sample is 1.50 years.

MS1c H **15–1** Determine how many half-lives have passed after 7.5 years. [2]

MS1c H **15–2** Determine what fraction of the original sample would remain undecayed after 7.5 years. [2]

MS4.1 **15–3** State the unit used to measure the activity of the sample. [1]

MS1c H **15–4** State the ratio of the final activity compared with the initial activity of the sample. [1]

Total: 6

16 Radioactive materials can decay through alpha decay, beta decay or gamma ray emission.

p94 4.4.2.2 **16–1** Complete this decay equation for an isotope of uranium. [2]

$${}^{\square}_{\square}\text{U} \rightarrow {}^{231}_{90}\text{Th} + {}^{4}_{2}\text{He}$$

p94 4.4.2.2 **16–2** Complete this decay equation for the decay of an isotope of potassium. [3]

$${}^{40}_{\square}\text{K} \rightarrow {}^{\square}_{20}\text{Ca} + {}^{0}_{\square}\text{e}$$

P103 4.4.2.4 WS1.5

16–3 The annual maximum dose permitted for radiation is 50 mSv. A researcher in a nuclear laboratory works in an environment which exposes them to an annual additional dose of radiation of 40 mSv.

Describe the likely effect of this dose on the researcher. *[2]*

P103 4.4.2.4 WS1.5

16–4 During an experiment an accident occurs, and the researcher is exposed to a dose of 5 Sv over a period of a few minutes.

Describe the likely effect of this dose on the researcher. *[2]*

Total: 9

17 The isotope americium-242 $\left({}^{242}_{95}\text{Am}\right)$ decays by alpha decay into an isotope of neptunium (Np).

p94 4.4.2.2

17–1 Copy and complete the decay equation for this alpha decay process. *[4]*

$${}^{242}_{95}\text{Am} \rightarrow {}^{\square}_{\square}\text{Np} + \_\_\_\_\_\_$$

p94 4.4.2.1 WS4.1

17–2 The isotope strontium-90 $\left({}^{90}_{38}\text{Sr}\right)$ decays into an isotope of yttrium $\left({}^{90}_{39}\text{Y}\right)$ by emitting a beta particle according to this decay equation.

$${}^{90}_{38}\text{Sr} \rightarrow {}^{90}_{39}\text{Y} + {}^{0}_{-1}\text{e}$$

Give the source of a beta particle and describe the changes which occur in the nucleus when one is emitted. *[2]*

p96 4.4.2.1

17–3 A Geiger counter is used to detect the radiation emitted from the sources. The counter is placed 10 cm away from each source and the count rate is recorded. The detector is then placed 1 cm away from the sources and the measurements repeated.

All the count rates are adjusted to take into account any background radiation present.

Source	Corrected count rate at 10 cm	Corrected count rate at 1 cm
Americium-242	0	156
Strontium-90	46	72

Explain why the Geiger counter does not detect radiation being emitted from the americium-242 source when it is placed 10 cm away. *[2]*

p96 4.4.2.1

17–4 Suggest why the count rate for the strontium-90 source is lower at 10 cm distance than for a 1 cm distance. *[2]*

p96 4.4.2.1

17–5 Describe how the results for the 1 cm distance would be different if a sheet of aluminium is placed between the sources and the detector. Explain your answer. *[4]*

Total: 14

18 **Figure 5** shows the activity of two different radioactive samples being monitored in a laboratory by a group of researchers.

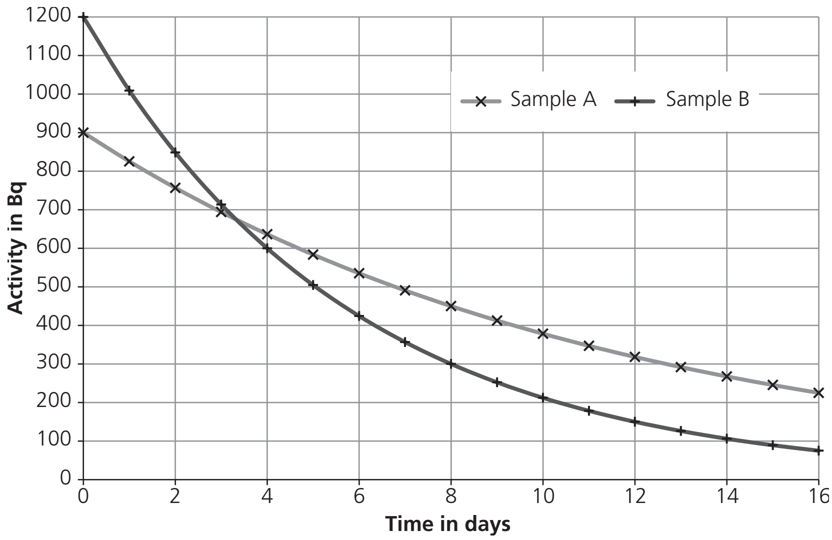


Figure 5

p100 4.4.2.3 MS4a WS2.5

18–1 Which sample has the greatest initial activity? *[1]*

p100 4.4.2.3 MS4a WS2.5

18–2 Give the time at which the samples have the same activity. *[1]*

p100 4.4.2.3 MS4a WS2.5

18–3 Determine the half-life of sample A using **Figure 5**. *[2]*

p102 4.4.2.4 WS1.5

18–4 Sample A decays by emitting alpha particles and sample B decays by beta decay.

Identify **two** measures the researchers should take to reduce the risk of irradiation from the sources during their experiments. *[2]*

p105 4.4.2.4 WS4.1

18–5 After an experiment, a researcher checks the laboratory for contamination.

Define 'contamination'. Explain why it is dangerous. *[3]*

Total: 9

Hazards and uses of radioactive emissions and background radiation

Quick questions

p102–3 4.4.3.1

1 These are all sources of background radiation. Which ones are natural sources and which are man-made sources?

fallout from weapons testing	cosmic rays from space	nuclear accidents	radon gas released from rocks

p102–3 4.4.3.1 WS4.1, 2.4

2 Why might the following jobs increase the average dose of radiation for the person doing them?

doctor	transatlantic aircraft crew	miner

p104–5 4.4.3.3 WS1.5, 4.1

3 Nuclear materials have a wide variety of uses. Give **two** examples of uses that are not connected to generating electricity.

Exam-style questions

p103 &104 | 4.4.3.3

4 During medical treatment a patient is injected with a radioactive tracer which contains the gamma emitter technetium-99. The gamma rays emitted are detected outside the body using a gamma camera.

4–1 Explain why a gamma ray emitting tracer is used in a tracer rather than a beta particle emitter. *[3]*

WS1.5

4–2 After the diagnostic treatment the patient is advised not to make physical contact with anybody else for 24 hours. Explain why this safety precaution needs to be taken. *[2]*

WS1.5

4–3 Suggest why the precaution only needs to last for 24 hours. *[2]*

Total: 7

5 The radioactive isotope cobalt-60 has a half-life of 5.3 years and is used to sterilise medical equipment. Cobalt-60 decays by emitting an electron followed by the emission of gamma rays. The electron is absorbed by shielding around the source, but the gamma rays penetrate the shielding so they irradiate biological materials near the source and kill them.

The dose of radiation absorbed by materials 25 cm away from a source containing 600 mg of Cobalt-60 is 1600 Sv per hour.

p103 | 4.4.3.1 | MS3a, 3c,3d

5–1 To be sure that surgical instruments have been sterilised they need to be exposed to a dose of 25 kSv.

Calculate the time it would take for the instruments to be sterilised if they were positioned 25 cm from the cobalt–60 source. *[2]*

p103 | 4.4.3.1

5–2 Suggest how the time of exposure could be reduced while still exposing the surgical instruments to the same dose of radiation. *[2]*

p105 | 4.4.2.4 | MS4.1

5–3 Explain why the surgical instruments are not contaminated by being positioned near the source. *[2]*

Total: 6

Nuclear fission and fusion

Quick questions

p106 | 4.4.4.1 | WS4.1

1 Name a nuclear fuel that undergoes fission in a reactor.

p106 | 4.4.4.1

2 Describe what happens during the fission of a single nucleus. Describe the products of the reaction.

p107 4.4.4.1 WS4.1, 3.5

3 **Figure 6** shows the start of nuclear fission chain reaction.

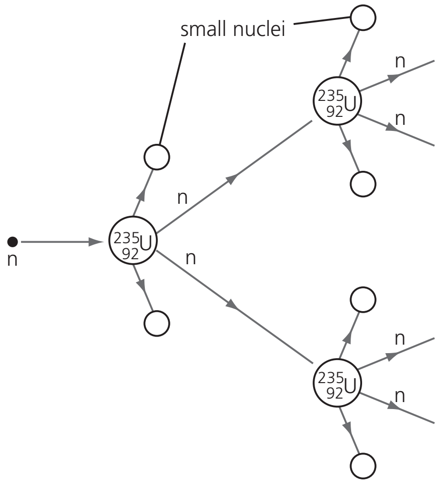


Figure 6

Describe how this process will cause a rapidly increasing energy output in a nuclear explosion.

p108 4.4.4.2 WS4.1

4 What is 'nuclear fusion'?

p108 4.4.4.2

5 Identify the type of nuclei that can undergo nuclear fusion.

p108 4.4.4.2

6 Give an example of where nuclear fusion happens.

Exam-style questions

7 The UK has several nuclear power plants which are used to generate electricity for the National Grid.

p107 4.4.4.1

7–1 Name the nuclear process which is currently used in nuclear power plants. *[1]*

Figure 7 shows the components of a nuclear reactor core.

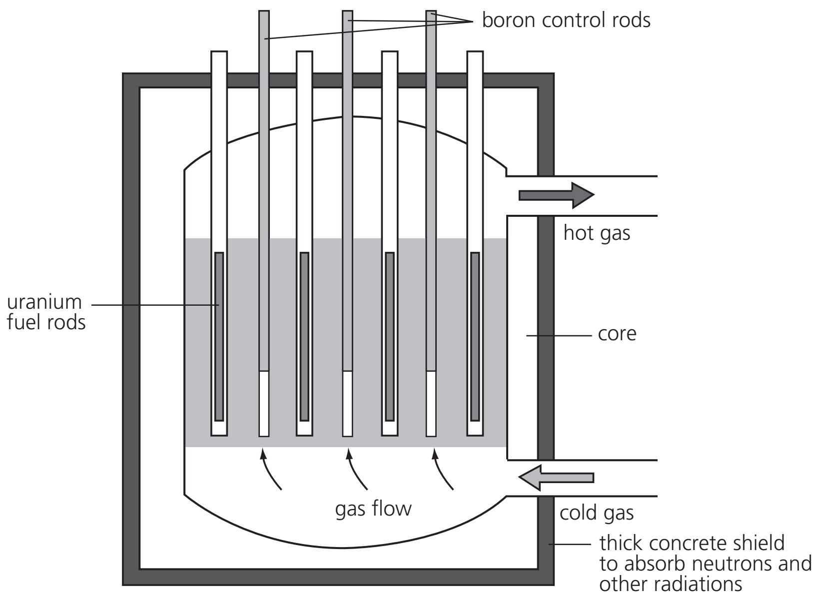


Figure 7

p107 | 4.4.4.1 | WS1.4,4.1 QWC

7–2 Describe the process in a nuclear reactor core which allows it to release a sustained and safe energy output. In your description you should include the names of the processes that occur, the types of radiation produced and how the rate of the processes can be controlled. *[6]*

p108 | 4.4.4.2

7–3 An experimental nuclear fusion reactor is being developed to generate electricity.

Suggest an isotope which could be used as fuel for this type of reactor. *[1]*

Total: 8

Atomic structure topic review

1 The isotope radium-223 $\left({}^{223}_{88}\text{Ra}\right)$ is used in the experimental treatment of some bone cancers. Doses of compounds containing the isotope are given to patients and the compounds are absorbed by bone tissue. Over the next few days alpha particles are released within the bones and these particles damage or kill nearby tumour cells.

p94 | 4.4.2.2

1–1 Copy and complete the alpha decay equation for radium-223. *[4]*

$${}^{223}_{88}\text{Radium} \rightarrow {}^{\square}_{\square}\text{Radon} + \_\_\_\_\_\_\_\_$$

p97 | 4.4.2.1

1–2 Explain why the damage caused by the decay of radium-223 only occurs in cells close to where it has been absorbed. *[2]*

p104 | 4.4.3.3 | WS1.5 QWC

1–3 Medical workers handling the radium-223 compounds need to take precautions to reduce their level of exposure to radiation.

Describe the precautions they should take and explain how these precautions would reduce their exposure and potential harm. *[6]*

Total: 12

2 Samples of wood contain small amounts of the isotope carbon-14 $\left({}^{14}_{6}\text{C}\right)$ which is radioactive. The carbon-14 was absorbed from the atmosphere when the tree from which the wood came was alive. Once a tree is cut down the amount of carbon-14 in the wood slowly decreases.

The amount of carbon-14 remaining in a sample of wood can be used to find the age of the wooden sample. This process is known as 'radiocarbon dating'.

p100 | 4.4.2.3 | WS4.1

2–1 Explain why the activity due to carbon-14 in a wood sample decreases over time. *[3]*

p100 | 4.4.2.3 | MS4a | WS3.5

2–2 **Figure 8** shows how the activity of a sample of wood containing carbon-14 would change over a long period.

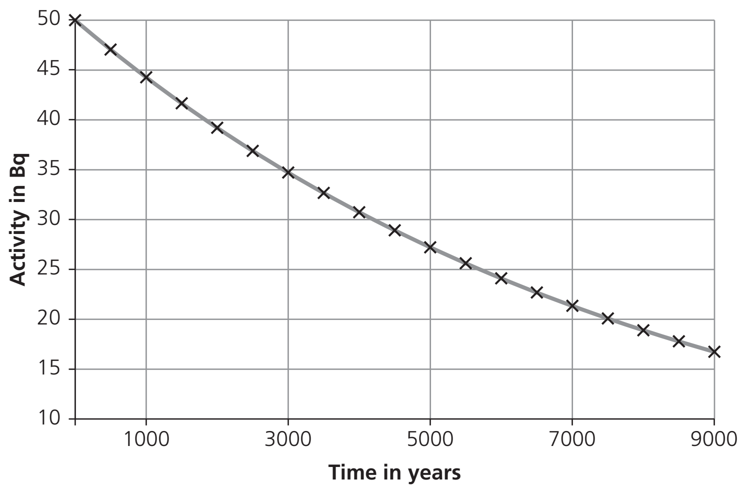


Figure 8

Use the graph to estimate the half-life of carbon-14. *[2]*

p100 | 4.4.2.3

2–3 A wood sample recovered from an archaeological site has an activity that is one-quarter of that of a modern equivalent piece of wood.

Estimate the age of the wood sample. *[2]*

p94 | 4.4.2.2

2–4 Carbon-14 decays through beta decay to form an isotope of nitrogen.

Copy and complete the nuclear decay equation to show the beta decay of carbon-14. *[2]*

$^{14}_{6}\text{Carbon} \rightarrow ^{\square}_{\square}\text{Nitrogen} + ^{0}_{-1}\text{e}$

Total: 9

H 3 A laboratory is testing a small container which is designed to hold a radioactive sample to see if it is contaminated. They do this by passing a Geiger-Muller tube over the surface and measuring changes in the count rate. The count rate is used to determine the overall activity of the container.

p96 | 4.4.2.1 | WS4.1 | MS1c

3–1 Name the unit used to measure the activity of a radioactive sample. *[1]*

p105 | 4.4.2.1 | WS4.1 | MS1c

3–2 Explain why the measured count rate is less than the overall activity of the container. *[2]*

p105 | 4.4.2.4 | WS4.1 | MS1c

3–3 Explain why the container may have a higher than background activity due to contamination but not due to irradiation. *[4]*

p94 | 4.4.2.2 | WS4.1 | MS1c

3–4 The sample which had been held in the container was nuclear waste containing the isotope of caesium $^{135}_{55}\text{Cs}$ which is radioactive. $^{135}_{55}\text{Cs}$ decays by a beta decay process to form an isotope of barium (Ba).

Complete the nuclear decay equation to show the beta decay of $^{135}_{55}\text{Cs}$. *[3]*

$^{135}_{55}\text{Cs} \rightarrow ^{\square}_{\square}\text{Ba} + ^{\square}_{\square}\text{e}$

p100 | 4.4.2.3 | WS4.1 | MS1c

3–5 The half-life of $^{135}_{55}\text{Cs}$ is approximately 30 years.

Calculate the time it will take for the activity of the $^{135}_{55}\text{Cs}$ in the nuclear waste to fall to $\frac{1}{16}$ of its original value. *[2]*

Total: 12

5 Forces

Forces and their interactions

Quick questions

p117 4.5.1.1

1 Define what is meant by:

- a scalar quantity
- a vector quantity.

p118 4.5.1.1

2 Describe how the magnitude and direction of a variable are indicated on a vector arrow.

p119 4.5.1.2

3 Name the unit of measure of a force.

p119 4.5.1.2

4 Give two examples of each of the following:

- a contact force
- a non-contact force.

p120 4.5.1.3

5 Write the equation linking weight, mass and gravitational field strength.

p120 4.5.1.3 WS4.3

6 What is the unit of measure of gravitational field strength?

p120 4.5.1.3

7 Define the term 'centre of mass'.

p120–1 4.5.1.4

8 What is meant by the term 'resultant force'?

Exam-style questions

p117 4.5.1.1

9–1 Select **two** scalar quantities from the selection below. *[2]*

time	momentum	acceleration	energy	displacement

p118 4.5.1.1

9–2 Describe the difference between distance and displacement. *[2]*

p118 4.5.1.1 WS1.2

9–3 Velocity is a vector quantity. Compare the velocities of the two rockets in **Figure 1** using their vector arrows. *[2]*

Total: 6

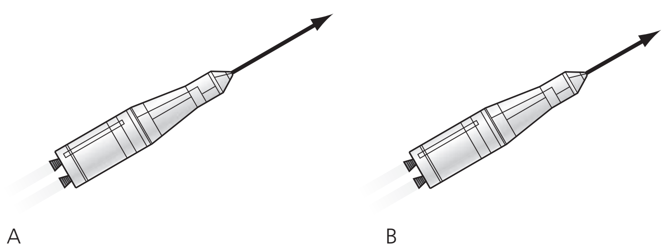


Figure 1

p118 4.5.1.2

10–1 Describe the **three** effects that an applied force can have on an object. *[3]*

WS1.2

10–2 The javelin in **Figure 2** is moving to the right. Copy **Figure 2** and label the **two** forces acting on the javelin. *[2]*

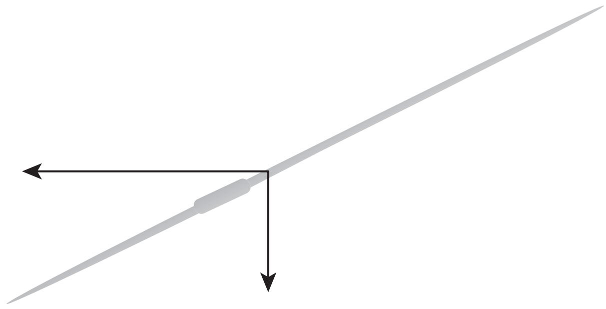


Figure 2

10–3 Explain the likely effect of these forces on the javelin. *[2]*

Total: 7

p120 4.5.1.3 MS3a

11–1 Give the relationship between the weight of an object and the mass of an object. *[1]*

MS2a,3c WS4.3

11–2 An astronaut on Earth has a mass of 80 kg. Assuming that the gravitational field strength is 9.8 N/kg, calculate the weight of the astronaut to 2 significant figures. *[3]*

MS3b,3c WS4.3

11–3 The astronaut travels to the Moon and has a weight of 128 N. Calculate the gravitational field strength on the Moon. *[3]*

Total: 7

p120–1 4.5.1.4

12–1 A skydiver with a weight of 700 N jumps from a plane. If the air resistance acting against the skydiver is 300 N, calculate the resultant force acting on the skydiver. *[1]*

p120–1 4.5.1.4

12–2 The air resistance increases as the skydiver falls. If the resultant force some time later is 0 N, give the force of the air resistance. *[1]*

p122 4.5.1.4 MS4a H WS1.2

12–3 Draw a free body diagram of these two forces acting on the sky diver when the resultant force is 0 N. *[3]*

Total: 5

p120 4.5.1.3 AT2

13–1 Name the piece of apparatus used to find the weight of an object. *[1]*

MS3b,3c WS4.3

13–2 A student measures the weight of a hair dryer to be 7.8 N, knowing that the gravitational field strength is 9.8 N/kg. Calculate the mass of the hairdryer. *[3]*

WS2.3

13–3 Suggest how the student could improve the accuracy of the weight measurement. *[1]*

Total: 5

p120 | 4.5.1.4

(H) **14–1** A car is travelling along the road to the right. A free body diagram of the car is shown in **Figure 3** along with the forces that act on it. Name the forces labelled Arrow ① and Arrow ② in the diagram. *[2]*

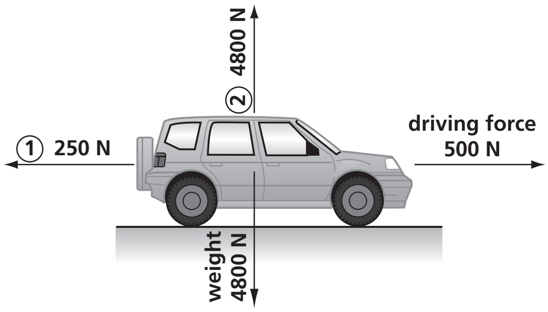


Figure 3

p122 | 4.5.1.4 | MS4a | WS1.2

(H) **14–2** Calculate the resultant force acting on the car. *[3]*

p118–121 | 4.5.1.2& 4.5.1.4

14–3 Explain what effect this resultant force will have on the car. *[2]*

Total: 7

p118 | 4.5.1.1

15–1 A tennis ball has a mass of 57 g. Copy **Figure 4** and draw a vector arrow to represent the weight of the tennis ball. *[2]*

Figure 4

p120 | 4.5.1.3 | MS3c | WS4.3,4.5

15–2 Show that the weight of the tennis ball is approximately 0.6 N. Assume that the gravitational field strength on Earth is 9.8 N/kg. *[3]*

p122 | 4.5.1.4 | MS4a | WS1.2

(H) **15–3** The tennis ball falls from a table. The resultant force on the tennis ball is 0.3 N downwards. Draw a free body diagram for this tennis ball. *[3]*

Total: 8

16 A car is towing a trailer behind it on a motorway. The trailer has a mass of 250 kg.

p120 | 4.5.1.3 | MS3c

16–1 Show that the weight of the trailer is approximately 2500 N (g = 9.8 N/kg). *[2]*

p122 | 4.5.1.4 | MS4a

16–2 Draw a free body diagram of the trailer including the following forces:

- A tension force of 1000 N pulling the trailer forwards (to the right). *[1]*
- A drag force of 500 N acting against the trailer. *[1]*
- The normal contact force. *[1]*
- The weight of the trailer. *[1]*

p120–2 | 4.5.1.4 | MS4a

16–3 Calculate the resultant force acting on the trailer and give the direction. *[2]*

p118–121 | 4.5.1.2

16–4 Explain, with reference to the trailer's motion, what change this resultant force could cause. *[2]*

Total: 10

p122–3 | 4.5.1.4 | MS4a,5b WS1.2 | H **17–1** A forklift truck applies an upwards force of 160 N and a horizontal forwards force of 85 N on a pallet. Draw a vector diagram to calculate the magnitude of the resultant force. *[3]*

MS5a | H **17–2** Use your diagram and a protractor to find the angle of the resultant force. *[1]*

Total: 4

18 When an aeroplane takes off from a runway, the thrust from the engine acts at an angle to the runway. The thrust is 4.6×10^6 N and acts at an angle of 12 degrees to the horizontal runway.

p122–3 | 4.5.1.4 | MS1b, 4a,5a,5b WS1.2 | H **18–1** Draw a vector diagram to identify the horizontal and vertical components of this force. *[4]*

p120–3 | 4.5.1.4 | H **18–2** The weight of the aeroplane is 323 500 N. Calculate the resultant force in the vertical direction. *[1]*

p120 | 4.5.1.3 | MS3b,3c **18–3** Calculate the mass of the aeroplane (g = 9.8 N/kg). *[2]*

p122–3 | 4.5.1.4 | MS4a, 5a,5b WS1.2 | H **18–4** When the aeroplane is at cruising altitude its engine produces a force of 25 000 N in a northerly direction. A wind blows with a force of 5000 N due east. Draw a vector diagram to calculate the resultant force acting on the plane and the direction of this force. *[4]*

Total: 11

Work done and energy transfer

Quick questions

p124 | 4.5.2 **1** What is the unit of measure of work done?

p124 | 4.5.2 **2** Write the equation that relates work done, force applied and distance.

p124 | 4.5.2 **3** Give an alternative unit of measure for the newton metre, Nm.

Exam-style questions

p124 | 4.5.2 | MS3c,3d **4–1** A firefighter with a weight of 735 N climbs a 10 m ladder to enter a building. Calculate how much work is done by the firefighter. *[2]*

p124 | 4.5.2 **4–2** Another firefighter climbs the same ladder and enters the same building but does not do as much work to reach the same height. Suggest why this may be the case. *[1]*

p125 | 4.5.2 **4–3** The firefighters need to push open a door to reach the fire. They apply a total force of 500 N on the door, but it doesn't move. Give the amount of work done by the firefighters and explain your answer. *[2]*

Total: 5

p125 | 4.5.2 | MS3b-d **5–1** A warehouse worker pushes a box with a force of 12 N across the floor doing 240 Nm of work. Assuming there are no frictional forces, calculate how far the box moves across the floor. *[3]*

MS1a,2a, 3c,3d WS4.3, 4.5,4.6 **5–2** Another worker then lifts the box 80 cm onto a shelf. The box weighs 78 N. Calculate how much work the second worker does. Give your answer to 2 significant figures. *[4]*

5–3 The first worker says that his job requires more energy. Justify this statement. [2]

Total: 9

p125 4.5.2

6 A student rolls a tennis ball across the laboratory floor by applying a force of 250 mN to the tennis ball. The student calculates that the ball will roll 3.6 m in the direction of the force applied.

MS1a WS4.4

6–1 Calculate how much work the student does in Nm. [3]

WS4.5

6–2 Give the work done by the student in joules. [1]

6–3 The ball actually rolls a distance of 2.8 m, and additional measurements show the temperature of the tennis ball to have increased slightly. Explain why it doesn't roll as far as the student calculated. [3]

Total: 7

Force and elasticity

Quick questions

p126 4.5.3

1 Give the equation that links force, spring constant and extension.

p126 4.5.3

2 If the force applied is measured in newtons, and the extension is measured in cm, what will be the unit of measure for the spring constant?

p126 4.5.3

3 What is:

- elastic deformation?
- inelastic deformation?

p128 4.5.3

4 What happens to a spring if it is extended beyond its limit of proportionality?

p126 &5 4.5.3

5 Give the equation that links elastic potential energy, spring constant and extension.

Exam-style questions

p126–8 4.5.3 MS1a, 3c,3d

6 A student stretches a spring, with spring constant 5.3 N/cm, in a laboratory. They observe an extension of 4.0 cm.

6–1 Show that the force applied to the spring is approximately 21 N. [2]

MS3b-d

6–2 The student increases the force applied by 2 N. Calculate the new extension of the spring. [3]

6–3 The student observes that the spring extends by 6 cm. Explain why the spring stretches further than calculated in question 6–2. [2]

Total: 7

p126–8 4.5.3

7 A student suspends a shoelace from a retort stand and clamp and attaches a mass hanger with masses to the other end of the shoelace. The shoelace extends.

7–1 Describe the forces acting on the shoelace when it is extended and stationary. [2]

MS3b, 3c,3d WS4.3 **7–2** A force of 4.2 N is added to the shoelace, and it extends by 1.3 mm. Calculate the spring constant and give the unit of measure. *[3]*

7–3 Give the assumption that you have made in your calculation in question 7–2. *[1]*

MS1a, 3c,3d WS4.4, 4.5 **7–4** The student swaps the shoelace to an elasticated shoelace which has a spring constant of 450 N/m. Calculate the elastic potential energy stored in the elasticated shoelace when it is extended by 55 mm. *[3]*

MS1d **7–5** Estimate the work done in stretching the shoelace. *[1]*

Total: 10

p126–8 4.5.3 **8** A soft drinks company is testing the structure of a new aluminium can. They apply a force to the can and then measure its height. Their results are shown in **Table 1**.

MS1a **8–1** Copy and complete **Table 1** to show the compression of the can. *[5]*

Force applied in mN	Height of the can in cm	Compression in cm
0	13.3	
200	13.1	
400	12.9	
600	12.6	
800	11.2	

Table 1

MS4a,4c WS3.1,3.2 **8–2** Plot a graph to show the relationship between the force applied and the compression of the can. *[4]*

8–3 Draw a line of best fit for your graph. *[1]*

MS1a,4a WS3.5,4.4 **8–4** The manufacturer claims that the can will be able to withstand a maximum force of 0.35 N. Use the data in **Table 1** and your graph to justify this claim. *[4]*

WS3.5 **8–5** The manufacturer wants to calculate the amount of elastic potential energy stored in the can when a force of 800 mN is applied. Explain why this is not possible. *[3]*

Total: 17

p126–7 4.5.3 **9** A student carries out an experiment to determine the spring constant of a spring and collects the data shown in Figure 5.

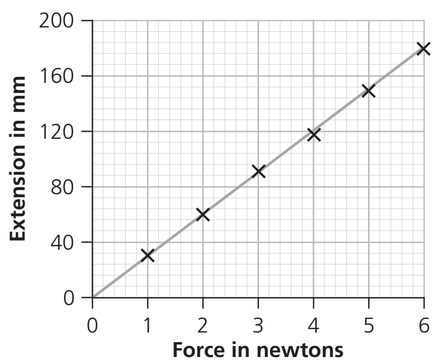


Figure 5

RP6 AT1&2 WS1.5, 2.2,2.3 QWC

9–1 Describe a method that the student could have used to collect the data in the graph shown. Your answer should include a safety precaution. You may include a labelled diagram in your answer. *[6]*

MS4b

9–2 Describe the mathematical relationship shown by the graph. *[2]*

MS4D WS3.3

9–3 Use **Figure 5** to calculate the spring constant of the spring in N/m. *[4]*

WS2.7,3.7

9–4 Suggest **one** strategy to improve the accuracy of the measurements in this investigation. *[1]*

MS3c,3d, 4a,4f

9–5 Calculate the elastic potential energy stored in the spring when a force of 1 N is applied. *[4]*

Total: 17

Moments, levers and gears

Quick questions

p129 4.5.4

1 Give the equation that links moment, force and perpendicular distance from a pivot.

p131–2 4.5.4

2 Give the **two** conditions necessary for an object to be in equilibrium.

p133 4.5.4

3 What are gears used for?

Exam-style questions

p129–31 4.5.4

4 **Figure 6** shows a decorator using a screwdriver to open a tin of paint.

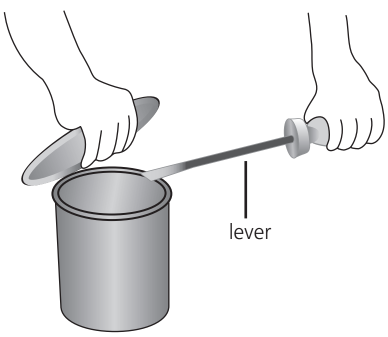


Figure 6

4–1 Explain why the decorator holds the screwdriver at its end when opening the paint tin. *[2]*

MS1a, 3b-d WS4.3,4.4

4–2 The decorator applies a force of 30 N, which creates a moment of 6.6 Nm. Show that the screwdriver is approximately 20 cm long. *[4]*

Total: 6

p129–32 4.5.4

5 Two children are playing on a playground seesaw, as shown in **Figure 7**.

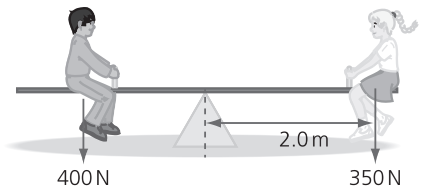


Figure 7

MS3c,3d WS4.3

5–1 Calculate the moment produced due to the girl's weight and give the unit of measure. *[3]*

5–2 Define what is meant by 'the principle of moments'. *[2]*

MS2a, 3b-d WS4.6

5–3 The boy is seated on the other side of the seesaw, when it is balanced. He has a weight of 400 N. Calculate the distance that he must sit from the pivot. Give your answer to 2 significant figures. *[4]*

Total: 9

p129–33 4.5.4

6 A crane is used to lift a large bag of cement using an arm of length 8 m. When the crane uses its counterbalance, it can withstand a total moment of 12 kNm without tipping over.

MS3b-d WS1.2,4.4

6–1 Calculate the maximum weight of the bag of cement that the crane can safely lift. *[4]*

MS1d WS3.4

6–2 If the arm of the crane is extended to 16 m, estimate without calculation the maximum weight that the crane can now lift and justify your answer. *[3]*

WS1.2

6–3 A gear system is used to rotate the arm of the crane. The input shaft has a diameter of 12 cm and the output shaft has a diameter of 48 cm. Calculate how many times greater the turning effect will be on the output shaft compared to the input shaft. *[2]*

MS3c,3d

6–4 The gear teeth exert a force of 300 N on each other. Calculate the turning moment produced on the input shaft. *[3]*

Total: 12

Pressure and pressure differences in fluids

Quick questions

p79 &135 4.5.5.1.1

1 What is the unit of pressure?

p135 4.5.5.1.1

2 Write the equation that relates pressure, force and area.

p135 4.5.5.1.1

3 Give the **two** states of matter that can be a fluid.

p139 4.5.5.2

4 Describe what happens to the density of the atmosphere as altitude increases.

p136–7 4.5.5.1.2 H

5 For the equation

pressure due to a column of liquid
= height of column × density of liquid × gravitational field strength

give the standard units of measure for the height of the column, the density of the liquid and gravitational field strength.

p137–8 4.5.5.1.2 H

6 Define 'upthrust'.

Exam-style questions

7 An Olympic swimming pool is 50 m long and 25 m wide. It contains water with a weight of 25 000 000 N.

p135 | 4.5.5.1.1 | WS4.3

7–1 Write down the equation that relates pressure, force and area. *[1]*

p135 | 4.5.5.1.1 | MS3c,3d WS4.3

7–2 Calculate the pressure on the floor of the pool due to the water in pascals. *[3]*

p136–7 | 4.5.5.1.2 | MS1a, 3b-d | H

7–3 Use the equation

pressure due to a column of liquid
= height of column × density of liquid × gravitational field strength (g)

to show that the height of the water is approximately 2.00 m if the density of water is 1000 kg/m^3 and g = 9.8 N/kg. *[3]*

Total: 7

p135–6 | 4.5.5.1.1 | MS1b, 3c,3d WS4.4

8–1 Hairdressers use chairs that make use of hydraulic pumps to change the height of the chair; these contain compressed liquid. The hairdresser applies a force of 120 N to the input piston, which has an area of 5×10^{-5} m^2. Calculate the pressure exerted on the liquid inside in kPa. *[3]*

MS1a, 3b-d

8–2 If the output piston has an area of 0.00125 m^2, calculate the force exerted by this piston. *[3]*

8–3 Explain why a liquid rather than a gas must be used inside a hydraulic pump. *[2]*

Total: 8

p139 | 4.5.5.2

9–1 Explain how air molecules in the atmosphere create atmospheric pressure on a surface. *[3]*

p139 | 4.5.5.2

9–2 Aeroplanes undergo a change in pressure on their surface as they ascend at the beginning of a flight. Explain how the atmospheric pressure changes as the aeroplane travels further from the Earth's surface. *[3]*

p135–6 | 4.5.5.1.1 | MS3b-d

9–3 At an altitude of 10 km, the air pressure is 27 500 Pa. If the aeroplane shell has a total surface area of 360 m^2, calculate the total force applied to the aeroplane shell by the atmosphere. *[3]*

p135–6 | 4.5.5.1.1 | MS1b, 3b-d WS4.4, 4.5

9–4 The pressure inside the cabin is 101 kPa, assuming that the surface area is 360 m^2. Show that the total force exerted by the air inside the plane on the aeroplane shell is 3.6×10^7 N. *[4]*

p135–6 | 4.5.5.1.1 | MS1d

9–5 Determine the minimum force that the aeroplane's shell must be able to withstand when travelling at this altitude without crumpling. *[2]*

Total: 15

p136–7 4.5.5.1.2 MS3c,3d WS4.4

10–1 A reservoir is 14 m deep and filled with water of density 1000 kg/m^3, where g = 9.8 N/kg. Use the equation

pressure due to a column of liquid
= height of column × density of liquid × gravitational field strength (g)

to calculate the pressure at the bottom of the reservoir in kPa due to the water. *[3]*

MS3c,3d

10–2 A fish swims 5 m above the bottom of the reservoir. Calculate the pressure acting on the fish due to the water in the reservoir. *[3]*

10–3 The walls of the reservoir in **Figure 8** are wedge shaped. Suggest why the walls are thicker at the bottom than at the top. *[2]*

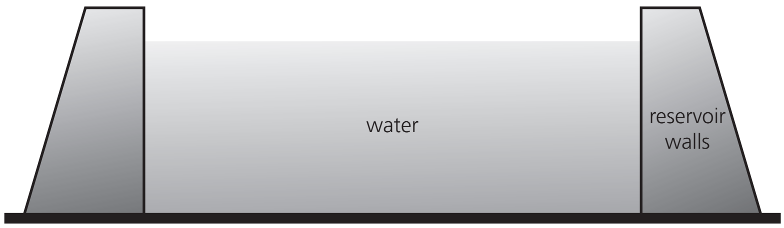


Figure 8

Total: 8

p136–8 4.5.5.1.2 H

11 A half full oil drum falls from the back of a ship and is fully submerged in the sea.

11–1 Explain why there is an upthrust force on the oil drum. *[3]*

MS1a, 3c,3d WS4.4, 4.5

11–2 The oil drum is 1.50 m tall and the top of the drum is located 50 cm below the surface of the water. Use the equation

pressure due to a column of liquid
= height of column × density of liquid × gravitational field strength (g)

to show that the pressure at the top of the drum is approximately 106 kPa. Assume that the density of seawater is 1020 kg/m^3, g = 9.8 N/kg and the atmospheric pressure is 101 kPa. *[4]*

MS2a, 3c,3d WS4.6

11–3 Calculate the pressure due to the seawater and the atmospheric pressure at the bottom of the drum to 3 significant figures. *[4]*

MS1d

11–4 Estimate the pressure difference between the top and bottom of the oil drum. *[1]*

11–5 A sailor notices another oil drum floating, with its top just at sea level. Suggest a value for the density of the partially filled oil drum and explain your answer. *[2]*

Total: 14

Describing motion along a line

Quick questions

p148 4.5.6.1.1 — **1** What is the difference between distance and displacement?

p149–50 4.5.6.1.4 — **2** What feature of a distance–time graph can be used to calculate the speed of an object?

p148–9 4.5.6.1.3 — **3** What is 'velocity'?

p152 4.5.6.1.5 — **4** Write down the equation that links acceleration, change in velocity and time.

p152 4.5.6.1.5 — **5** What is 'deceleration'?

p152 4.5.6.1.5 — **6** What feature of a velocity–time graph can be used to calculate the acceleration of an object?

p152–3 4.5.6.1.5 H — **7** Describe how the distance travelled or displacement can be found using a velocity–time graph.

p156–7 4.5.6.1.5 — **8** What is 'terminal velocity'?

Exam-style questions

9 A jogger is running around a park. She travels a total distance of 5.5 km and her displacement is 1.6 km.

p147 4.5.6.1.2 WS4.4, 4.5 — **9–1** Estimate the typical speed for a person running. *[1]*

p147 4.5.6.1.2 — **9–2** Give **one** factor that could affect the jogger's speed. *[1]*

p148 4.5.6.1.2 WS4.4, 4.5 MS3c,3d — **9–3** The jogger takes 33.5 minutes to complete her run. Calculate her average speed in m/s. *[3]*

p148 4.5.6.1.1 — **9–4** Suggest a reason why her displacement is less than the total distance that she has travelled. *[1]*

Total: 6

10 **Figure 9** shows a distance–time graph of a car's journey.

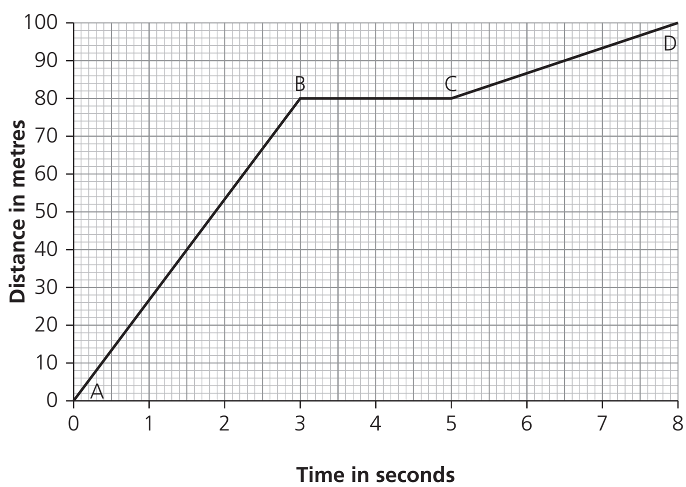


Figure 9

p147 4.5.6.1.2

10–1 What is the typical speed for a car travelling along a motorway? Choose an answer from the options below. *[1]*

3 m/s	330 m/s	10 m/s	30 m/s

p149–50 4.5.6.1.4 WS3.5 MS2c

10–2 Using **Figure 9**, copy and complete these sentences. *[2]*

The car is travelling fastest between letters __________ and __________.

The speed of the car can be calculated using the __________ of the line.

p149–150 4.5.6.1.4

10–3 Describe the motion of the car for the final 5 seconds of this journey. *[2]*

p149–50 4.5.6.1.4 WS3.2 MS2c,4a

10–4 Use **Figure 9** to calculate the average speed of the car for the full journey. *[2]*

p149–50 4.5.6.1.4 WS3.2, 3.3 MS2c, 4a,4d

10–5 Use **Figure 9** to calculate the speed of the car between the points marked C and D. *[3]*

Total: 10

p152 4.5.6.1.5 WS3.3 MS3c,3d

11–1 A speed skater races across an ice rink, initially starting at rest and reaching a speed of 9 m/s after 4 seconds. Show that the acceleration of the speed skater is approximately 2 m/s². *[3]*

p153 4.5.6.1.5 WS3.3 MS3b-d

11–2 Use the equation

$$(\text{final velocity})^2 - (\text{initial velocity})^2 = 2 \times \text{acceleration} \times \text{distance}$$

to calculate the distance travelled by the speed skater in the first 4 seconds of the race. *[3]*

p152 4.5.6.1.5 WS3.1, 3.2 MS2c, 4a,4c

11–3 After the race, the speed skater was presented with some data about his race. Use the data in **Table 2** to plot a velocity–time graph for his race. *[4]*

Time in seconds	Velocity in m/s
0	0
4	9
8	10
9	11

Table 2

p152–3 4.5.6.1.5 WS3.3 MS4a,4f H

11–4 Use the graph that you have drawn in question 11–3 to determine the total distance travelled in this race. *[3]*

Total: 13

12 A skydiver jumps from a plane. Initially she has a speed of 0 m/s and after falling 50 m she has a speed of 31 m/s.

p153 4.5.6.1.5 WS3.3 MS3b-d

12–1 Use the equation

$$(\text{final velocity})^2 - (\text{initial velocity})^2 = 2 \times \text{acceleration} \times \text{distance}$$

to show that the skydiver is initially accelerating at approximately 9.6 m/s². *[3]*

p152 4.5.6.1.5 WS3.3 MS3b-d

12–2 Calculate how long the skydiver takes to fall the first 50 m of her skydive. *[3]*

p156–7 | 4.5.6.1.5 | WS3.2 MS4a

12–3 **Figure 10** shows a velocity–time graph of the skydive. Identify the time at which the skydiver first reaches terminal velocity. *[1]*

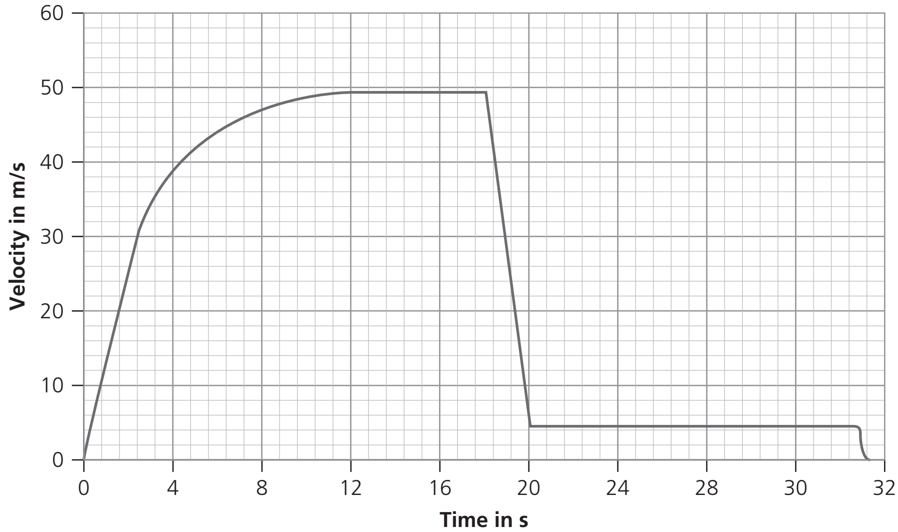


Figure 10

p156–7 | 4.5.6.1.5

12–4 Explain, in terms of forces, why terminal velocity is reached. *[2]*

p156–7 | 4.5.6.1.5

12–5 Suggest and explain why the parachutist undergoes a large deceleration at around 18 seconds. *[3]*

p152–3 | 4.5.6.1.5 | WS3.3 MS4a,4f

H **12–6** Use **Figure 10** to estimate the total distance travelled by the parachutist in the first 18 seconds. *[3]*

Total: 15

13 A student is planning an investigation to see how the diameter of a cupcake case affects the average speed at which it falls.

p155 | 4.5.6.1.2 | WS2.2, 2.3 AT1,3 QWC

13–1 Design a method that the student could use to investigate this relationship. *[6]*

p156–7 | 4.5.6.1.5 | WS2.1, 3.2,3.5, 3.6 MS1d,4a

13–2 While testing one of the cupcake cases, the student uses a data logger to measure the exact distance that the cupcake case is above the ground each second. **Figure 11** shows the data collected.

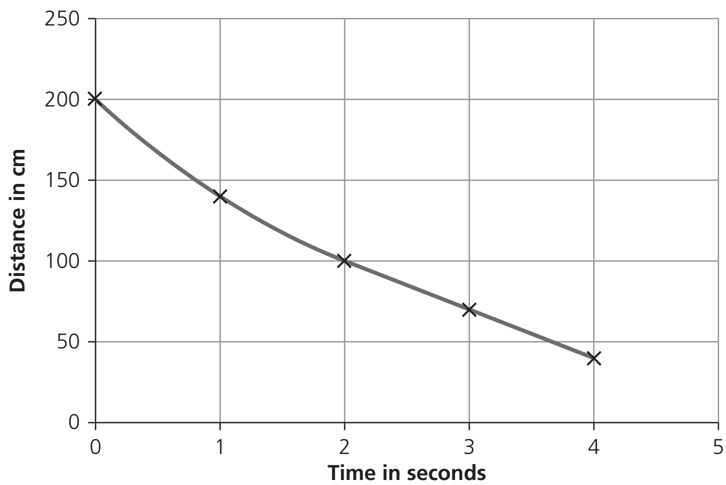


Figure 11

Use **Figure 11** to predict and explain the distance that the cupcake case will be above the ground after 5 seconds and justify this answer. *[3]*

p150 4.5.6.1.4 WS3.3 MS4a,4e H **13–3** Use **Figure 11** to calculate the velocity of the cupcake case in m/s after 0.5 seconds. *[5]*

Total: 14

Forces, accelerations and Newton's laws of motion

Quick questions

p158 4.5.6.2.1 **1** What does Newton's First Law state must be true for an object to be stationary?

p159 4.5.6.2.2 **2** Write down Newton's Second Law in words.

p159 4.5.6.2.2 **3** Write down the equation that links resultant force, mass and acceleration.

p159 4.5.6.2.2 **4** Give the standard units of measure for each of the variables in the equation in question 3.

p159 4.5.6.2.2 **5** What do each of these two symbols mean?

$\propto$	$\sim$

p162 4.5.6.2.3 **6** Write down Newton's Third Law.

p161 4.5.6.2.2 H **7** What is 'inertial mass'?

Exam-style questions

8 A 10 000 kg lorry is waiting at a set of traffic lights. It then accelerates at 0.5 m/s^2.

p159 4.5.6.2.2 WS4.3 MS3c,3d **8–1** Calculate the resultant force acting on the lorry. *[2]*

p159 4.5.6.2.2 **8–2** As it accelerates, two boxes each with a mass of 50 kg fall off the back of the lorry. The resultant force remains constant, explain what will happen to the acceleration of the lorry. *[2]*

p158 4.5.6.2.1 **8–3** After a short time, the lorry travels at a constant speed. Describe the forces, including magnitudes and directions, acting on the lorry in the plane of the lorry's motion. *[3]*

Total: 7

p159–61 4.5.6.2.2 RP7

9 A student wants to investigate the relationship between force and acceleration of a trolley. The student uses a mounted card that has constant mass, and a light gate system that records the velocity of the trolley (**Figure 12**).

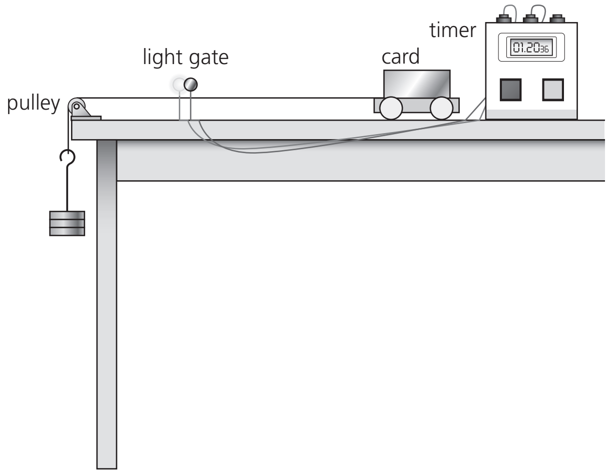


Figure 12

AT1,2,3 WS2.2

9–1 Design a method for the student to use to investigate this relationship. *[5]*

WS2.4

9–2 Give **one** hazard and an appropriate control measure that the student should follow to reduce risks. *[2]*

MS3a

9–3 Which relationship best matches the data that the student should collect? Choose an answer from the options below. *[1]*

$F \propto m$	$F \propto \frac{1}{a}$	$F \propto a$	$a \propto m$

MS2g

9–4 Describe what a graph of this relationship will look like. *[2]*

Total: 10

p158 4.5.6.2.1

10–1 A rocket is stationary awaiting lift off on a launch pad.

Copy and complete these sentences: *[5]*

The rocket is stationary on the launch pad because the resultant force acting on it is __________.

The two forces acting on the rocket are __________ and __________ force.

These forces have the same __________.

This is an example of Newton's __________ Law.

p159 4.5.6.2.2 WS3.3, 4.3 MS1b-c, 3b-d

10–2 The rocket takes off and initially has an acceleration of $5.25\,m/s^2$. The resultant force required to create this acceleration is $1.57 \times 10^7\,N$. Calculate the mass of the rocket to the correct number of significant figures. *[4]*

p159 4.5.6.2.2

10–3 As the rocket rises and burns fuel its acceleration increases despite it having the same resultant force. Suggest with reasons why this happens. *[2]*

p163 4.5.6.2.3

10–4 The rocket's acceleration is due to a Newton's third law pair of forces between the engine and the rocket fuel exhausts. Give **two** features of Newton's third law pair forces. *[2]*

Total: 13

11 A fisherman steps out of a boat. To do so he exerts a force of 30 N onto the boat. This is an example of a third law pair of forces (**Figure 13**).

Figure 13

p162–3 4.5.6.2.3

11–1 Describe the force exerted by the boat on the fisherman. *[2]*

p159 4.5.6.2.2 WS4.3 MS3c,3d

11–2 The boat has a mass of 85 kg and accelerates away from the man at 0.2 m/s². Calculate the resultant force that acts on the boat. *[2]*

p159 4.5.6.2.2

11–3 Calculate the drag acting against the boat. *[1]*

p159 4.5.6.2.2 WS4.3 MS3c,3d

11–4 The man has the same mass as the boat but accelerates at 0.33 m/s². Calculate the resultant force acting on the man. *[2]*

p161 4.5.6.2.2 H

11–5 The man suggests that because he accelerated faster, he has a smaller inertial mass than the boat. Evaluate this statement. *[3]*

Total: 10

Forces and braking

Quick questions

p164 4.5.6.3.1

1 What is 'thinking distance'?

p164 4.5.6.3.1

2 What is 'braking distance'?

p164 4.5.6.3.1

3 Write down the equation that links the stopping distance, thinking distance and braking distance.

p164 4.5.6.3.2

4 Give a typical value of human reaction time.

p165 4.5.6.3.4

5 Copy and complete this sentence.

The greater the speed of the car, the ____________ the braking force required to stop the vehicle in a certain distance.

Exam-style questions

6 A car is travelling along a road and the driver sees a hazard. The car has a stopping distance of 23 m.

p165 4.5.6.3.3

6–1 Give **two** factors that could affect the braking distance. *[2]*

p164 4.5.6.3.1 MS1d

6–2 The car has a braking distance of 14 m. Calculate the thinking distance. *[1]*

p164 4.5.6.3.1

6–3 If the car was moving faster, describe the effect this would have on the thinking distance, braking distance and stopping distance of this car. *[3]*

Total: 6

p164–5 4.5.6.3.2

7 A student wishes to find his laboratory partner's reaction time.

WS2.2,2.3 AT1,2

7–1 Design an experiment that he could perform to measure this reaction time. *[4]*

WS3.7

7–2 Describe how you could improve the reliability of this experiment. *[1]*

7–3 Which **two** factors would increase his partner's reaction time? Choose your answers from the options below. *[2]*

he was tired	he had recently drunk caffeine	the weather conditions	he was chatting to his friend

WS3.5 MS2c

7–4 The graph in **Figure 14** shows how the thinking distance of a car is affected by its speed.

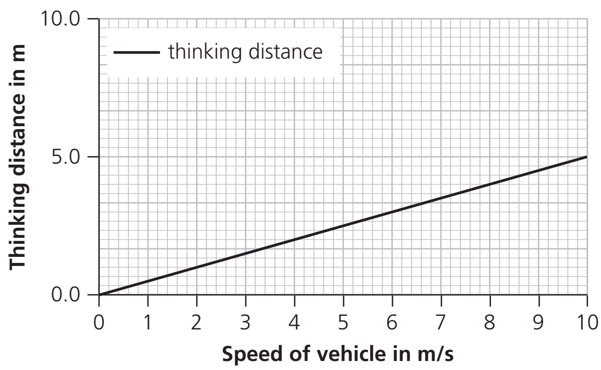


Figure 14

Describe the relationship between thinking distance and speed. *[2]*

7–5 Draw a line on this graph to show how the thinking distance would vary with speed if the driver was tired. *[2]*

Total: 11

8 The graph in **Figure 15** shows how the thinking distance and braking distance of a car change with speed for a certain braking force.

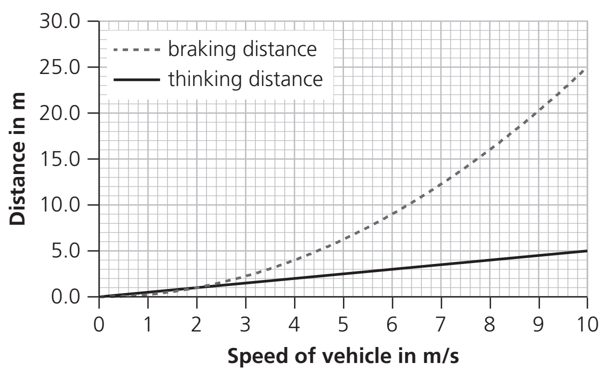


Figure 15

p165 4.5.6.3.3 WS3.5 MS2c **8–1** Describe the relationship between braking distance and speed. *[2]*

p164–5 4.5.6.3.3 **8–2** Describe how the lines on this graph would change if the braking force remained the same but the mass of the car increased. *[2]*

p165 4.5.6.3.4 **8–3** Explain how the braking distance would change at 4 m/s if the brakes were poorly maintained. *[3]*

p164 4.5.6.3.1 WS3.2 MS4a **8–4** Calculate the stopping distance for a car travelling at 4 m/s. *[2]*

p164 4.5.6.3.1 MS2c **8–5** Compare the situation of a car travelling at 4 m/s and your results for question 8–4 to the stopping distance for a car travelling at 8 m/s. *[3]*

Total: 12

9 In France, speed limits for roads change depending on the weather. The speed limits are slower when it is raining.

p165 4.5.6.3.3 WS1.4 **9–1** Describe how rainy weather conditions affect the stopping distances of cars and evaluate whether these variable speed limits are sensible. *[5]*

p165 4.5.6.3.4 **9–2** Explain the energy transfers that take place when a car brakes. *[3]*

p165 4.5.6.3.4 WS1.5 **9–3** A lorry travelling at high speed must perform an emergency stop. Explain the dangers caused by the large braking forces required to do this. *[3]*

p164–5 4.5.6.3.4 WS1.5 MS1d **9–4** When the lorry is travelling at a speed of 14 m/s, a braking force of 9800 N is required to stop the vehicle in 25 m. Estimate, showing your reasons, the braking force required to stop the lorry if it were travelling at 28 m/s and stopped in a distance of 50 m. *[5]*

Total: 16

Momentum

Quick questions

p166 4.5.7.1 H **1** Write down the equation that links momentum, mass and velocity.

p167 4.5.7.1 H **2** Is momentum a vector quantity or a scalar quantity?

p166 4.5.7.1 H **3** Give the units of measure of momentum.

p169 4.5.7.2 H **4** What is ‘the conservation of momentum‘?

p167 4.5.7.3 H **5** What does Δv mean?

Exam-style questions

6 A football is kicked across a football pitch. The football has a mass of 0.4 kg and a velocity of 8m/s.

p166 4.5.7.1 WS4.3 MS1a, 3c,3d **6–1** Calculate the momentum of the football and give the unit of measure. *[3]*

p167 | 4.5.7.3 | WS4.3 MS3b, 3c,3d

6–2 The footballer applied a force of 50 N to the ball when it was stationary to produce this velocity. Use the equation

$$\text{force} = \frac{\text{change in momentum}}{\text{time taken}}$$

to calculate the time taken for this impact. *[3]*

p167 | 4.5.7.3 | WS4.3, 4.6 MS2a, 3c,3d

6–3 The ball rolls along the grass until it comes to a stop, 14 seconds later. The surface applies a constant frictional force. Use the equation above to calculate the frictional force required to bring the ball to rest after it has been struck. Give your answer to the correct number of significant figures. *[3]*

Total: 9

7 A cannon fires a cannonball with a mass of 20 kg and a momentum of 760 kgm/s.

p166 | 4.5.7.1 | WS4.3, MS3b, 3c,3d

7–1 Calculate the velocity of the cannonball. *[3]*

p169 | 4.5.7.2

7–2 As the cannonball is fired, the cannon recoils. Explain why this happens. *[3]*

p169–70 | 4.5.7.2 | WS4.3 MS3b-d

7–3 The cannon has a mass of 700 kg. Calculate its recoil velocity. *[4]*

p167 | 4.5.7.3 | WS4.4, 4.5 MS3c, 3d

7–4 The explosion that causes the firing of the cannonball lasts 4 ms. Use the equation

$$\text{force} = \frac{\text{change in momentum}}{\text{time taken}}$$

to calculate the force exerted by the cannon. *[3]*

Total: 13

p169–70 | 4.5.7.2

8 A teacher wants to demonstrate the conservation of momentum using two light gates, two laboratory trollies or carts and a frictionless track during a lesson.

WS2.2, 2.3 AT1,3

8–1 Design a method that the teacher could use to prove the conservation of momentum. *[5]*

WS3.7

8–2 The frictionless track is not completely level, so the carts are travelling down the slope. This introduces an external force into the system, so it is no longer a closed system.

Describe the effect that this would have on the results. *[2]*

WS4.3 MS3b-d

8–3 The teacher corrects the set up so that the track is level and sends two carts down the track as shown in **Figure 16**.

Figure 16

The two carts stick together when they collide.

Show that the final velocity of the carts is approximately 3 m/s. *[4]*

Total: 11

9 Two cars are travelling along a road, when they collide head on. **Figure 17** shows their motion before the collision.

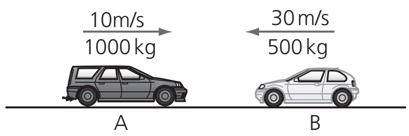


Figure 17

p166 | 4.5.7.1 | WS4.3 MS3c,3d

9–1 Calculate the momentum of car A in **Figure 17**. *[2]*

p169–70 | 4.5.7.2 | WS4.3 MS3b-d

9–2 Upon collision the two cars stick together.
Calculate the final velocity of the two cars and state the direction. *[5]*

p169–70 | 4.5.7.2 | WS4.3 MS3b-d

9–3 Calculate the exact velocity that car A would need to travel at for both cars to end up stationary at the end of the collision. Assume the initial momentum of car B remains the same as in **Figure 17**. *[3]*

p168 | 4.5.7.3 | QWC

9–4 Explain how the crumple zones inside both cars reduce the injuries to passengers during these collisions. *[4]*

Total: 14

Forces topic review

1 A student is measuring the frictional force from different surfaces.

p119 | 4.5.1.2

1–1 Copy and complete these sentences. Choose your answers from the options below. *[2]*

contact force	non-contact force	stops	moves

Friction acts between the trolley and the surface when the trolley ___________.

Friction is an example of a ___________.

p119&122 | 4.5.1.4 | WS1.2 | H

1–2 **Figure 18** shows a trolley placed on a friction surface attached to a newtonmeter.

Label the forces (1)–(3). *[3]*

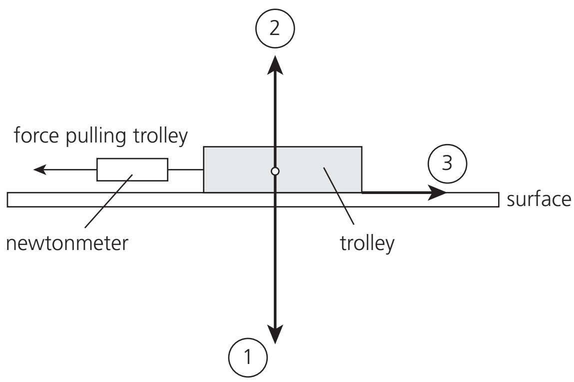


Figure 18

p119 4.5.1.2

1–3 **Table 3** shows the results from the experiment.

The teacher suggests that the student should use a bar chart to display the data in **Table 3**.

Explain why this is the correct way to display the data. *[1]*

Material	Frictional force in N
Smooth desk	2.0
Bricks	2.9
Marble surface	1.0
Concrete	3.0

Table 3

p119 4.5.1.2 WS3.1, 3.2,3.3 MS2c

1–4 Draw a bar chart to show how the material affects the frictional force. *[4]*

p120, 121&158 4.5.1.4& 4.5.6.2.1

1–5 The frictional force is recorded on the newtonmeter when the trolley is travelling at a constant speed. Explain why the trolley must be travelling at a constant speed for the reading to be accurate. *[2]*

Total: 12

2 A motorcyclist makes a journey between their home and place of work. They travel a total distance of 14 km in 12 minutes.

Figure 19 shows a distance–time graph of this journey.

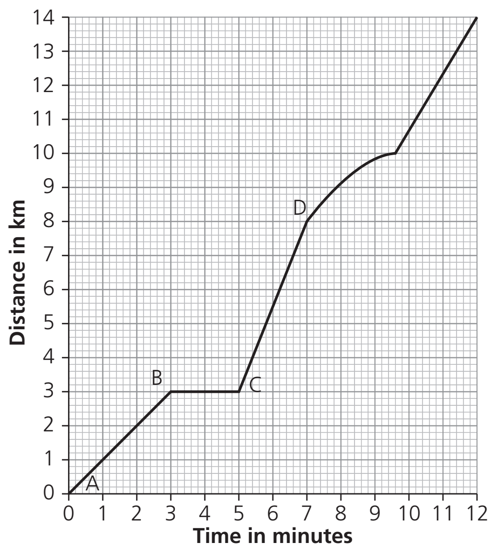


Figure 19

p149–50 4.5.6.1.4 WS3.2

2–1 Describe the motorcyclist's motion between points A and C. *[2]*

p149–50 4.5.6.1.4 WS3.2, 3.3,4.4 MS4a,4d

2–2 Calculate the motorcyclist's speed at 6 minutes in km/minute. *[3]*

2–3 Calculate the average speed of the motorcyclist in m/s. *[3]*

p148 4.5.6.1.2 WS4.3-5

2–4 At point B on **Figure 19**, the motorcyclist made an emergency stop. Give **two** factors that will affect the motorcyclist's braking distance. *[2]*

p165 4.5.6.3.3

p15–159 4.5.6.2.2

2–5 Give the equation that links resultant force, mass and acceleration. *[1]*

p15–159 4.5.6.2.2 WS4.6 MS2a, 3c,3d

2–6 When performing the emergency stop, the motorcyclist decelerated at 6.8 m/s^2. The motorcycle and motorcyclist have a combined mass of 410 kg. Calculate the resultant force on the motorcycle to the correct number of significant figures. *[3]*

Total: 14

3 A librarian lifts a pile of 12 books up onto a high shelf in the library. The books each have a weight of 2.45 N.

The book shelf is 1.8 m above the ground.

p124 4.5.2 — **3–1** Write down the equation that links work done, force and distance. *[1]*

p124 4.5.2 — **3–2** Define 'one joule of work'. *[1]*

p124 4.5.2 WS4.2 — **3–3** Which unit is equivalent to 1 joule? Choose your answer from the options below. *[1]*

Nm	N/m	Ncm	N/cm

p124 4.5.2 MS1a, 3c,3d — **3–4** Calculate the work done in joules by the librarian when placing the books on the book shelf. *[3]*

p153 4.5.6.1.5 MS1a, 3c,3d — **3–5** One of the books falls off the shelf. The acceleration due to gravity is 9.8 N/kg. Use the equation

$$(\text{final velocity})^2 - (\text{initial velocity})^2 = 2 \times \text{acceleration} \times \text{distance}$$

to calculate the speed at which the book hits the ground. *[3]*

Total: 9

4 A student designs an experiment to investigate the relationship between force and extension for a thin glass rod.

The student adds masses of 100 g to the glass rod and measures the extension.

p126–7 4.5.3 WS2.2, 2.3 RP6 AT1,2 — **4–1** Describe how the student can measure the extension of the thin glass rod. *[3]*

p120 4.5.1.3 — **4–2** Write down the equation that links weight, mass and gravitational field strength. *[1]*

p120 4.5.1.3 WS4.3, 4.4,4.5 MS1a, 3c,3d — **4–3** The gravitational field strength is 9.8 N/kg. Show that each 100 g mass adds approximately 1 N of weight to the thin glass thread. *[3]*

p126–7 4.5.3 — **4–4** **Figure 20** shows a graph of the force and extension measured by the student.

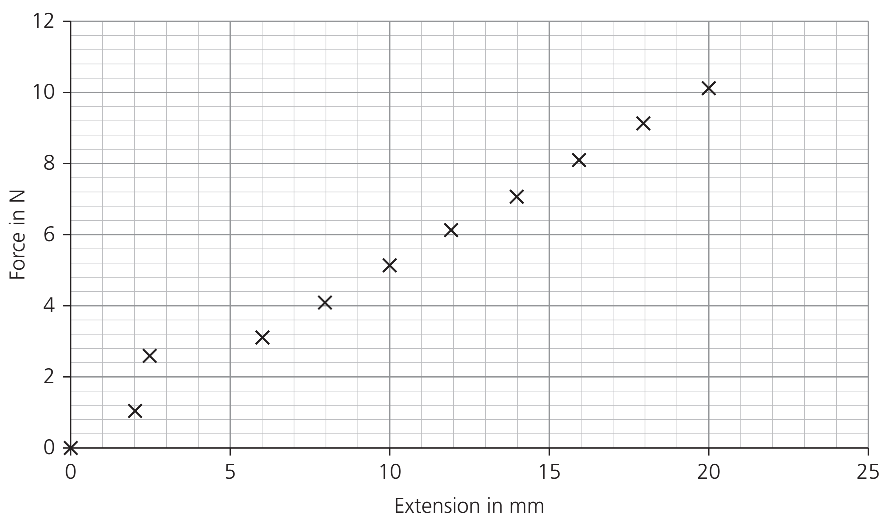


Figure 20

Identify the anomalous point on **Figure 20**. *[1]*

p127 | 4.5.3 | WS3.2, 3.3 | MS4a,4d

4–5 Use **Figure 20** to calculate the spring constant of the glass rod between 0 and 10 N. *[3]*

p126–7 | 4.5.3 | WS4.2, 4.4

4–6 Which is the correct unit of measure for the spring constant of the glass rod? Choose your answer from the options below. *[1]*

Nm	g/m	Nmm	N/mm

p126 | 4.5.3

4–7 The thin glass rod experiences elastic deformation. Define 'elastic deformation'. *[2]*

Total: 14

5 **Figure 21** shows a simple moments system with a 1 m long beam.

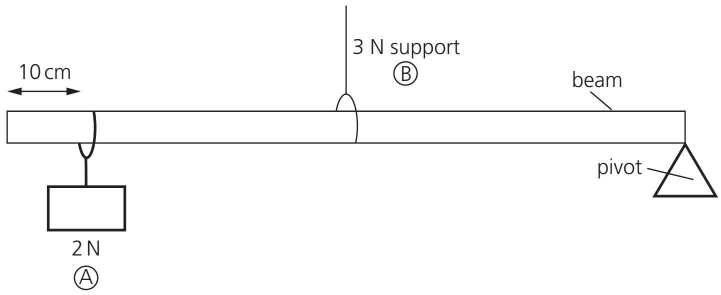


Figure 21

p131 | 4.5.4

5–1 The system is balanced. Describe what is meant by 'balanced'. *[1]*

p129 | 4.5.4

5–2 Write down the equation that links moment of a force, force and distance. *[1]*

p129 | 4.5.4 | WS1.2, 4.4,4.5 | MS1a, 3c,3d

5–3 Calculate the moment of the weight, A, about the pivot in **Figure 21**. Give the unit of measure. *[4]*

p131–2 | 4.5.4 | WS1.2, 3.3 | MS1a, 3b-d

5–4 Use **Figure 21** to calculate the distance from the pivot to the support B. *[4]*

Total: 11

6 A pitcher in a baseball game throws a ball towards the batter.

p152 | 4.5.6.1.5

6–1 Write down the equation that links acceleration, change in velocity and time taken. *[1]*

p152 | 4.5.6.1.5 | WS4.2, 4.3 | MS1a, 3c,3d

6–2 Professional pitchers aim to throw the ball with a speed of 45 m/s. The ball accelerates to this speed from rest in 0.03 seconds.

Calculate the acceleration of the baseball and give the unit of measure for acceleration. *[3]*

p167 | 4.5.7.3 | WS4.3, 4.4,4.5 | MS1a, 3c,3d | H

6–3 The baseball has a mass of 145 g.

Use the equation

$$\text{force} = \frac{\text{change in momentum}}{\text{time taken}}$$

to calculate the force applied by the pitcher. *[3]*

p119 | 4.5.1.2

6–4 Describe the forces that act on the ball as it travels to the batter. *[2]*

p168 4.5.7.3 H **6–5** Explain how the batter's helmet is designed to protect him should the baseball hit him. Reference the rate of change of momentum in your answer. *[4]*

Total: 13

7 An ice skater is travelling around the outer edge of a circular ice rink in a relay race.

p148–9 4.5.6.1.2 QWC WS2.2, 2.3,2.5 **7–1** Describe a method that an observer could use to calculate the ice skater's average speed for one lap. Include a strategy to improve the accuracy of this measurement. *[6]*

p149 4.5.6.1.3 H **7–2** Explain how the ice skater can have a constant speed, but changing velocity. *[2]*

p162–3 4.5.6.2.3 **7–3** The ice skater applies a force to the ice and the ice applies a force on the skater. This is an example of Newton's Third Law. Describe **two** features of this Newton's third law pair of forces. *[2]*

p122–3 4.5.1.4 WS1.2 MS5b H **7–4** **Figure 22** shows the force from the ice on the ice skater. Copy and complete **Figure 22** to show the vertical and horizontal components of this force. *[2]*

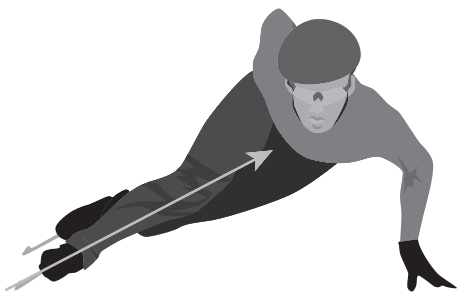


Figure 22

p166 4.5.7.1 H **7–5** After the corner, the ice skater travels with a velocity of 12 m/s and has a mass of 70 kg.

Write down the equation that links momentum, mass and velocity. *[1]*

p166 4.5.7.1 MS3c, 3d H **7–6** Calculate the momentum of the ice skater. *[2]*

p169–70 4.5.7.2 WS3.3 MS3b-d H **7–7** The ice skater pushes his team mate. His team mate has a mass of 75 kg and is stationary. After the push the first ice skater has a velocity of 4 m/s. Calculate the velocity of the second ice skater. *[4]*

Total: 19

6 Waves

Waves in air, fluids and solids

Quick questions

p181	4.6.1.1		1	What is a 'transverse wave'?
p182	4.6.1.1		2	What is a 'longitudinal wave'?
p183	4.6.1.2		3	What is the 'amplitude' of a wave?
p183	4.6.1.2		4	What is the 'wavelength' of a wave?
p184	4.6.1.2		5	Write down the equation that links wave speed, frequency and wavelength.
p183–4	4.6.1.2		6	What are the units of frequency?
p189	4.6.1.3		7	Give the law of reflection.
p189	4.6.1.3		8	What is a 'virtual image'?
p191	4.6.1.4	H	9	What is the normal range of frequencies for human hearing?
p191–2	4.6.1.5	H	10	What is 'ultrasound'?
p192	4.6.1.5	H	11	Give the states of matter that P-waves can travel through.
p192	4.6.1.5	H	12	Give the states of matter that S-waves can travel through.

Exam-style questions

p181–2 4.6.1.1

13–1 Which **two** of these waves are transverse? Choose your answers from the options below. *[2]*

light	sound	ultraviolet	P-waves

p181–2 4.6.1.1

13–2 Describe the differences between transverse and longitudinal waves. *[2]*

p183 4.6.1.2

13–3 **Figure 1** shows a wave as it travels across the sea.

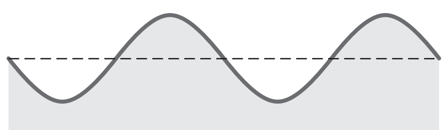


Figure 1

Copy **Figure 1** and draw the wavelength of the wave. Mark this distance W. *[1]*

p183 4.6.1.2

13–4 Complete **Figure 1** by drawing the amplitude of the wave. Mark this distance A. *[1]*

Total: 6

p188–90 4.6.1.3

14–1 Draw a diagram showing the reflection of light on a mirrored surface. Label each of the following: the incident ray, the reflected ray, the normal, the angle of incidence, the angle of reflection. *[5]*

p188–9 4.6.1.3

14–2 Copy and complete the sentences below: *[4]*

The normal is a line drawn at __________ to the boundary.

The angle of incidence is measured between the incident ray and the ____________, and the angle of reflection is measured between the reflected ray and the _____________.

When light is reflected from the mirror, the angle of incidence ___________ the angle of reflection.

p188–90 4.6.1.3

14–3 The mirror drawn in your diagram (question 14–1) is replaced with a sheet of black paper. Explain what happens to the light at this new boundary. *[2]*

Total: 11

15 A student carries out an experiment to measure the speed of sound in air. He stands 30m away from a tall building and bangs two blocks together. Each time he hears the echo from the building he immediately bangs the blocks together again. He asks a friend to time how long it takes to hear 10 echoes. They do this three times. They then repeat this experiment at two different distances from the building.

Table 1 shows their data.

	Time in seconds		
Distance in metres	**Trial 1**	**Trial 2**	**Trial 3**
30	1.88	1.73	1.82
35	2.10	2.34	1.98
40	2.36	2.45	2.46

Table 1

p190 4.6.1.3

15–1 Explain how an echo is formed. *[2]*

p185 4.6.1.2 WS4.3 MS3f

15–2 Calculate the mean of the time measured at 40 m. *[1]*

p185 4.6.1.2 WS3.4

15–3 Calculate the uncertainty of this measurement. *[2]*

p185 4.6.1.2 WS4.3 MS3c,3d

15–4 Calculate the speed of sound as measured 40 m from the building. *[3]*

p185 4.6.1.2 WS3.4

15–5 The time measured has a range of values at each distance. Name the type of error that causes this range. *[1]*

p185 4.6.1.2 WS2.3

15–6 The student's friend suggests that a more accurate approach would be to complete this experiment in the laboratory using a loudspeaker and oscilloscope.

Give the piece of apparatus that he would need to plug into the oscilloscope to detect the sound waves. *[1]*

p183–4 4.6.1.2 WS2.2

15–7 Design a method using this equipment to measure the speed of sound in the laboratory. *[5]*

Total: 15

16 A student is producing a longitudinal wave with a slinky, as shown in **Figure 2**.

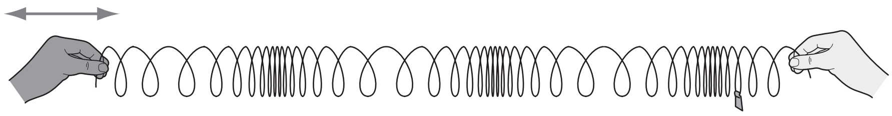


Figure 2

p182 | 4.6.1.1

16–1 Copy **Figure 2** and label it with a C where a compression is shown, and an R where a rarefaction is shown. *[2]*

p184 | 4.6.1.2 | WS4.4, 4.5 | MS1a, 3c,3d

16–2 The longitudinal wave produced has a frequency of 0.5 Hz, and a wavelength of 15 cm. Calculate the speed of the wave and give an appropriate unit of measure. *[3]*

p184 | 4.6.1.2

16–3 Define 'wave speed'. *[2]*

Total: 7

17 **Figure 3** shows a ripple tank used to demonstrate water waves.

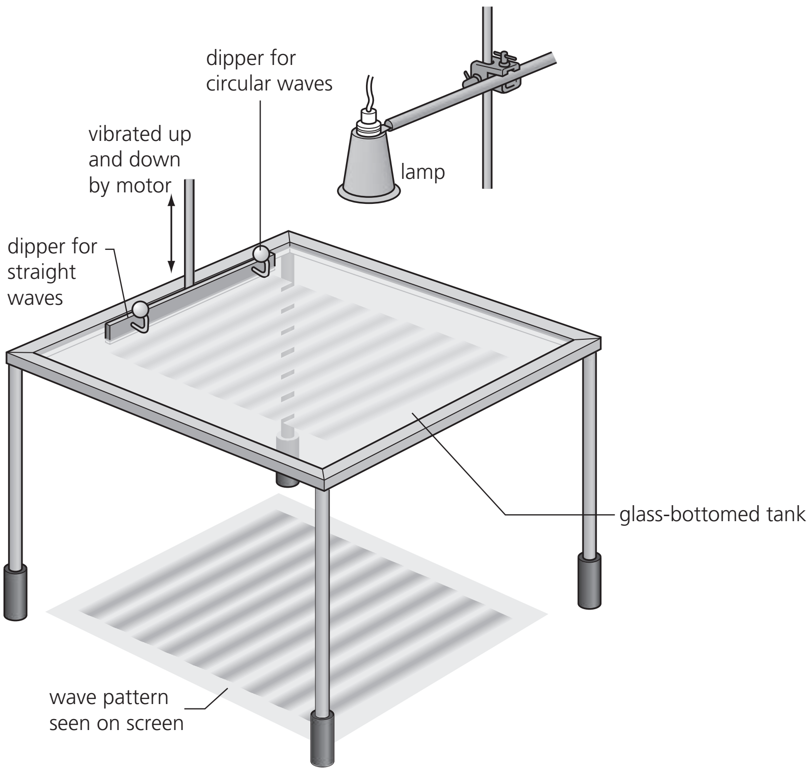


Figure 3

p183–4 | 4.6.1.2 | WS2.2 | QWC

17–1 Design a method to measure the speed of the waves in the ripple tank. You should describe the measurements that you would take. *[6]*

p181 | 4.6.1.1

17–2 Give **one** piece of evidence that shows that it is the wave and not the water itself that travels across the ripple tank. *[1]*

p184 | 4.6.1.2 | WS4.3, 4.4,4.5 | MS3b-d

17–3 The wavespeed of the waves is measured to be 0.12 m/s and the wavelength is 4.4 cm. Show that the frequency of the waves is approximately 3 Hz. *[4]*

p183 4.6.1.2 WS4.3 MS3c,3d

17–4 Use the equation

$$\text{period} = \frac{1}{\text{frequency}}$$

to calculate the time period of the waves in the ripple tank. *[2]*

Total: 13

p188–90 &197 4.6.1.3

18 A student is investigating how the angle of reflection varies with angle of incidence for a plane mirror.

WS2.2 QWC **18–1** Design a method the student can use to investigate this relationship. *[6]*

WS2.7, 3.4 **18–2** Suggest **one** source of inaccuracy in the measurements taken. *[1]*

WS3.1, 3.2 MS4a, 4c **18–3** **Table 2** shows the data the student collects.

Angle of incidence in °	Angle of reflection in °
10	11
20	19
30	30
40	50
50	51
60	60
70	70

Table 2

Plot a graph of this data. *[5]*

WS3.7 **18–4** Identify the anomalous point. *[1]*

WS3.1 **18–5** Draw a line of best fit. *[1]*

MS2g, 4b **18–6** Describe the relationship shown on the graph. *[2]*

Total: 16

p191 4.6.1.4 H **19–1** Which **one** of the statements below is incorrect? *[1]*

Sound waves are longitudinal waves.	Sound waves can travel through solids, liquids and gases causing vibrations.	Sound waves can travel through a vacuum.	Sound waves have a frequency and wavelength.	Sound waves are made up of compressions and rarefactions.

19–2 Describe how sound waves are transmitted through the ears to create signals in the brain. *[3]*

19–3 Explain why the process of hearing sound waves only works over a limited frequency range for humans. *[2]*

Total: 6

20 A fishing boat uses ultrasound to detect the depth of the sea bed and shoals of fish.

p192 4.6.1.5 WS2.2 H **20–1** Describe how the boat uses the ultrasound to detect the depth of the sea bed. *[4]*

p184 | 4.6.1.2 | WS4.3, 4.4,4.5 MS3b-d

20–2 The speed of the ultrasound in water is 1500 m/s and the frequency used is 30 kHz. Calculate the wavelength of these waves. *[4]*

p192 | 4.6.1.5 | WS4.3 MS1a, 3b-d | H

20–3 It takes 0.4 seconds for the ultrasound to be emitted and received. Calculate the distance between the sea bed and the boat. *[3]*

p191 | 4.6.1.5 | H

20–4 Ultrasound is also used in many medical applications, as it is a very safe imaging technique. Describe what happens to the ultrasound waves when they reach a boundary between two different media. *[2]*

Total: 13

p192 | 4.6.1.5

21 Seismic waves are produced by earthquakes. They can cause lots of damage to buildings.

21–1 Describe how the seismic waves cause damage to buildings. *[1]*

H **21–2** Compare the path of P-waves and S-waves through the Earth. *[5]*

WS1.1 H **21–3** Give **one** reason why the study of seismic waves is important. *[1]*

H **21–4** Explain why it is important to have many monitoring stations around the world to identify the exact location of a seismic event. *[3]*

Total: 10

Electromagnetic waves

Quick questions

p194 | 4.6.2.1 — **1** List the groups that form the electromagnetic spectrum.

p194 | 4.6.2.1 — **2** Name the group of waves in the electromagnetic spectrum that eyes are able to detect.

p195 | 4.6.2.2 — **3** When does refraction occur?

p199 | 4.6.2.3 — **4** What is 'radiation dose'?

p205 | 4.6.2.5 — **5** Why does magnification not have a unit?

p203 | 4.6.2.5 — **6** Draw diagrams to show how:

- a convex lens
- a concave lens

are represented in ray diagrams.

p203 | 4.6.2.5 — **7** What is the 'principal focus' of a lens?

p208 | 4.6.2.6 — **8** Which colour of light in the visible spectrum has the longest wavelength?

p209 | 4.6.2.6 — **9** What colour does an object appear if all wavelengths of light are absorbed?

p209 | 4.6.2.6 — **10** What is a 'transparent object'?

Exam-style questions

11 Visible light is an example of an electromagnetic wave.

p194 | 4.6.2.1

11–1 Which **two** of these statements describe electromagnetic waves? *[2]*

Electromagnetic waves are longitudinal	Electromagnetic waves are transverse	Electromagnetic waves travel at the same speed through a vacuum	Electromagnetic waves cannot travel through a vacuum

p194 4.6.2.1 **11–2** Name the group of electromagnetic waves that have the longest wavelength. *[1]*

p201 4.6.2.4 **11–3** Give **one** use of gamma rays. *[1]*

p199 4.6.2.3 **11–4** Give **one** danger of gamma rays. *[1]*

p199 4.6.2.3 **11–5** Describe how gamma rays are produced. *[1]*

Total: 6

12 Four groups of the electromagnetic spectrum are given below.

visible	X-rays	ultraviolet	microwaves

p194 4.6.2.1 **12–1** List these groups in order, from lowest to highest frequency. *[4]*

p200–1 4.6.2.4 **12–2** Identify which group of the electromagnetic spectrum matches each of the following uses. *[4]*

Treating cancers	Sun tanning	Optical fibre communication	Cooking food

p199 4.6.2.3 **12–3** Give **one** danger of ultraviolet waves. *[1]*

Total: 9

p203–6 4.6.2.5 **13** A student is investigating refraction through a convex lens.
Figure 4 shows multiple parallel rays of light incident on the lens.

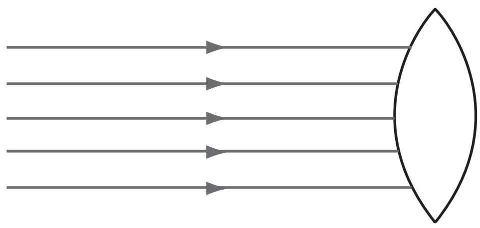


Figure 4

WS1.2 MS5b **13–1** Copy and complete **Figure 4** to show the path of these rays of light. *[3]*

WS1.2 **13–2** Label the principal focal point on your diagram with the letter F. *[1]*

13–3 Name the distance between the lens and the principal focus. *[1]*

13–4 Convex lenses can produce real images. Define the term 'real image'. *[1]*

WS1.2 **13–5** The student replaces the convex lens with a concave lens. The concave lens produces a virtual focus.

Copy and complete **Figure 5** to show where the virtual focus is found. *[4]*

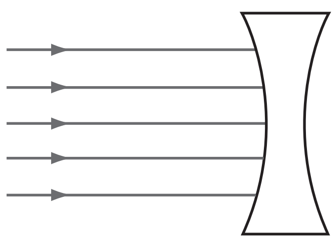


Figure 5

Total: 10

p208–9 4.6.2.6

14 Specular and diffuse reflection are different types of reflection.

14–1 Compare specular and diffuse reflection. Include a reference to type of boundary surface. *[4]*

14–2 White light is incident on a red poppy. Explain why the poppy appears red. *[3]*

14–3 A blue filter is placed in front of the white light. Describe what happens to the white light. *[2]*

14–4 This filtered light is now incident on the red poppy. What colour will the poppy now appear? Explain your answer. *[3]*

Total: 12

p203–6 4.6.2.5

15 A convex lens is used as a part of a telescope. **Figure 6** shows a ray diagram for a convex lens where the object is beyond the principal focus.

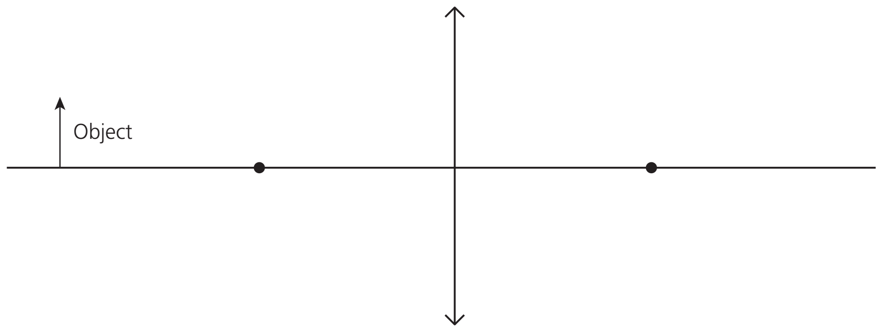


Figure 6

WS1.2 MS5b

15–1 Copy **Figure 6** and complete the ray diagram to identify the position of the image produced. *[4]*

15–2 Describe the image produced by the telescope. *[3]*

WS1.2 MS5b

15–3 A similar lens is used as an eyepiece, which magnifies the object. **Figure 7** shows an incomplete ray diagram for this lens.

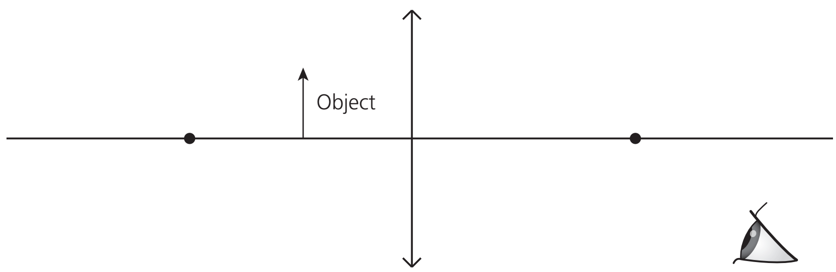


Figure 7

Copy **Figure 7** and complete the ray diagram to identify the position of the image produced. *[4]*

15–4 Compare this image to the image in question 15–2. *[3]*

WS3.3, 4.3 MS3c,3d

15–5 The object has a height of 9mm and the image has a height of 22 mm.

Use the equation

$$\text{magnification} = \frac{\text{image height}}{\text{object height}}$$

to calculate the magnification of the image. *[2]*

Total: 16

16 Infrared cameras can be used to take photographs of objects at night.

p200 4.6.2.4 16–1 Give **one** other use of infrared radiation. [1]

p195 4.6.2.2 H 16–2 Some objects are better absorbers of infrared radiation than others. Define the term 'absorbs'. [1]

p202 4.6.2.2 RP10 16–3 A student is investigating the emission of infrared radiation in the laboratory using hot water and three different covered tins: a black matt tin, a silver shiny tin and a white matt tin.

Which of the tins will be the best emitter of infrared radiation? [1]

p202 4.6.2.2 RP10 AT1,4 WS2.2, 2.3 16–4 Plan an experiment that the student could carry out to identify which surface is the best emitter of infrared radiation. Describe how the student will know which is the best emitter. [5]

p202 4.6.2.2 RP10 16–5 Name the type of graph that would be most appropriate to display the data collected. [1]

Total: 9

17 Radio waves and X-rays are both electromagnetic waves.

p194 4.6.2.1 17–1 Compare the properties of radio waves and X-rays. [4]

p198–9 4.6.2.3 H 17–2 Describe how radio waves are produced on Earth. [2]

p200 4.6.2.4 H 17–3 Give **one** use of radio waves. Explain why radio waves are used for this purpose. [3]

p199 4.6.2.3 17–4 X-rays can be used for medical imaging purposes, but they are also hazardous. Give **one** danger that they pose to the human body. [1]

p199 4.6.2.3 WS1.4, 1.5 17–5 A patient requires a chest X-ray. **Table 3** shows the dose received by the human body in a variety of situations.

Situation	Dose received by the body in millisieverts
Chest X-ray	0.014
Dental X-ray	0.005
Annual UK dose from natural sources	2.7
Transatlantic flight	0.08

Table 3

The patient is worried about the risk to their health from the chest X-ray. They claim that the chest X-ray is too dangerous.

Use the data in the table to evaluate the risk associated with a chest X-ray. [4]

Total: 14

p195–6 4.6.2.2 18 A student is investigating how light is transmitted from the air through a rectangular transparent glass block and back to the air.

WS1.2 MS5b 18–1 Copy and complete **Figure 8** to show the path of the light. [2]

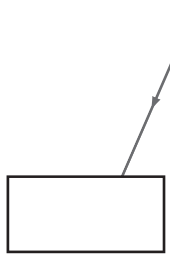


Figure 8

H **18–2** Explain why refraction occurs as the light travels from air into the glass. *[2]*

WS1.2 H **18–3** **Figure 9** shows a wave front diagram of refraction occurring in water.

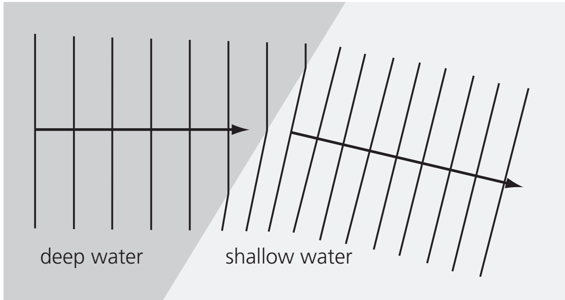


Figure 9

Explain how **Figure 9** shows refraction. Use the terms wavelength and wave speed in your explanation. *[3]*

Total: 7

Black body radiation

Quick questions

p210 4.6.3.2 **1** What happens to the wavelength of visible light emitted by an object when the temperature increases?

p211 4.6.3.2 **2** Define 'intensity'.

p212 4.6.3.2 H **3** What effect do clouds have on infrared radiation?

Exam-style questions

p210 4.6.3.1 **4–1** Describe what happens to radiation incident on a perfect black body. *[1]*

p210 4.6.3.2 H **4–2** Copy and complete these sentences. Choose your answers from the options below. *[5]*

transmitter	reflector	emitter	transmit	reflect
emit	increasing	decreasing	constant	

A black body is not only a very good absorber, it is also a very good _____________.

A black body does not __________ or ___________ any radiation.

If a perfect black body absorbs 1000 J of radiation a second, it will also ________ 1000 J of radiation a second.

This means its temperature is _________.

p211 4.6.3.2 H **4–3** A cold jacket potato is placed in an oven at 200 °C. It is not a perfect black body. Explain why the potato's temperature increases. *[2]*

Total: 8

5 **Figure 10** shows how the temperature of water varies with time as it cools in a laboratory.

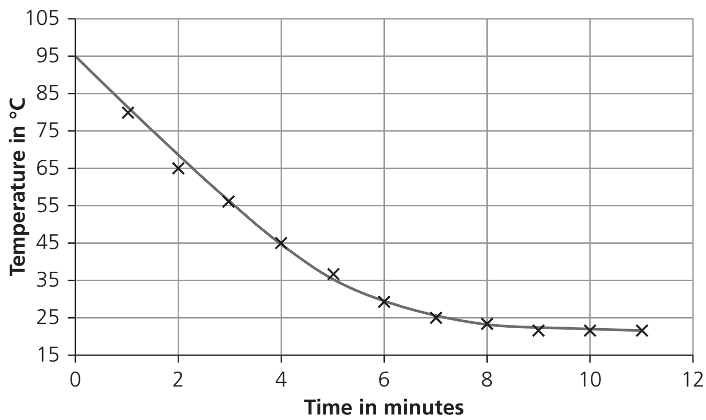


Figure 10

p210 | 4.6.3.1 | WS3.5

5–1 Describe how **Figure 10** shows that the rate of infrared radiation emission is highest at the start of the experiment. *[1]*

p211 | 4.6.3.2 | WS2.1 | H

5–2 Explain why the temperature decreases between 0 and 8 minutes. *[3]*

p211 | 4.6.3.2 | WS2.1 | H

5–3 After 8 minutes the temperature is constant. Explain why the water remains at a constant temperature. *[2]*

p211 | 4.6.3.2 | WS2.2 | H

5–4 The student repeats the experiment to investigate how long it takes the water to cool from an initial temperature of 80 °C. Give **two** control variables needed. *[2]*

p211 | 4.6.3.2 | H

5–5 Copy **Figure 10,** and sketch a line to predict how the water will cool if it starts at 80 °C rather than 95 °C. *[3]*

Total: 11

Waves topic review

p181, 192&194 | 4.6.1.2

1–1 Visible light is a transverse wave. Give another example of a transverse wave. *[1]*

p181& 194 | 4.6.1.1& 4.6.2.1

1–2 Copy and complete the sentences. Choose your answers from the options below. *[6]*

colour	energy	matter	eyes	solid	electromagnetic
ears	air	radio waves	vacuum	ultraviolet	

We detect light using our _______. Light is a part of the ________________ spectrum.

This group of waves transfer __________ from the source to an absorber.

__________ have a longer wavelength than visible light but ___________ has a shorter wavelength.

These waves all travel at the same speed through a __________.

p200 | 4.6.2.4

1–3 Give **one** use of ultraviolet light. *[1]*

Total: 8

2 **Figure 11** is an incomplete reflection ray diagram from a plane mirror.

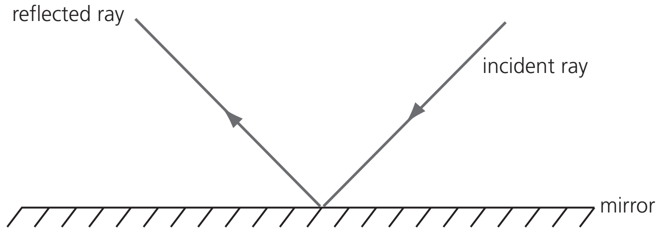


Figure 11

p188–9 | 4.6.1.3 | WS1.2

2–1 Copy **Figure 11** and draw a normal line for the site of reflection. Label this line N. *[1]*

p188–9 | 4.6.1.3 | WS1.2

2–2 Label the angle of incidence, *i*, and the angle of reflection, *r*, on your diagram from question 2–1. *[2]*

p208 | 4.6.2.6

2–3 **Figure 11** is an example of specular reflection. Describe what diffuse reflection is. *[2]*

p209 | 4.6.2.6

2–4 The mirror is replaced by a transparent block of glass. Define the term 'transparent'. *[1]*

p190, 195–6 | 4.6.1.3& 4.6.2.2

2–5 Describe what happens to the light when it reaches the air–glass boundary. Use the terms reflect, transmit and refract in your answer. *[3]*

Total: 9

p183–7 | 4.6.1.2

3 **Figure 12** shows a wave on a string. The central, dashed line is the undisturbed (or equilibrium) line.

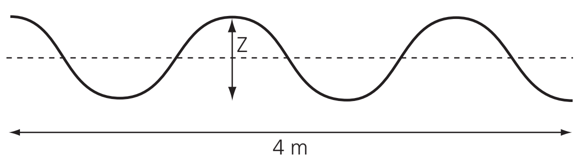


Figure 12

WS1.2

3–1 Describe what label Z represents. *[1]*

3–2 Copy **Figure 12** and draw on the wavelength. Mark this W. *[2]*

WS1.2

3–3 The total length of the string shown in **Figure 12** is 4 m. Calculate the wavelength of the waves on the string. *[3]*

WS4.2

3–4 Which of the units of measure below corresponds to frequency? *[1]*

seconds	metres	hertz	joules	metres/second

RP8 | AT1,4 | WS2.2, 2.3 | QWC

3–5 Design a method to calculate the speed of the waves on a string. *[6]*

Total: 13

4 A student is investigating visible light and colour. She directs a white beam of light towards a green filter.

p209 4.6.2.6 **4–1** Explain how the green filter works. *[2]*

p209 4.6.2.6 **4–2** **Figure 13** shows a white block placed behind the green filter.

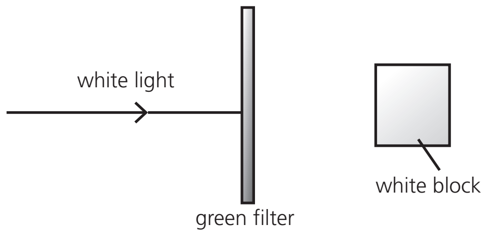


Figure 13

Explain the appearance of the white block through the green filter. *[2]*

p209 4.6.2.6 **4–3** The white block is swapped with a red block. Explain the red block's appearance through the green filter. *[4]*

p196 4.6.2.2 WS1.2 **4–4** A student directs a white ray of light towards a glass triangular prism. The light on the other side is dispersed and split into the different colours of the spectrum. **Figure 14** shows the apparatus set up.

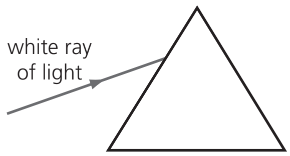


Figure 14

Copy **Figure 14** and draw the ray inside the prism. *[1]*

p194 &200 4.6.2.1& 4.6.2.4 WS2.1 **4–5** The student then placed thermometers in each of the different colours of light coming from a triangular prism, and one thermometer just outside the red region of light.

Suggest why the thermometer outside the red part of the colour spectrum had the highest temperature. *[1]*

Total: 10

5 Ultraviolet waves and microwaves are both groups in the electromagnetic spectrum.

p194 4.6.2.1 **5–1** Compare the properties of ultraviolet waves and microwaves. *[4]*

p199 4.6.2.3 **5–2** Ultraviolet waves can have a hazardous effect on the human body. Give **one** danger of ultraviolet waves. *[1]*

p199 4.6.2.3 **5–3** X-rays and gamma rays are examples of ionising radiation. Scientists measure radiation dose in sieverts, Sv.

Define the term 'radiation dose'. *[1]*

p199 4.6.2.3 WS4.4, 4.5 **5–4** The average annual radiation dose in the UK is 2.7 mSv. Calculate this dose in Sv. *[1]*

p184 4.6.1.2 **5–5** Write down the equation that links wave speed, frequency and wavelength. *[1]*

p184 4.6.1.2 WS3.3 MS1b, 3b-d **5–6** The wavelength of a particular X-ray is 3×10^{-9} m. It has a wave speed of 3.0×10^{8} m. Calculate its frequency in Hz. *[3]*

Total: 11

p203–6 4.6.2.5

6 Lenses form images by refracting light.

6–1 Compare the path of parallel light incident on convex and concave lenses and describe the types of images that they can form. You may draw a diagram to help. *[4]*

WS3.3 **6–2** A convex lens has a magnification of ×2. The object that is being tested has a height of 25 mm.

Use the equation

$$\text{magnification} = \frac{\text{image height}}{\text{object height}}$$

to calculate the image height. *[3]*

WS1.2 MS5b **6–3** The real image from the lens in question 6–2 is found 9.5 cm from the lens. Draw a diagram to show how this image is formed. *[4]*

WS1.2 MS1d **6–4** Estimate, from your diagram, the focal length of the lens. *[1]*

Total: 12

p195–8 4.6.2.2

7 A student is investigating refraction. **Figure 15** shows their apparatus set up.

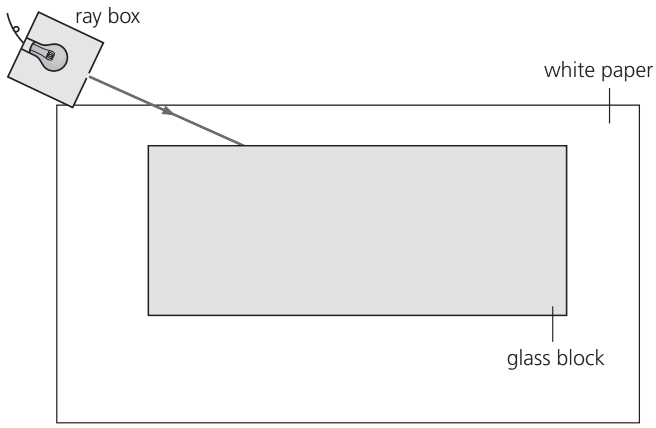


Figure 15

WS1.2 **7–1** Copy and complete **Figure 15** to show the path of the ray of light. (You do not have to draw the ray box.) *[2]*

H **7–2** Explain why refraction occurs. *[2]*

RP9 AT4,8 WS2.2 QWC **7–3** The student wants to investigate how the angle of refraction is dependent on the angle of incidence. Design a method to measure these angles. *[6]*

WS1.5 **7–4** Give **one** safety precaution that the student should take when completing the experiment. *[1]*

Total: 11

p192 4.6.1.5

H 8 Seismic waves are produced by earthquakes. There are two types of seismic wave. **Figure 16** shows the path of P-waves and S-waves from an earthquake.

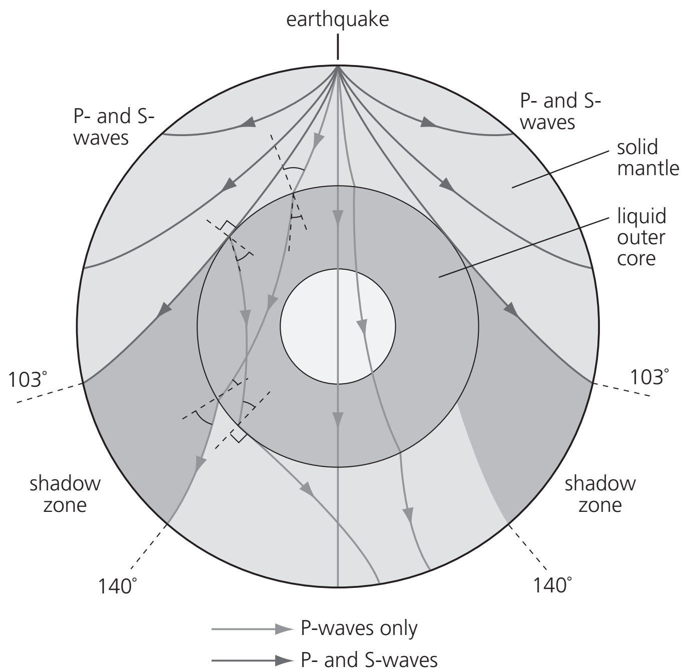


Figure 16

8–1 Compare P-waves and S-waves. *[2]*

8–2 A seismic monitoring station only detects a P-wave from the earthquake. The staff assume that they are far away from the earthquake. Explain why they make this assumption. *[3]*

8–3 Shadow zones are where no seismic waves can be detected. State why S-waves can't reach these locations. *[1]*

8–4 Explain, using the ideas of refraction, why P-waves cannot reach the shadow zones. *[3]*

Total: 9

p210–12 4.6.3.2

H 9 The Sun is a yellow coloured star.

9–1 Describe how the Sun's appearance would change if its temperature decreased. *[1]*

9–2 The Sun is a source of infrared radiation for the Earth. Explain why the Earth's surface is much hotter at the equator compared to the poles. *[3]*

WS1.2 3.5

9–3 **Figure 17** shows a diagram of how the radiation from the Sun interacts with the Earth on a cloudy day.

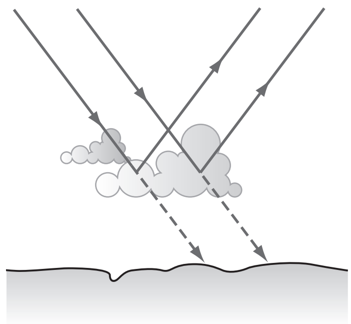


Figure 17

Describe how **Figure 17** shows that the clouds affect the radiation delivered to the Earth from the Sun. *[3]*

WS1.2

9–4 Sketch a diagram to show how radiation would be emitted from the Earth at night time when it is cloudy. *[3]*

Total: 10

10 Heinrich Hertz discovered radio waves in 1886. He was experimenting with apparatus that created sparks of electricity.

p198–9 4.6.2.3 H 10–1 Describe how radio waves are produced. *[2]*

p198–9 4.6.2.3 H 10–2 Hertz directed his radio waves towards a loop of wire with a gap. Describe what is created in the loop of wire. *[2]*

p184 4.6.1.2 WS3.3, 4.4,4.6 MS1b,2a, 3b-d

10–3 The radio waves travelled with a speed of 3.0×10^8 m/s and had a wavelength of 98 cm. Calculate the frequency of the waves. Give your answer to the correct number of significant figures. *[4]*

p200 4.6.2.4 WS1.3 H 10–4 Give **one** use of radio waves today. Explain why radio waves are practical for this application. *[2]*

Total: 10

11 Sound waves are an example of a longitudinal wave.

p182 4.6.1.1 11–1 Describe a longitudinal wave. *[2]*

p191 4.6.1.4 H 11–2 Give the range of frequencies for normal human hearing. *[1]*

p191 4.6.1.4 H 11–3 Explain why the human range of hearing is limited to this frequency range. *[2]*

p191 4.6.1.5 H 11–4 Define 'ultrasound'. *[1]*

p191 4.6.1.5 WS1.3 H 11–5 Explain how ultrasound is used to image organs inside our bodies. *[5]*

Total: 11

7 Magnetism and electromagnetism

Permanent and induced magnetism, magnetic forces and fields

Quick questions

p221 4.7.1.1 **1** Describe the type of force between:

- two like poles
- two unlike poles.

p221 4.7.1.2 **2** Name **three** magnetic materials.

p223 4.7.1.1 **3** What is a 'permanent magnet'?

p223 4.7.1.1 **4** What is an 'induced magnet'?

p222 4.7.1.2 **5** Define a 'magnetic field'.

Exam-style questions

p221 4.7.1.1 **6–1** Copy and complete the following sentences. Choose your answers from the options below. *[3]*

contact	non-contact	north	south	attract	repel

When two magnets are brought close to each other, they exert a ____________ force on each other.

When a north pole of a magnet is placed close to a north pole of another magnet, they _______.

When a south pole of a magnet is placed close to a _________ pole of another magnet, they attract.

p222 4.7.1.2 **6–2** Two magnets are moved closer together. Describe what happens to the force between them. *[1]*

p222 4.7.1.2 **6–3** One of the magnets is replaced by a small block of copper. The magnet and the copper block are placed close together. Explain what will happen. *[2]*

p221 4.7.1.1 **6–4** A student accidentally mixes two boxes of paper clips. One box contained steel paperclips and the other contained aluminium paper clips. Describe how the student could separate these two types of paperclips. *[3]*

Total: 9

p222 4.7.1.2 **7–1** Draw the magnetic field pattern around a bar magnet. *[2]*

p222 4.7.1.2 **7–2** Complete your diagram by adding arrows to show the direction of the magnetic field. *[1]*

p222 4.7.1.2 **7–3** Explain what the direction of the magnetic field shows. *[2]*

p222 4.7.1.2 WS2.2,2.3 QWC **7–4** A student wishes to plot the field pattern around a bar magnet in the laboratory. Design a method that they could use to do this. You should name any apparatus needed. *[6]*

p222 4.7.1.1 **7–5** Identify where the magnetic force close to a bar magnet would be strongest. *[1]*

Total: 12

p223 4.7.1.1 **8–1** Describe the force that acts between an induced magnet and a permanent magnet. *[1]*

p223 4.7.1.1 **8–2** A builder drops a packet of steel nails on the floor. She decides to collect them using the north end of a permanent magnet. Use the idea of induced magnetism to explain why the nails are attracted to the magnet. *[3]*

p222 4.7.1.2 **8–3** The builder notices that the closer she brings the magnet to the steel nails the more nails are attracted to the end of the magnet. Give a reason for this. *[2]*

p223 4.7.1.1 **8–4** Compare permanent and induced magnets. *[4]*

p223 4.7.1.1 WS2.2 QWC **8–5** When removed from the magnet, the steel nails are still attracted to each other. The builder suggests that these nails have now become permanent magnets. Design a method that the builder could use to test this hypothesis. Describe how the builder will know if the hypothesis is correct. *[6]*

Total: 16

p222–3 4.7.1.2 WS1.4 **9–1** A compass is a small bar magnet. Describe how the compass can be used for navigation. *[3]*

p222–3 4.7.1.2 **9–2** **Figure 1** shows the Earth, using a bar magnet to model its magnetic core. It shows the direction of two compasses on the Earth.

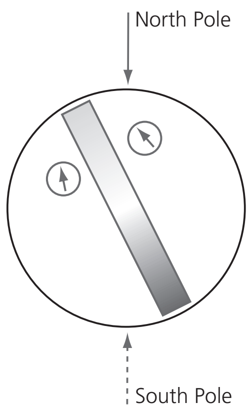


Figure 1

Copy **Figure 1** and label the Earth's magnetic poles. *[1]*

p222–3 4.7.1.2 **9–3** Draw the Earth's magnetic field on your diagram. *[3]*

Total: 7

The motor effect

Quick questions

p225 4.7.2.1 — 1 What is a 'solenoid'?

p225 4.7.2.1 — 2 What is an 'electromagnet'?

p224 4.7.2.1 — 3 What is the 'right-hand grip rule'?

p228 4.7.2.2 (H) — 4 What does Fleming's left-hand rule represent?

p227 4.7.2.2 (H) — 5 What is 'magnetic flux density'?

p227 4.7.2.2 (H) — 6 What is the unit of measure of magnetic flux density?

Exam-style questions

p224 4.7.2.1 — 7 **Figure 2** shows a magnetic field produced around a wire carrying a current.

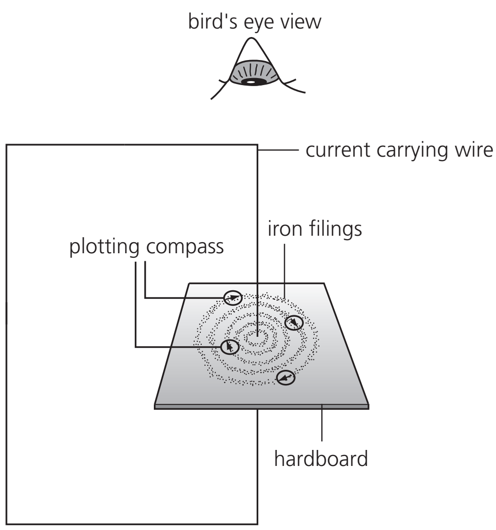


Figure 2

WS1.2 — 7–1 Identify the direction of the current. *[1]*

7–2 The direction of the current is reversed. Describe what will happen to the plotting compasses. *[1]*

7–3 Give **two** factors that affect the strength of the magnetic field around the wire. *[2]*

Total: 4

p225 4.7.2.1 — 8 A student is investigating electromagnets in the laboratory using a solenoid.

Figure 3 shows a solenoid with the magnetic poles labelled.

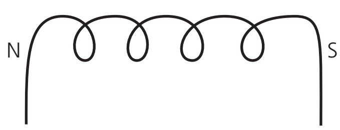


Figure 3

WS1.2 — 8–1 Copy **Figure 3** and draw the magnetic field around and inside the solenoid. *[3]*

8–2 Copy and complete the following sentences. Choose your answers from the options below.

size	shape	increases	decreases	uniform	non-uniform

Shaping a current carrying wire to form a solenoid ___________ the magnetic field strength as compared to the wire.

The field inside the solenoid is ______________, the field outside the solenoid is the same __________ as a bar magnet. *[3]*

8–3 The student adds a soft iron core to strengthen the magnetic field. Give **two** other ways in which the magnetic field strength can be increased. *[2]*

WS2.2 **8–4** Describe a method that the student could use to test the strength of the electromagnet. *[2]*

Total: 10

9 **Figure 4** shows a diagram of an electric bell, which uses an electromagnet.

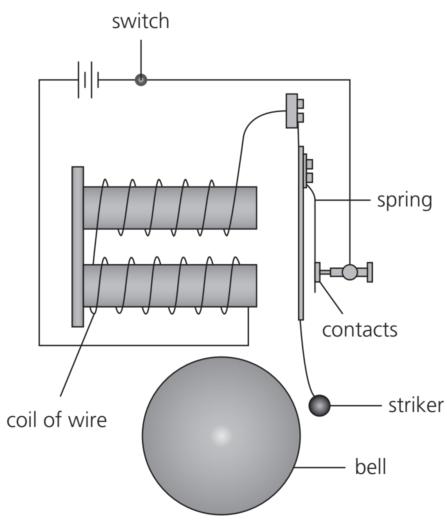


Figure 4

p225–6 4.7.2.1 **9–1** Describe how to create an electromagnet. *[2]*

WS1.2,1.4 **9–2** The striker and the bar it sits upon are made of steel. Explain what will happen when the switch is closed. *[5]*

WS1.2,1.4 **9–3** The bell is adapted by reducing the number of coils in the coil of wire. As a result, the bell stops working. Suggest why the bell no longer works. *[2]*

Total: 9

p228–9 4.7.2.2 **10** **Figure 5** shows a current carrying wire inside a magnetic field.

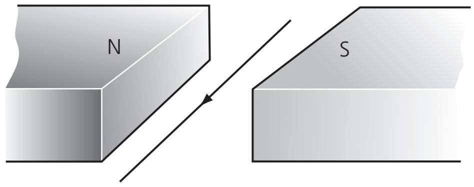


Figure 5

WS1.2 **10–1** Predict the direction in which the wire will move. *[1]*

10–2 Name the rule that allows you to predict the direction of the force on the wire. *[1]*

WS4.3, 4.4 MS1a, 3c,3d **10–3** The magnets have flux density of 50 mT.

- Current = 1.2 A
- Length of wire = 0.2 m

Use the equation

force = magnetic flux density × current × length

to calculate the force exerted on the wire. *[3]*

10–4 Explain why the conducting wire and magnet exert a force on each other. *[2]*

p231 4.7.2.4 QWC H **11** **Figure 6** shows a loudspeaker. A loudspeaker is an example of an everyday object that makes use of the motor effect.

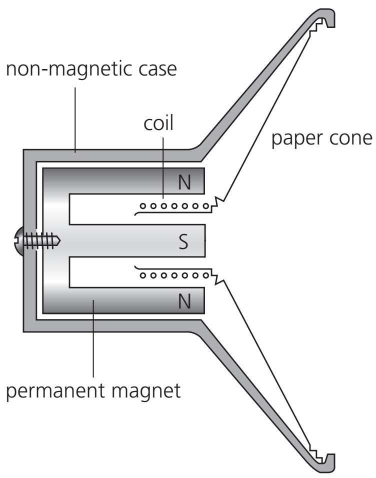


Figure 6

Explain how the loudspeaker generates sound. *[6]*

Total: 13

12 **Figure 7** shows a simple electric motor.

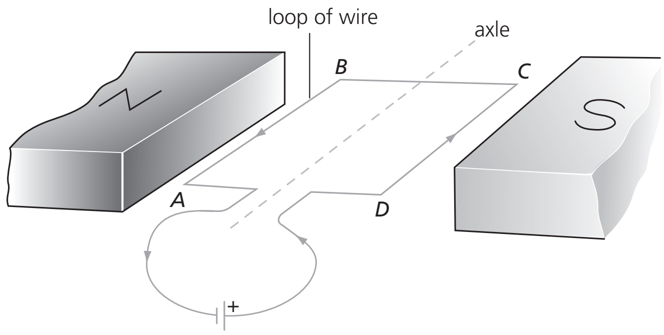


Figure 7

p230–1 4.7.2.3 WS1.2 H **12–1** Identify which way the motor will turn. *[1]*

p230–1 4.7.2.3 H **12–2** Explain why the loop of wire rotates to a vertical position. *[4]*

p227 4.7.2.2 WS4.3, 4.4,4.6 MS1a,2a, 3b-d H **12–3** The length of wire AB is 30 cm. It experiences a force of 0.15 N. The current through the wire is 2.1 A.

Use the equation

force = magnetic flux density × current × length

to calculate the magnetic flux density. Give your answer to an appropriate number of significant figures. *[4]*

Total: 9

Induced potential, transformers and the National Grid

Quick questions

p232 4.7.3.1 H 1 Give **two** factors that affect the size of an induced potential difference.

p235 4.7.3.2 H 2 What is a 'dynamo'?

p234 4.7.3.2 H 3 What is an 'alternator'?

p236 4.7.3.4 H 4 Give the **three** main components of a transformer.

p237 4.7.3.4 H 5 In the equation, $\frac{V_p}{V_s} = \frac{N_p}{N_s}$, what do the terms, V_p, V_s, N_p and N_s stand for?

Exam-style questions

p232 4.7.3.1 H **6** **Figure 8** shows an induced current produced when a student passes a conducting wire through a magnetic field.

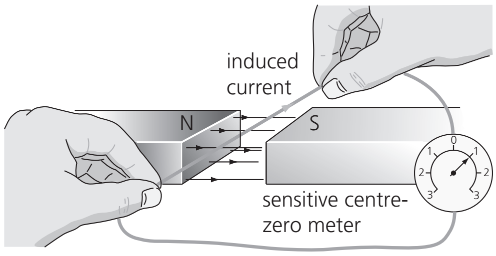


Figure 8

6–1 Give **one** change that can be made to reverse the direction of the induced current. *[1]*

6–2 The student moves the conducting wire faster. Describe what happens to the induced current. *[1]*

7 **Figure 9** shows a simple electricity generator.

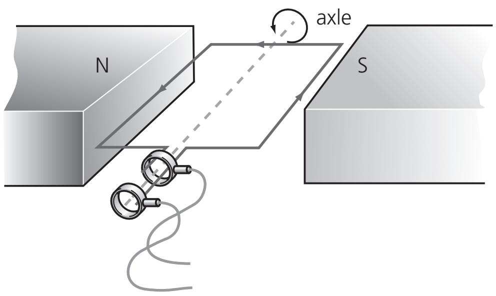


Figure 9

p234 4.7.3.2 WS1.4 H **7–1** Explain how an induced current is produced when the axle is turned. *[4]*

p233 4.7.3.1 H **7–2** The faster the axle is turned, the harder it is to turn. Explain why this happens. *[3]*

Total: 9

p235 4.7.3.2 H **8** **Figure 10** shows a dynamo connected to an oscilloscope and the oscilloscope output when the dynamo is turned.

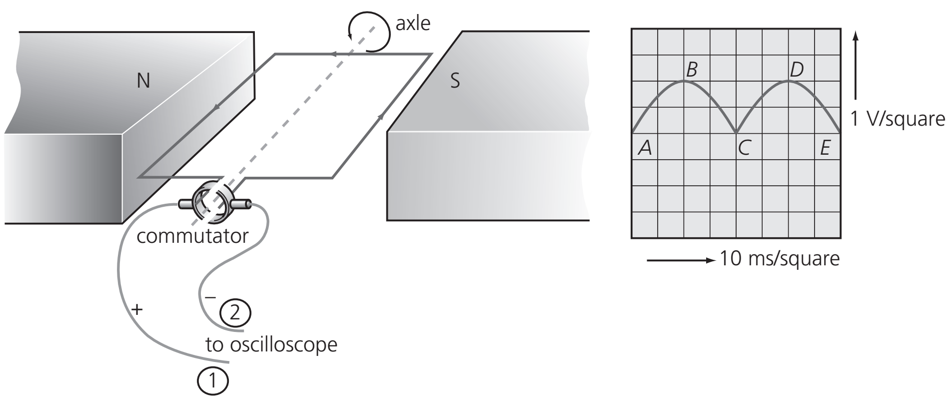


Figure 10

8–1 Identify the type of current induced by a dynamo. *[1]*

WS1.2, 3.5 8–2 Describe the position of the coil of wire when the induced potential difference at point C on the oscilloscope is produced. *[1]*

WS1.2, 3.5 8–3 Explain why a maximum induced potential difference is produced at point D. *[2]*

8–4 Copy the oscilloscope graph in **Figure 10** and draw a new line to show the induced potential difference when the dynamo is rotated twice as fast. *[2]*

Total: 6

p236–7 4.7.3.4 H 9 **Figure 11** shows a simple transformer.

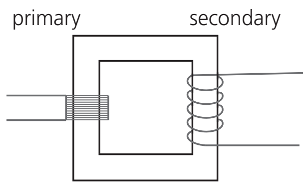


Figure 11

MS3a 9–1 Name the material used for the core. Explain why this material is most suitable. *[2]*

QWC 9–2 The input potential difference is 50 V. An engineer suggests that $V_s < V_p$. Use **Figure 11** to explain whether or not this is true. *[2]*

9–3 Explain how an alternating current is induced in the secondary coil. *[6]*

MS1c, 3b-d 9–4 There are 140 turns on the primary coil and 20 turns on the secondary coil.

Use the equation

$$\frac{\text{potential difference across primary coil}}{\text{potential difference across secondary coil}} = \frac{\text{number of turns in primary coil}}{\text{number of turns in secondary coil}}$$

to calculate the potential difference in the secondary coil. *[3]*

Total: 13

p236–9 4.7.3.4 H 10 **Figure 12** shows a transformer connected to the National Grid.

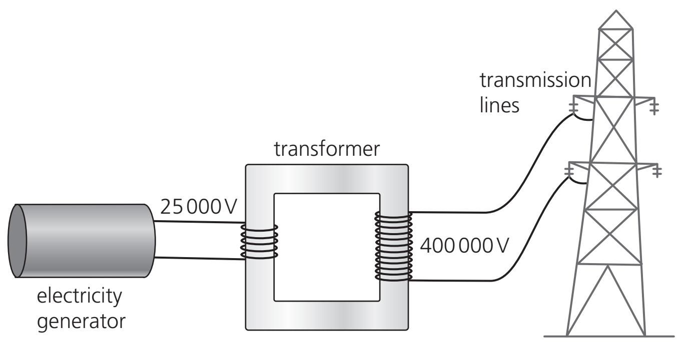


Figure 12

10–1 Name this type of transformer. *[1]*

MS3b-d **10–2** The input current is 500 A.

Use the equation

potential difference across primary coil × current in primary coil
= potential difference across secondary coil × current in secondary coil

to calculate the output current. *[3]*

10–3 Explain why we use transformers in the transmission of electrical power at high potential differences. *[3]*

Total: 7

Magnetism and electromagnetism topic review

1 A student is investigating how magnets behave.

p221 4.7.1.1 **1–1** **Table 1** describes the forces between the two magnets. Copy and complete the table. Some of the cells have been completed for you. *[3]*

Magnetic pole 1	Magnetic pole 2	Attractive or repulsive force?
North	North	Repulsive
North	South	
South		Repulsive
South		Attractive

Table 1

p222 4.7.1.2 **1–2** **Figure 13** shows the magnetic field pattern for two interacting bar magnets. The direction of the magnetic field is missing. Copy and complete **Figure 13** adding the direction of the magnetic field lines. *[2]*

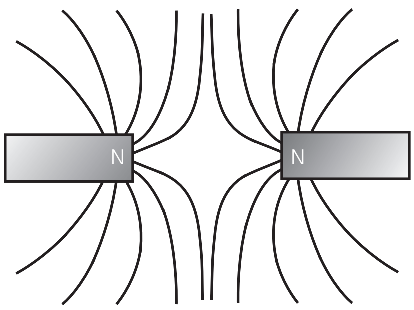


Figure 13

p222 4.7.1.2 **1–3** Define the term 'magnetic field'. *[2]*

p222 4.7.2.2 QWC **1–4** Design a method that could be used to find the magnetic field pattern seen in **Figure 13**. *[6]*

Total: 13

p224–6 4.7.2.1

2 **Figure 14** shows a current flowing through a wire, which creates a magnetic field around it. The X inside the wire means that the current is flowing into the paper.

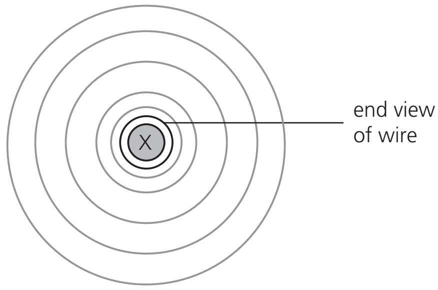


Figure 14

WS1.2 **2–1** Copy **Figure 14** and draw the direction of the magnetic field produced. *[2]*

2–2 Describe how the magnetic field around the wire can be demonstrated. *[2]*

WS1.2 **2–3** The wire is used to create a solenoid. Draw a diagram of the magnetic field inside and around the outside of a solenoid. *[3]*

2–4 Describe **two** ways to increase the strength of the magnetic field of a solenoid. *[2]*

p227 4.7.2.1 WS1.2, 1.5 **2–5** **Figure 15** shows the use of an electromagnet in a relay switch.

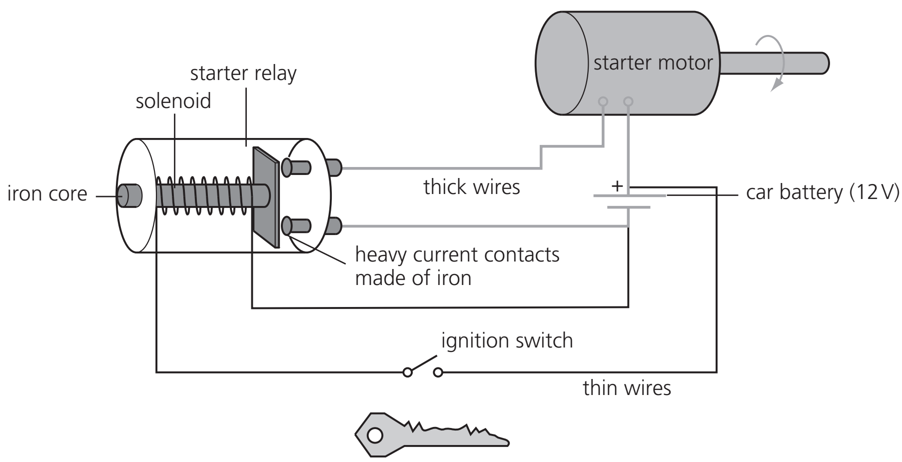


Figure 15

Use **Figure 15** to explain how the relay switch is involved in starting the car. *[4]*

Total: 13

3 **Figure 16** shows a wire carrying a current inside a magnetic field.

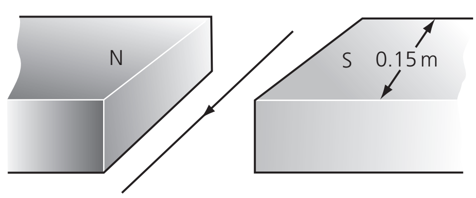


Figure 16

p227 4.7.2.2 **3–1** Describe the motor effect. *[2]*

p227–8 4.7.2.2 **3–2** Explain what will happen to the wire in **Figure 16**. *[4]*

p227 4.7.2.2 MS1a, 3c,3d WS3.3, 4.4,4.5 **3–3** The wire in **Figure 16** is inside a magnetic field of 75 mT and is carrying a current of 3.2 A.

Use the equation

force = magnetic flux density × current × length

to calculate the force acting on the wire. *[3]*

p231 4.7.2.4 QWC H **3–4** The wire is curled up into a solenoid and placed over a new magnet configuration. This is used to model how headphones work. **Figure 17** shows a simple version of this set up.

Explain how the headphone produces sound. *[6]*

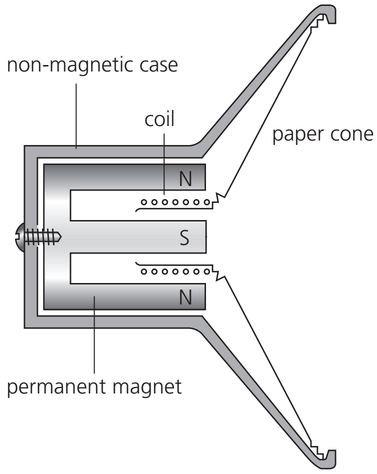


Figure 17

Total: 15

p232 4.7.3.1 H **4–1** Copy and complete the following sentences. Choose your answers from the options below. *[5]*

current	potential difference	electric field	magnetic field
faster	slower	decreased	increased

A __________________ is induced across the ends of a conductor when it is moved through a ________________________.

A ______________ is induced if the conductor is part of a complete circuit.

To increase the current generated the conductor should be moved ____________, or the strength of the field should be ________________.

4–2 Give **one** way that the direction of the induced current can be reversed. *[1]*

QWC **4–3** A microphone makes use of the generator effect. **Figure 18** shows the construction of a simple microphone.

Use **Figure 18** to explain how this microphone works. *[6]*

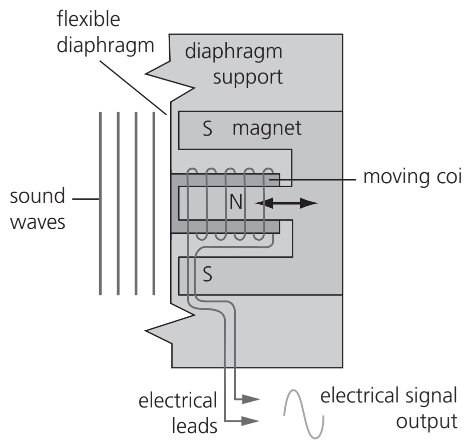


Figure 18

Total: 12

p236–7 4.7.3.4 H **5** A transformer block is attached to a laptop lead to decrease the potential difference from the mains supply before it reaches the laptop.

5–1 Sketch a diagram of a transformer that is designed to decrease the potential difference. *[3]*

5–2 Explain how this transformer reduces the potential difference from the primary circuit. *[5]*

5–3 The laptop transformer changes the potential difference on the primary coil of 230 V, to approximately 45 V across the secondary coil. The primary coil has 1000 turns.

Use the equation

$$\frac{\text{potential difference across primary coil}}{\text{potential difference across secondary coil}} = \frac{\text{number of turns in primary coil}}{\text{number of turns in secondary coil}}$$

to calculate the number of turns on the secondary coil. *[4]*

5–4 The transformer is assumed to be 100% efficient. The current in the primary coil is 3.0 A.

Use the equation

potential difference across primary coil × current in primary coil
= potential difference across secondary coil × current in secondary coil

to calculate the current in the secondary coil.

Give your answer to the correct number of significant figures. *[4]*

Total: 16

8 Space physics

Solar System; stability of orbital motions; satellites

Quick questions

p248 4.8.1.1 1 How many planets are there in our Solar System?

p252 4.8.1.2 2 Name the process that happens inside the Sun to produce naturally occurring elements.

p248 4.8.1.1 3 What is a 'planet'?

p249 4.8.1.1 4 Give an example of a natural satellite.

p254 4.8.1.3 5 Name the force that allows planets and satellites to maintain circular orbits.

Exam-style questions

p248 4.8.1.1 6–1 Name the star in our Solar System. *[1]*

p250 4.8.1.1 6–2 Name the galaxy that our Solar System is a part of. *[1]*

p249–50 4.8.1.1 6–3 Give the name of **one** natural object that orbits a planet. *[1]*

p248–9&253 4.8.1.3 6–4 Describe **one** similarity and **one** difference between a planet and a moon. *[2]*

p249 4.8.1.1 6–5 The Solar System contains planets and dwarf planets. Describe **one** similarity and **one** difference between planets and dwarf planets. *[2]*

Total: 7

p251–2 4.8.1.1& 4.8.1.2 7 Toliman is a star close to the Sun in a neighbouring solar system. It has a very similar mass to the Sun.

7–1 Describe how the star, Toliman, was formed. *[3]*

7–2 Toliman is in the most stable stage of its life cycle. Name this stage. *[1]*

7–3 Copy and complete the following sentences. Choose your answers from the options below.

nuclear	atomic	are greater than	are smaller than	balance	helium
hydrogen	red super giant	red giant	black hole	white dwarf	supernova

Toliman is in a state of equilibrium, where the _________ reactions inside the star _________ the gravitational collapse of the star.

When the star's supply of ______________ runs out the star will become unstable and turn into a __________________, and then a ___________________. *[5]*

7–4 Name the final stage of Toliman's life cycle. Describe this stage. *[2]*

Total: 11

p252–3 4.8.1.2

8 Stars all go through a life cycle which depends on the size of the star.

QWC 8–1 Describe the life cycle of a star with a mass much greater than the Sun. *[6]*

8–2 Explain how the initial fusion process in stars creates a new element. *[3]*

8–3 Not all elements can be produced by fusion. Name the other process that produces elements. *[1]*

8–4 Explain why it is assumed that the Earth's atoms were once part of a very large star. *[2]*

Total: 12

p253–4 4.8.1.3

9–1 Describe the shape of the orbit of the Earth around the Sun. *[1]*

H 9–2 Explain how the Earth's velocity changes in this orbit, but its speed remains constant. *[2]*

Table 1 shows the approximate radii and orbital speeds of some of the planets in the Solar System.

Planet	Radius in 10^8 km	Orbital speed in km/s
Venus	1	35
Earth	1.5	30
Mars	2	24
Jupiter	8	13
Uranus	29	7
Neptune	45	5

Table 1

WS3.2 MS1b, 4a,4c 9–3 Plot a graph of Orbital radius against Orbital speed for the planets in **Table 1**. *[4]*

9–4 Draw a suitable line of best fit. *[1]*

WS3.5 MS2g H 9–5 Explain the relationship shown on your graph. *[2]*

WS3.5 MS1b,1d H 9–6 Mercury has an orbital radius of 0.6×10^8 km. Use your graph to estimate a value for the orbital speed of Mercury. *[1]*

Total: 11

Red-shift

Quick questions

p256 4.8.2 1 What property is observed to change when red-shift occurs?

p257 4.8.2 2 What is the name of the theory that scientists believe best models how the universe began?

p256 4.8.2 3 What determines how much red-shift occurs from a source?

Exam-style questions

p256 4.8.2

4 Astronomers measure light from distant galaxies to model how the universe is changing.

Figure 1 shows the light emitted from the Sun (A) and the light emitted by a distant similar star (B). These are called light spectra.

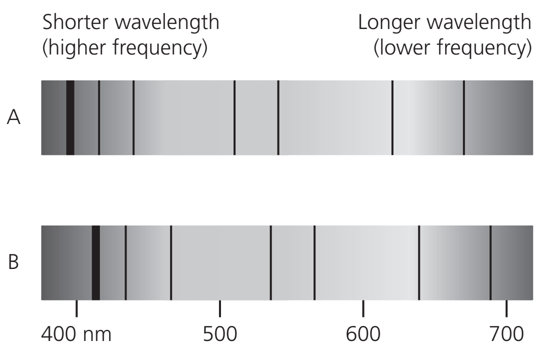


Figure 1

4–1 Explain how **Figure 1** shows that red-shift has occurred. [3]

4–2 Describe the motion of the star in the distant galaxy relative to the Sun. [1]

WS1.2 4–3 The light from a third star in a distant galaxy is measured. This star is much further away from the Sun than the star shown in **Figure 1**.

Copy **Figure 1** and draw a new light spectrum for this third star. [2]

Total: 6

p256–7 4.8.2

5 The Big Bang theory suggests that the universe began from a small region.

5–1 Give **two** other properties of the region where the universe began. [2]

WS1.2 5–2 Explain how red-shift provides evidence for the Big Bang theory. [2]

5–3 In 1998, observations of supernovae showed a new relationship between the recessional speed of galaxies and their distance from the Sun.

Sketch a graph to show this relationship. [2]

WS1.2 5–4 What would an astronomer notice about the wavelengths of light emitted from the galaxies furthest away from the Sun? Explain your answer. [3]

WS1.3 5–5 Copy and complete these sentences. Choose your answers from the options below.

increasing	decreasing	constant
dark matter	dark energy	supernova

It is not well understood why the rate of expansion of the universe is ________________.

Scientists suggest that this might be because of _____________. [2]

Total: 11

Space physics topic review

1 A star is formed from a nebula.

p251 4.8.1.1 **1–1** Describe a nebula. *[1]*

p251–2 4.8.1.1 **1–2** Describe how a star initially forms from a nebula. How does it reach equilibrium? *[3]*

p252 4.8.1.2 **1–3** Name the type of star that is formed when equilibrium is reached. *[1]*

p251–2 4.8.1.2 QWC **1–4** Describe the evolution of a star, similar in mass to our own Sun, from the protostar stage. *[6]*

p252 4.8.1.2 **1–5** Stars similar in mass to our own Sun can only produce relatively light nuclei, such as carbon, oxygen, nitrogen and sometimes silicon. Explain how elements heavier than this are produced. *[2]*

Total: 13

2 Some stars will become black holes.

p252 4.8.1.2 **2–1** Describe a black hole. *[1]*

p253 4.8.1.2 **2–2** Describe the evolution of a star from main sequence to a black hole. *[4]*

p252 4.8.1.2 **2–3** Only the most massive stars will go through a supernova. Describe what is meant by the term 'supernova'. *[1]*

p256 3.8.2 **2–4** Since 1998 physicists have been measuring the speed that supernovae travel away from us. Explain how scientists measure this speed. *[3]*

p257 3.8.2 WS1.2 **2–5** Explain what these observations of the speed of supernovae tell us about the universe. *[2]*

Total: 11

p256–7 3.8.2 **3** **Table 2** gives information about the distances of different galaxies and the speed that they are travelling away from us.

Galaxy	Distance from the Earth in 10^9 light-years	Recessional speed in km/s
A	1.0	15 000
B	1.4	22 000
C	2.5	39 000
D	3.3	51 000
E	3.7	30 000
F	4.0	61 000
G	5.0	77 000

Table 2

WS3.1, 3.2 MS1a,1b, 4a,4c **3–1** Plot a graph using **Table 2**, to show the relationship between the distance from the Earth and the recessional speed of these measured galaxies. *[4]*

3–2 Identify the anomalous point. *[1]*

WS3.2, 3.5 **3–3** Draw a line of best fit. *[1]*

WS3.5 MS2g **3–4** Describe the relationship between the distance from the Earth and the recessional speed. *[2]*

WS3.2, 3.5 | MS1d, 4a

3–5 Another galaxy is found at 4.5×10^9 light-years away from the Earth. Use your graph to estimate its recessional speed in km/s. *[1]*

WS1.2

3–6 Explain how the evidence provided in **Table 2** supports the Big Bang theory. *[2]*

Total: 11

4 The Sun is at the centre of our Solar System.

p250 4.8.1.1

4–1 Our Solar System is a small part of our galaxy. Name our galaxy. *[1]*

p249 4.8.1.1

4–2 Mars is a planet in our Solar System. Name **two** other planets in our Solar System. *[2]*

p249 4.8.1.1

4–3 Mars has two moons, called Deimos and Phobos. Define the term 'moon'. *[2]*

p250 4.8.1.3

4–4 Name the force that allows Deimos and Phobos to stay in orbit around Mars. *[1]*

p250 4.8.1.3 | WS3.5, 4.3,4.4 | MS1a, 1b

4–5 **Table 3** gives information about Deimos, Phobos and the Earth's moon.

Moon name	Associated planet	Distance from planet in km	Mass of moon in kg	Diameter of moon in km
Moon	Earth	382 500	7.3×10^{22}	3476
Deimos	Mars	23 460	2.0×10^{15}	12.6
Phobos	Mars	9377	1.1×10^{16}	22.2

Table 3

Compare the Earth's moon with the moons of Mars. *[3]*

p250 4.8.1.3

H 4–6 The Moon can be considered to have a stable orbit. Identify what other property of the Moon's orbit would change if it had a stable orbit further away from the Earth. *[1]*

p250 4.8.1.3

H 4–7 The Earth and Mars orbit the Sun in approximately circular orbits. Explain why these planets have a changing velocity but an unchanged speed during their orbit. *[2]*

Total: 12

Practice exam papers

Paper 1

1 **Figure 1** shows a crane powered by a petrol engine being used to lift a pallet of bricks to the top of a building.

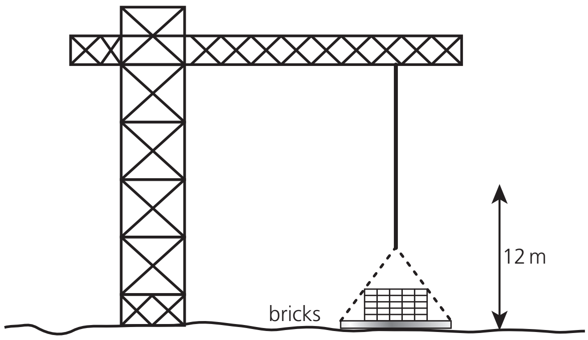


Figure 1

1–1 Copy and complete the sentence describing the energy changes which take place as the crane lifts the bricks. Choose your answers from the options below. *[3 marks]*

thermal	chemical	elastic potential	kinetic	gravitational potential

As the __________ energy stored in the petrol decreases and the __________ energy store of the bricks increases, the temperature of the engine increases and so its _________ energy store increases.

1–2 The mass of the bricks is 2500 kg and they are lifted through a height of 12 m.

Calculate the increase in gravitational potential energy (g.p.e.) for the bricks.

Include the correct unit for energy.

Gravitational field strength = 9.8 N/kg. *[2 marks]*

1–3 When the engine is operating, its temperature increases until it reaches a maximum, even though it is still burning petrol.

Explain why the temperature of the engine stops increasing. Answer in terms of energy transfer. *[2 marks]*

Total: 7

2 A variable resistor is used to control the current through a lamp in a simple electric circuit. The variable resistor is connected in series with the lamp, a 6.0 V battery and a switch as shown in **Figure 2**. The symbol for the variable resistor has been left off the diagram.

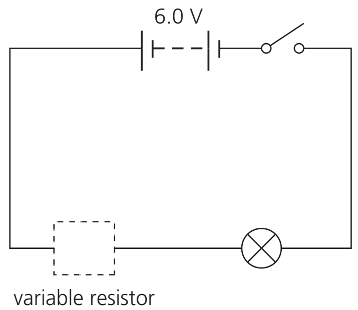


Figure 2

The resistance of the variable resistor is set to 4.5 Ω and a current of 0.5 A passes through it.

2–1 Draw the symbol for a variable resistor. *[1 mark]*

2–2 Give the size of the current through the lamp. *[1 mark]*

2–3 Calculate the total resistance of the circuit. *[2 marks]*

2–4 Calculate the resistance of the lamp. *[1 mark]*

2–5 Calculate the potential difference across the variable resistor. *[1 mark]*

2–6 The resistance of the variable resistor is gradually decreased.

What happens to the size of the current through the lamp? Choose your answer from the options below. Give a reason for your answer. *[3 marks]*

It increases	It decreases	It does not change

Total: 9

3 While playing football on a five a side pitch, a player becomes positively charged due to friction between their boots and the plastic pitch.

3–1 Explain how the player has become charged. Answer in terms of electron movement. *[2 marks]*

3–2 The player notices that, when they are charged, the hairs on their arms stand upright.

Describe the forces between the hairs which cause them to stand upright. *[2 marks]*

3–3 When the player touches the metal outer fence of the pitch, they feel a small electric shock. Explain why this happens. *[3 marks]*

3–4 During the game, the ball also becomes positively charged as it rubs against the plastic pitch material.

Figure 3 shows the positively charged ball when it is in the air.

Figure 3

Copy **Figure 3** and draw four arrows to show the shape of the electric field around the ball when it is charged evenly across its surface. *[2 marks]*

Total: 9

4 A group of students attempt to measure the specific heat capacity of a metal cylinder by heating it electrically using the apparatus shown in **Figure 4**.

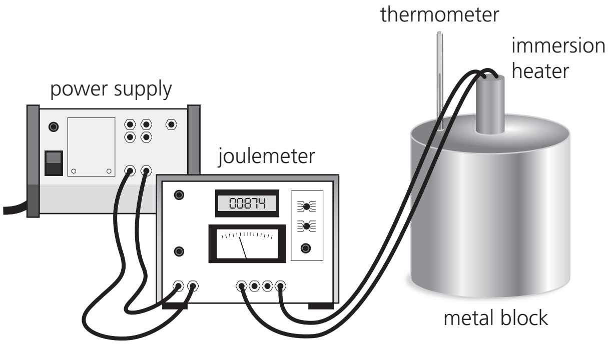


Figure 4

The students measure the energy supplied electrically to the block and the temperature increase. Their results are recorded in **Table 1**.

Energy supplied in kJ	**Temperature of block in °C**
0.00	26.5
1.20	29.6
2.40	33.7
3.60	37.8
4.80	41.9
6.00	43.5
7.20	48.2
8.40	51.8

Table 1

4–1 Use the data in **Table 1** to plot a graph of Energy supplied (x-axis) against Temperature of the block (y-axis). *[4 marks]*

4–2 Calculate the gradient of your graph. *[3 marks]*

4–3 Calculate the energy required to increase the temperature of the metal block by 1 °C. Use the value for the gradient of the graph. *[3 marks]*

4–4 The mass of the block is 0.95 kg.

Calculate the specific heat capacity of the block. *[2 marks]*

Total: 12

5 A student designed an experiment to verify the principle of conservation of energy using a pendulum and a light gate.

Figure 5 shows a pendulum bob of mass 0.050 kg that was lifted through a small height and released so that it passed through the light gate at the bottom of its swing.

The velocity at the bottom of the swing was measured; this is the maximum velocity the pendulum reaches during the swing.

The student dropped the pendulum from a range of heights, measured the resulting maximum velocities and produced the graph in **Figure 6** to show the relationship.

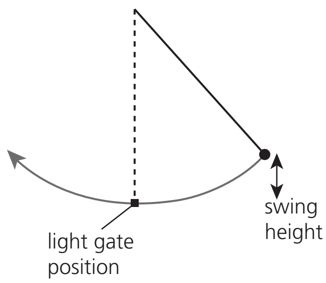


Figure 5

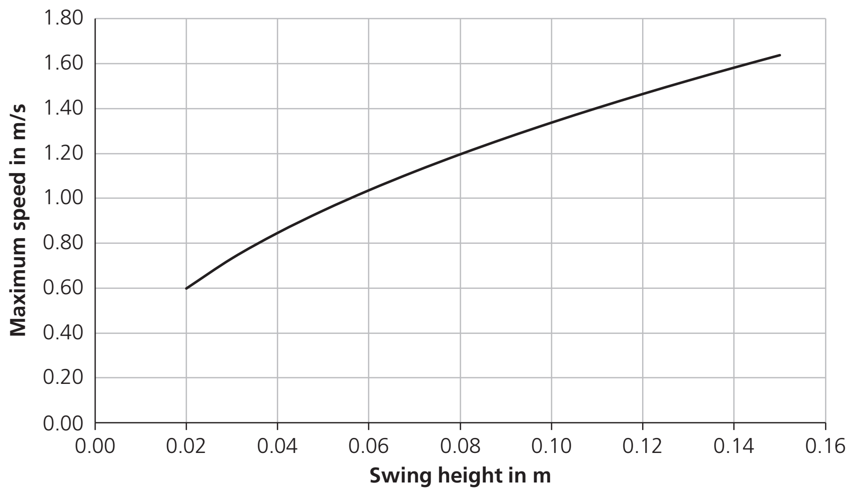


Figure 6

Gravitational field strength = 9.8 N/kg

5–1 Write the principle of conservation of energy. *[1 mark]*

5–2 Calculate the change in gravitational potential energy (g.p.e.) of the pendulum bob when it had been lifted by 0.08 m. *[1 mark]*

5–3 Determine the maximum velocity the pendulum bob reached when it had been swung from 0.08 m. Use **Figure 6**. *[1 mark]*

5–4 Use the value from question 5–2 to calculate the maximum kinetic energy the pendulum bob could have had after it had been dropped from 0.08 m. *[3 marks]*

5–5 Compare the values for change in gravitational potential energy and the maximum kinetic energy. Explain whether this experiment has shown that energy has been conserved during the swing. *[2 marks]*

5–6 A teacher suggests that the light gate has a systematic error in its measurements of velocity, and this could account for the difference in the two energy values.

What is a 'systematic error'? *[1 mark]*

5–7 The student checks the information supplied with the light gate, which specifies that the light gate can measure velocities between 0 m/s and 20 m/s with a precision of ±5%.

Evaluate whether the possible error in precision of the light gate accounts for the difference in the measurement of the kinetic energy and gravitational potential energy. *[4 marks]*

Total: 13

6 A gift shop uses a cylinder of helium at an initial pressure of 300 kPa to inflate balloons.

The cylinder will be used to inflate balloons to the atmospheric pressure of 100 kPa. When the pressure of the helium inside the cylinder falls to 100 kPa it will no longer be able to inflate more balloons.

6–1 Explain why all of the helium in the cylinder cannot be used to inflate balloons and why some helium gas remains in the cylinder. *[2 marks]*

6–2 The cylinder contains a warning label instructing that it should not be stored in direct sunlight and should be kept away from other sources of heating.

Explain what would happen to the behaviour of the gas particles in the cylinder and how this would affect the pressure inside the cylinder if the cylinder was heated. *[3 marks]*

Total: 5

7 A sealed syringe contains 6×10^{-5} m^3 of gas at a pressure of 2×10^4 Pa. The gas in the syringe is compressed as the plunger is slowly pushed in.

Calculate the pressure of the gas when the volume of the syringe has decreased to 3×10^{-5} m^3.

You can assume that there is no change in temperature. *[4 marks]*

Total: 4

8 A house has a stairlift to assist a person in getting upstairs, as shown in **Figure 7**.

The stairlift seat and the person have a combined weight of 550 N. The stairlift lifts the person from the ground floor up to the upper floor through a height of 2.5 m in 15 s.

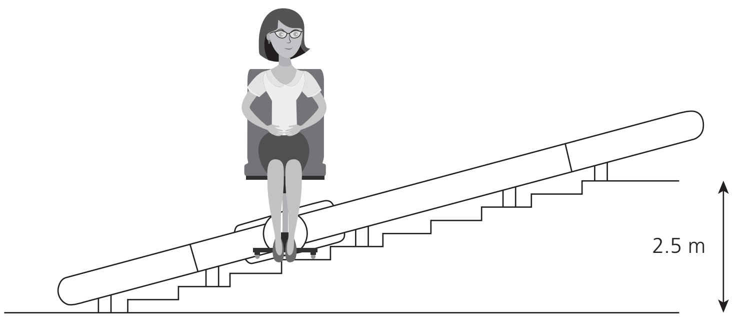


Figure 7

8–1 Calculate the work done against gravity in lifting the seat and person from the ground floor to the upper floor.

Give your answer to an appropriate number of significant figures. *[3 marks]*

8–2 Calculate the effective power rating of the stairlift as it lifts the person. *[2 marks]*

8–3 The lift operates using an electric motor which is connected to a mains supply of 230 V a.c. drawing a current of 3.5 A.

State **one** difference between an a.c. supply and a d.c. supply. *[1 mark]*

8–4 Calculate the power of the motor driving the stairlift. *[2 marks]*

8–5 Calculate the efficiency of the stairlift based on the power of the motor and the effective power in lifting the person. *[2 mark]*

8–6 Describe where and how energy is wasted in this system. *[2 marks]*

Total: 12

9 Nuclear power plants produce nuclear waste during the electricity generation process. This waste can be transported by train to long-term storage facilities in remote locations.

The nuclear waste is carried in thick metal containers.

During transport, the trains are irradiated by radiation from the waste. After each journey the trains are checked for contamination.

9–1 Name the type of radiation that can penetrate the thick metal containers. *[1 mark]*

9–2 Compare nuclear irradiation and nuclear contamination. *[4 marks]*

9–3 Nuclear waste contains the isotope of caesium $^{135}_{55}Cs$ which is radioactive. $^{135}_{55}Cs$ decays by a beta decay process to form an isotope of barium (Ba).

Copy and complete the nuclear decay equation to show the beta decay of $^{135}_{55}Cs$. *[3 marks]*

$$^{135}_{55}Cs \rightarrow {}^{\square}_{\square}Ba + {}^{\square}_{\square}e$$

9–4 The half-life of $^{135}_{55}Cs$ is approximately 2.3 million years.

Calculate the time it will take for the activity of the $^{135}_{55}Cs$ in the nuclear waste to fall to one-eighth of its original value. *[2 marks]*

9–5 Explain why the nuclear waste needs to be stored for a very long time. *[2 marks]*

Total: 12

10 A company wishes to produce electricity by building a power station which burns locally grown wood. In a community meeting, an opponent to the scheme presents an argument that doing this will cause damage to the local environment and would be more polluting than burning other fuels. **Figure 8** shows the graph they use as part of their argument.

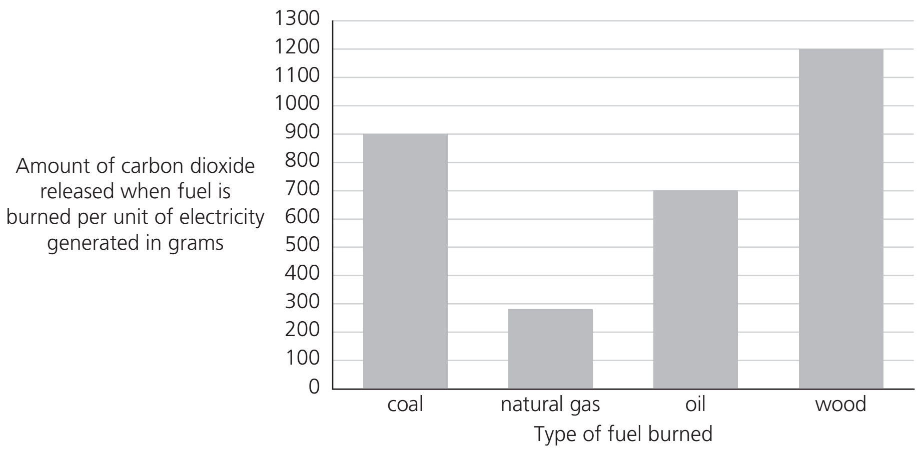


Figure 8

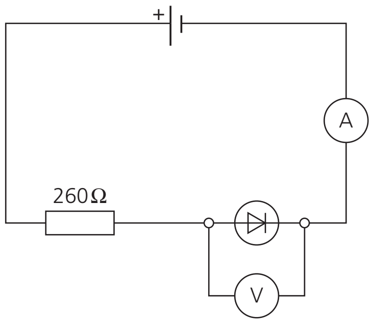
10–1 Suggest whether the opponent's argument against building the power station is a valid one. Suggest the advantages and disadvantages of using the wood burning power station as opposed to building a fossil fuel burning station. *[6 marks]*

10–2 The wood burned in the power station stores 15.5 MJ of energy per kilogram and will produce 4.6 MJ of energy which can be transferred electrically from the power station.

Calculate the efficiency of the power station. *[1 mark]*

Total: 7

11 The circuit shown in **Figure 9** contains a resistor and diode placed in series. The potential difference provided by the cell is 6.0 V and the potential difference across the diode is 0.8 V.



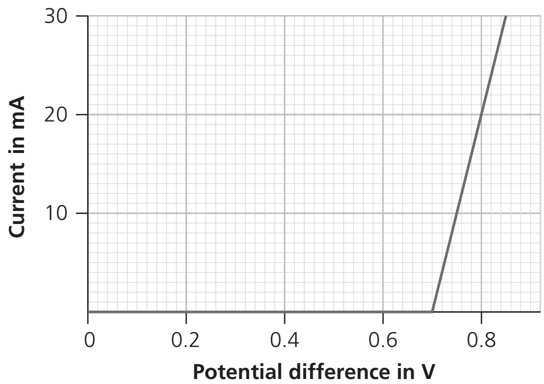


Figure 9

11–1 Determine whether the diode is an ohmic or non-ohmic conductor.

Explain your answer using information from **Figure 9**. *[2 marks]*

11–2 Use the graph to find the current in the circuit when the potential difference across the diode is 0.8 V. *[1 mark]*

11–3 Calculate the resistance of the diode when the potential difference across it is 0.8 V. *[3 marks]*

11–4 What is the potential difference across the resistor in the circuit? *[1 mark]*

11–5 Calculate the power of the resistor in the circuit. *[2 marks]*

11–6 The charge on a single electron is 1.6×10^{-19} C.

Calculate the change in energy for each electron as it passes through the diode in the circuit. *[1 mark]*

Total: 10

Total marks for Paper 1: 100

Paper 2

1 The stopping distance is the sum of the thinking distance and the braking distance.

1–1 Give **one** factor which will increase the thinking distance. *[1 mark]*

1–2 Explain why a car with worn tyres will have an increased braking distance. *[2 marks]*

1–3 Describe the energy transfers that take place when a force is applied to stop a car. *[2 marks]*

Total: 5

2 Electromagnetic waves are transverse waves.

2–1 Give **two** other properties of electromagnetic waves. *[2 marks]*

2–2 Choose **one** use of ultraviolet, from the options below. *[1 mark]*

Transmitting television signals	Cooking food	Detecting forged bank notes	Treating cancers

2–3 Name **one** part of the electromagnetic spectrum which has a higher frequency than ultraviolet. *[1 mark]*

Infrared is another part of the electromagnetic spectrum. Infrared is emitted by the Sun. Infrared is absorbed at different rates by different materials. A student places a black and a silver container of water outside in the sunshine and measures their temperature over time. **Table 1** shows the student's results.

Time in minutes	**Temperature of the black container of water in °C**	**Temperature of the silver container of water in °C**
0	10	12
1	11	12
2	11	12
3	12	13
4	12	13
5	13	13
6	14	14
7	14	14
8	15	14

Table 1

2–4 The student wants to draw a graph to display his data. Give the name of the type of graph he should draw. *[1 mark]*

2–5 Use **Table 1** to describe which of the two containers is the better absorber of infrared waves. *[2 marks]*

2–6 Give **one** way the student could improve this experiment. *[1 mark]*

2–7 Suggest **one** variable that the student should aim to keep the same in this experiment. *[1 mark]*

Total: 9

3 A student adds water to a transparent container, as shown in **Figure 1**.

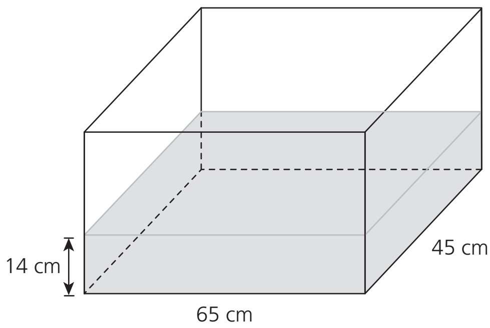


Figure 1

3–1 Define the term 'transparent'. *[1 mark]*

3–2 The density of water is 1000 kg/m^3 and gravitational field strength, *g*, is 9.8 N/kg.

Calculate the pressure in pascals acting at the bottom of the container due to the water. *[3 marks]*

3–3 The student pushes a small cork under the surface of the water, and it quickly rises to the surface. Explain why the cork quickly rises to the surface and floats. Answer using the idea of forces. *[3 marks]*

3–4 The student then picks up one end of the container and quickly forces it back down onto the table. This creates a wave that travels across the water's surface. Identify the type of wave produced. Choose your answer from the options below. *[1 mark]*

transverse	longitudinal

3–5 The floating cork moves once the wave has been created. Describe the motion of the cork on the surface of the water. *[2 marks]*

Total: 10

4 A student wants to verify the spring constant of a spring. It is labelled as having a spring constant of 0.42 N/cm. **Table 2** shows the data collected.

Force in N	Length of spring in cm	Extension in cm
0	6.0	0
1	8.4	2.4
2	10.8	
3	13.1	7.1
4		9.5
5	17.9	
6	20.3	14.3

Table 2

4–1 Copy and complete **Table 2**. *[3 marks]*

4–2 Design a method that the student could use to collect this data. Suggest what the student should do next to verify the spring constant. Include **one** safety precaution. *[6 marks]*

4–3 Plot a graph to show the relationship between force and extension. *[4 marks]*

4–4 Draw a line of best fit. *[1 mark]*

4–5 Use your graph to calculate the spring constant of the spring. *[4 marks]*

4–6 Evaluate whether the manufacturer's estimate for the spring constant is correct. *[2 marks]*

4–7 Another student repeated the experiment and it was found that their measurements for the length of the spring were different. They were all affected by a systematic error in the length measurements. Explain how this will affect the second student's value for the spring constant. *[2 marks]*

Total: 22

5 Our Sun is the star at the centre of our Solar System.

5–1 Describe how our Sun was formed. *[2 marks]*

5–2 Give the name of the stage that best describes our Sun's current position in the life cycle of stars. *[1 mark]*

5–3 Describe the remaining life cycle that our Sun will undergo. *[3 marks]*

5–4 Give the name of our galaxy. *[1 mark]*

5–5 The light from most other galaxies is observed to undergo red-shift. Explain how the red-shift that is observed provides evidence for the Big Bang. *[4 marks]*

5–6 The Big Bang is scientists' best model to describe what happened shortly after the start of the universe.

Describe the process that must be undertaken before new scientific models are accepted. *[2 marks]*

Total: 13

6 A student is investigating the motor effect. **Figure 2** shows a thick copper wire inside a magnetic field.

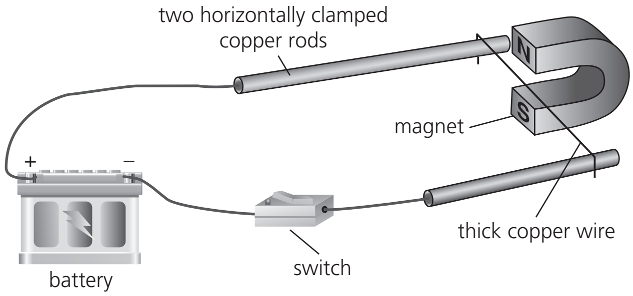


Figure 2

6–1 Predict the direction that the copper wire will move when the switch is closed. *[1 mark]*

6–2 The magnetic field flux density of the magnet is 62 mT, and a current of 2.1 A flows. The force acting on the wire is measured to be 0.0091 N.

Calculate the length of copper wire inside the magnetic field.

Give your answer to the correct number of significant figures. *[5 marks]*

6–3 The loudspeaker is an electrical device that makes use of the motor effect. **Figure 3** shows the basic arrangement of the components inside a loudspeaker.

Explain how the variations in current are used to create sound waves. *[4 marks]*

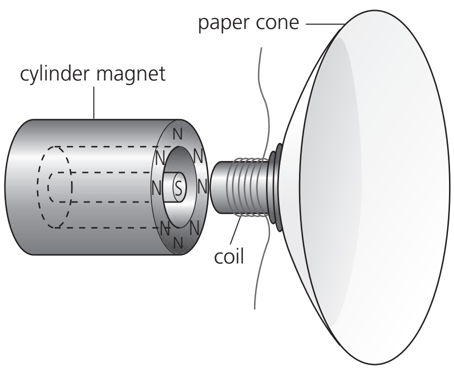


Figure 3

6–4 Give the equation that links wave speed, frequency and wavelength. *[1 mark]*

6–5 Sound waves travel at 330 m/s in air. A sound wave has a wavelength of 16.5 cm. Calculate the frequency of the sound wave. *[4 marks]*

6–6 Evaluate whether a person with normal human hearing could hear this sound. *[2 marks]*

Total: 17

7 A student is using a ticker timer to investigate the velocity of a ball after it has been dropped. The ball has a mass of 240 g. **Figure 4** shows a section of the tickertape from this investigation.

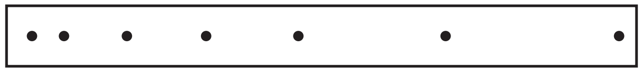


Figure 4

7–1 Explain how **Figure 4** shows that the ball is accelerating. *[2 marks]*

7–2 The ball falls through 1.2 m. It has an average acceleration of 9.8 m/s^2.

Calculate the final speed of the ball as it hits the ground.

Assume that the initial speed of the ball is 0 m/s.

Give your answer to the correct number of significant figures. *[4 marks]*

7–3 The student repeats the experiment, but this time drops the ball from a height of 10 m. Explain why the average acceleration of the ball is smaller than the value measured at 1.2 m. *[3 marks]*

7–4 Give the equation that links resultant force, mass and acceleration. *[1 mark]*

7–5 Calculate the air resistance that acts on the ball when it has an average acceleration of 6 m/s^2.

The gravitational field strength on Earth, g = 9.8 N/kg. *[5 marks]*

Total: 15

8 **Figure 5** shows the arrangement of a magnet and solenoid connected to a sensitive ammeter.

Figure 6 shows a simple transformer.

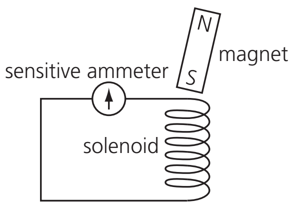


Figure 5

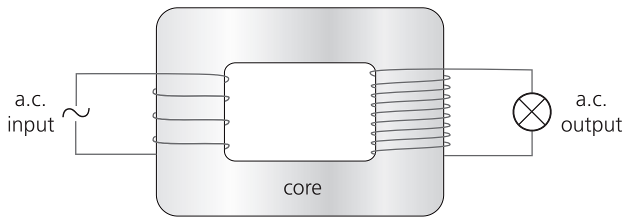


Figure 6

8–1 When the magnet moves inside the solenoid (**Figure 5**), the ammeter deflects to the right. Explain why the ammeter needle deflects when the magnet is moving inside the solenoid. *[3 marks]*

8–2 Give **one** way to increase the current produced in the solenoid. *[1 mark]*

8–3 A transformer (**Figure 6**) makes use of the generator effect.

Explain why an alternating current must be used in a transformer. *[2 marks]*

8–4 The transformer has 10 turns on the primary coil and 75 turns on the secondary coil. The input potential difference is 12 V.

Calculate the potential difference produced across the secondary coil. *[3 marks]*

Total: 9

Total marks for Paper 2: 100

Answers

Energy changes in a system (p.1)

Quick questions

1 A system is any object or group of objects.

2 Car: increase the speed of the car (make it go faster); Potato: increase the temperature of the potato (heat it up more).

3 The chemical store of the fuel decreases and the thermal stores of the water and surroundings increase.

4 mass = kilogram, kg; distance (or extension) = metre, m; speed (or velocity) = metre per second, m/s; energy = joule, J; gravitational field strength = newtons per kilogram, N/kg *m/s^2 is also an acceptable unit for g*; spring constant = newtons per metre, N/m

5 kinetic energy = 0.5 × mass × speed^2 OR $E_k = \frac{1}{2}mv^2$

6 A: $E_k = \frac{1}{2}mv^2 = 0.5 \times 800\,\text{kg} \times (3.0\,\text{m/s})^2 = 3600\,\text{J}$ (3.6 kJ)

B: $E_k = \frac{1}{2}mv^2 = 0.5 \times 1200\,\text{kg} \times (2.5\,\text{m/s})^2 = 3750\,\text{J}$ (3.8 kJ)

7 $E_e = \frac{1}{2}ke^2 = 0.5 \times 200\,000 \times (0.04)^2 = 160\,\text{J}$

8 The specific heat capacity of a substance is the amount of energy required to raise the temperature of one kilogram of the substance by one degree Celsius.

9 $E = mc\Delta\theta = 0.25 \times 4200 \times 15 = 15.8\,\text{kJ}$

10 Power is defined as the rate at which energy is transferred or the rate at which work is done.

11 $P = \frac{E}{t} = \frac{42\,000}{60} = 700\,\text{W}$

12 $P = \frac{E}{t} = \frac{3400}{2.2} = 1.5\,\text{kW}$

13 $P = \frac{E}{t}$; $250 = \frac{E}{3600}$; so $E = 250 \times 3600 = 900\,\text{kJ}$

14 $P = \frac{E}{t}$; $75 = \frac{3600}{t}$; so, $t = 3600 \div 75 = 48\,\text{s}$

Exam-style questions

15–1 $E_k = \frac{1}{2}mv^2$ [1] $= 0.5 \times 300\,\text{kg} \times (4.0\,\text{m/s})^2 = 2.4$ [1] kJ [1] OR 2400 [1] J [1]

15–2 The kinetic energy would be four times as much OR 9.6 kJ [1]

15–3 The kinetic store decreases [1] and the gravitational (potential) store increases [1].

16–1 The increase in length when it stretches OR the amount it stretches by. [1]

16–2 The spring with the high spring constant stores more energy than the spring with the low spring constant OR the spring with the low spring constant stores a smaller amount of energy [1].

16–3 $E_e = \frac{1}{2}ke^2 = 0.5 \times 5000 \times (0.05)^2$ [1] $= 6.25\,\text{J}$ [1]

16–4 *Accept energy explanation*: The elastic store decreases [1] causing an increase in a thermal store [1]. Alternatively, *accept a force-based explanation*: The (compressive and tensile) forces acting on the spring [1] increase its temperature [1].

17–1 g.p.e. = mass × gravitational field strength × height or $E_p = mgh$

17–2 $E_p = mgh = 120 \times 9.8 \times 2.3$ [1] $= 2.7\,\text{kJ}$ (2700 J) [1]

17–3 $E_p = mgh = 120 \times 1.6 \times 2.3$ [1] $= 0.44\,\text{kJ}$ (442 J) [1]

17–4 On Earth, more gravitational potential energy will be stored by the astronaut [1] and so they will have more kinetic energy when they reach the ground [1] and, therefore, a greater speed [1].
Alternatively, accept an answer involving forces, such as: a greater force (weight) on the Earth causes a greater acceleration [1] over the same distance [1] meaning a higher final velocity [1].

18–1 As the rocket accelerates the store of elastic potential energy (of the spring) decreases and the kinetic store of the rocket increases [1]. As the rocket rises upwards its kinetic store decreases as its gravitational store increases [1].

18–2 $E_e = \frac{1}{2}ke^2$ [1] $= 0.5 \times 50 \times (0.04)^2 = 0.04\,\text{J}$ [1]

18–3 0.04 J [1]

18–4 From the principle of conservation of energy [1].

18–5 $E_k = \frac{1}{2}mv^2$ [1]; $0.04 = \frac{1}{2}mv^2$; $0.04 = 0.5 \times 0.15 \times v^2$; $0.04 = 0.075 \times v^2$ [1]; $v^2 = 0.04 \div 0.075 = 0.533$ [1];
$v = 0.73\,\text{m/s}$ [1]

18–6 $E_p = mgh$ [1]; $0.04 = 0.15 \times 9.8 \times h$ [1]; $0.04 = 1.47 \times h$; so, $h = 0.04 \div 1.47 = 2.7\,\text{cm}$ [1]

19–1 The gravitational potential energy decreases [1] while the kinetic energy (and thermal stores) increase [1].

19–2 $E_p = mgh$ [1] $= 0.12 \times 9.8 \times 0.30 = 0.35\,\text{J}$ (0.3528 J) [1]

19–3 0.35 J [1]

19–4 $E_k = \frac{1}{2}mv^2$ [1]; $0.3528 = \frac{1}{2}mv^2 = 0.5 \times 0.12 \times v^2$ [1]; $0.35 = 0.06 \times v^2$; so, $v^2 = 0.35 \div 0.06 = 5.88$ [1]; $v = 2.42\,\text{m/s}$ [1]

19–5 Some energy is lost due to the work done by friction OR the friction causes the ramp and wheels to heat up [1].

20–1 Temperature change = 27.3 °C – 25 °C = 2.3 °C [1]; $E = mc\Delta\theta = 0.20 \times 4200 \times 2.3$ [1] = 1932 J (1.93 kJ) [1]

20–2 80 °C – 27.3 °C = 52.7 °C [1]

20–3 1932 J [1]

20–4 $E = mc\Delta\theta$; $1932 = 0.10 \times c \times 52.7$ [1]; $1932 = c \times 5.27$; so, $c = 1932 \div 5.27$ [1] = 367 J/kg °C [1]

20–5 To reduce energy loss to the surroundings [1].

21–1 Motor C (145.6 J)[1]

21–2 Motor A: $P = \frac{W}{t} = \frac{45 \times 3.0}{21} = 6.43\,\text{W}$ [1]

Motor B: $P = \frac{W}{t} = \frac{35 \times 2.7}{14} = 6.75\,\text{W}$ [1]

Motor C: $P = \frac{W}{t} = \frac{104 \times 1.4}{32} = 4.55\,\text{W}$ [1]

Motor B is the most powerful [1].

21–3 $P = \frac{W}{t}$; $12 = \frac{W}{15}$; $W = 12 \times 15 = 180\,\text{J}$ [1]

Conservation and dissipation of energy (p.5)

Quick questions

1 Energy can be transferred usefully, stored or dissipated, but cannot be created or destroyed.

2 An efficient energy transfer results in more energy being transferred usefully than an inefficient energy transfer.

3 0.2 kJ is wasted going into the thermal store of the surroundings (heating the surroundings).

4 $\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$

5 Energy cannot be created; if the efficiency was greater than one, then the device would be producing more energy than it uses.

6 $\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$

$= \frac{55\,\text{W}}{75\,\text{W}} = 0.73$ (or 73%)

7 The efficiency could be improved by reducing the frictional forces in the motor. This would reduce energy loss to the surroundings by heating effects.

8 Instead of using energy equations use the heights for the ball: efficiency = 0.93 ÷ 1.00 = 0.93 (or 93%)

9

Device	Power input in W	Useful power output in W	Power wasted in W	Efficiency
Loudspeaker	1.4	0.40	**1.0**	**0.29**
LED light	4.0	**3.0**	1.0	**0.75**
Fluorescent light	9.0	**1.0**	8.0	**0.11**
Electric drill motor	**1500**	1200	**300**	0.80

Exam-style questions

10–1 3 kJ [1]

10–2 efficiency = useful output energy transfer ÷ total input energy transfer = 22 kJ ÷ 25 kJ [1] = 0.88 (or 88%) [1]

10–3 The energy ends up stored thermally in the surroundings [1].

10–4 Thermal insulation would increase the temperature of the motor [1] and would decrease the efficiency [1]. Lubrication would reduce friction [1] and could increase the efficiency [1].

11–1 useful power = total power × efficiency = 110 × 0.94 = 103.4 kW [1] = 103.4 J/s [1]

11–2 Some radiation is emitted via visible light. [1]

11–3 The visible light will be absorbed [1] and cause heating [1].

11–4 An efficiency greater than 1 would mean energy is being created which cannot happen. [1]

12–1 *Maximum [6] marks from:*
The different beakers should be <u>wrapped in layers of the polystyrene</u> [1] with each container having a <u>different number of layers</u> (0, 1, 2, 3 layers and so on) [1]. Use a <u>measuring cylinder</u> to pour 100 cm^3 of very hot water into the containers making sure that they all start at the same temperature [1]. Let the containers cool for five minutes using a <u>stopwatch</u> [1] and measure the end temperature of the water in each of the containers using a <u>thermometer</u> [1]. The container at the highest temperature is the best insulated one [1].

12–2 The number of layers of polystyrene. [1]

12–3 *Any* [2] *marks from:*
starting temperature of the water [1]; volume of water used [1]; room temperature [1]

12–4 Use a lid. [1]

12–5 The greater the number of layers the better insulated the beaker is [1]. The increase in insulation is less effective when more than two layers are added [1].

13–1 No insulation: 21 °C; Layer of cardboard: 18 °C; Layer of polystyrene: 16 °C; Layer of cotton wool: 13 °C [*2 marks for all correct, 1 for two or more and 0 for none*]

13–2 Cotton wool [1]

13–3 Repeat the experiment to find an average value for the temperature change [1], make sure that water is the same temperature at the start for all of the containers [1].

National and global energy reserves (p.7)

Quick questions

1 A non-renewable energy resource is one which cannot be replaced when used. Examples include fossil fuels (coal, oil, natural gas) and nuclear fuel.

2 A renewable energy resource is one which can be replaced or will not run out. Examples include: hydroelectricity, biofuels, solar power, geothermal power.

3 Uranium is non-renewable.

4 The waste is radioactive and will stay radioactive for a long period of time.

5 Advantages: can generate large amounts of electricity; renewable; no CO_2 produced during use.
Disadvantages: expensive to construct; damage to local habitats in river; could reduce shipping on river.

Exam-style questions

6–1

Fuel	Application
Petrol [1]	To power a motorcycle.
Natural gas [1]	In a central heating system used to heat a house
Coal	**Fuel for a power station** [1]

6–2 Reliable means that the resource can be used at any time [1].

6–3 Coal (or another fossil fuel) or nuclear power [1] a reliable resource because a coal-based power station can operate at any time; it does not depend on the weather [1].

6–4 Wind turbines/solar power [1] may be considered unreliable as the amount of wind/sunlight varies from day to day [1].

7–1 More energy is required during winter for heating and lighting [1].

7–2 *Any* [2] *marks from:* People are getting up, putting on the heating [1], putting on the kettle [1], having a power shower [1], cooking breakfast [1], and using trains and trams [1]. *Allow other sensible answers.*

7–3 People return home [1] and cook, turn on the television, and so on [1].

8–1 Ethanol is produced from plants which can be regrown [1], but crude oil takes millions of years to form from fossilised remains [1].

8–2 The carbon released when burning biofuels/ethanol is offset by the amount absorbed from the atmosphere when the plants grew [1] so the total amount of carbon in the atmosphere remains around the same [1].

8–3 Growing plants for ethanol requires land which could be used to grow food instead [1]. This could make food more expensive and reduce the amount grown [1]. There would be pressure to cut down forests to provide more land to grow food and fuel crops [1].

9–1 In batteries (a chemical store) [1]

9–2 Fuel is not burnt by the car [1], so no pollution is produced/released locally as the car drives [1].

9–3 The cars need a mains supply of electricity to recharge [1]. This means more electrical consumption and so more power stations are needed [1].

10 *Maximum [6] marks from:*
Building the power station will be <u>very expensive</u> [1] and so the <u>cost of electricity might increase to pay for this</u> [1]. The power station will <u>produce nuclear waste</u> [1] which is very dangerous <u>and stays dangerous</u> for thousands of years [1]. There could also be <u>accidents</u> which release radioactive material into the atmosphere and can cause cancer [1].
On the other hand, there will be <u>more jobs</u> from the power plant [1] and nuclear power is a <u>low carbon producer</u> so it will help with climate change [1].

Energy topic review (p.9)

1–1 $E = mc\Delta\theta$ [1] = 50 × 4200 × 9 [1] = 1.89 MJ (1890 kJ) [1]

1–2 efficiency = useful output energy transfer ÷ total input energy transfer = 1.89 MJ ÷ 2.5 MJ [1] = 0.76 [1]

1–3 Heating of the surroundings or materials in the boiler [1].

2–1 $E_k = \frac{1}{2}mv^2$ [1] $= \frac{1}{2} \times 42 \times 3.0^2$ [1] = 189 J [1]

2–2 $P = \frac{E}{t}$; 75 W = E ÷ 4.5 [1]; so, E = 338 J (337.5 J) [1]

2–3 efficiency = useful output energy transfer ÷ total input energy transfer = 189 ÷ 338 [1] = 0.56 [1]

3–1 $E_p = mgh$ [1] = 0.25 × 9.8 × 0.40 [1] = 0.98 J [1]

3–2 efficiency = useful output energy transfer ÷ total input energy transfer = 0.98 ÷ 4.4 [1] = 0.22 [1]

3–3 A gravitational potential energy store decreases while a kinetic store increases [1].

3–4 0.98 J [1]

3–5 $E_k = \frac{1}{2}mv^2$ [1]; $0.98 = \frac{1}{2}mv^2 = 0.5 \times 0.25 \times v^2$ [1]; $0.98 = 0.125 \times v^2$; so, $v^2 = 0.98 \div 0.125 = 7.84$ [1], and v = 2.8 m/s [1]

4–1 $E_p = mgh$ [1] = 1000 × 9.8 × 50 = 490 kJ/s [1]

4–2 efficiency = useful output energy transfer ÷ total input energy transfer = 490 kJ/s ÷ 600 kJ/s [1] = 0.82 [1]

4–3 Energy has been lost to the surroundings [1] by heating [1] OR through friction [1].

4–4 $E_p = mgh$ [1] = 5000 × 9.8 × 50 = 2.45 MJ/s (2.5 MW) [1]

4–5 efficiency = useful output energy transfer ÷ total input energy transfer; 0.75 = useful output energy transfer ÷ 2.45 MJ/s; so, useful output energy transfer = 0.75 × 2.45 MJ/s [1] = 1.84 MJ/s (1.84 MW) [1]

5–1 elastic potential energy = 0.5 × spring constant × (extension)^2 = 0.5 × 100 × (0.08)^2 [1] = 0.32 J [1]

5–2 0.32 J [1]

5–3 $E_k = \frac{1}{2}mv^2$; $0.32 = \frac{1}{2}mv^2 = 0.5 \times 0.08 \times v^2$ [1] $= 0.040 \times v^2$; so, $v^2 = 0.32 \div 0.040 = 8.0$ [1], and v = 2.8 m/s [1]

5–4 Work is being done on the ball by the forces acting on it [1].

5–5 $E = mc\Delta\theta$; $94 = 0.08 \times 460 \times \Delta\theta$ [1] $= 36.8 \times \Delta\theta$; $\Delta\theta = 94 \div 36.8$ [1] = 2.6 °C [1]

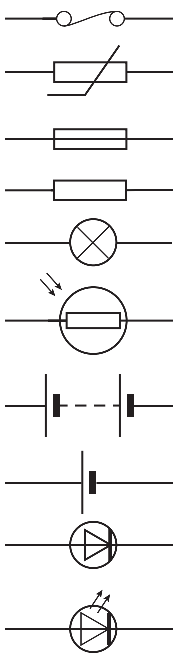
6–1 If they build wind turbines some people might think they are ugly and noisy [1] and this might mean that there will be less tourism on the island reducing their income [1]. The wind turbines will work most of the year but there might be some power cuts in the days that are not windy [1]. The turbines might scare away wild birds so that might affect tourism too [1].
The turbines have some big advantages, they are good for the environment because they are not a carbon dioxide producer so don't contribute to global warming [1]. They are cheap to operate so electricity bills will be lower OR They would probably look nicer than a coal or oil power station on the island [1].

6–2 efficiency = useful output energy transfer ÷ total input energy transfer = 0.50 ÷ 6.00 [1] = 0.08 [1]

Current, potential difference and resistance (p.11)

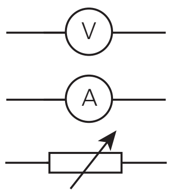
Quick questions

1



switch
thermistor
fuse
resistor
lamp
LDR
battery
cell
diode
LED

2



voltmeter
ammeter
variable resistor

ammeter: used to measure the current in a circuit. It is placed in series with components.
voltmeter: used to measure the potential difference in a circuit. It is placed in parallel with components.
variable resistor: used to control the current in a circuit by altering the resistance (manually)

3 An electric current is the movement of charge (The rate of transfer of charge) and charges move because of a potential difference.

4 charge = current × time ($Q = It$)

5 The size of the current is the same at any point of a closed loop in a circuit.

6 $Q = It = 3.2 \times 30 = 96$ C

7 $Q = It$; $1.5 = 620 \times 10^{-3} \times t$; so, $t = 1.5 \div 620 \times 10^{-3}$; so I = 2.4 s

8 Q = It; $20 = I \times 0.42 \times 10^{-3}$; so $I = 20 \div 0.42 \times 10^{-3}$ = 48 kA (48 000 A)

9 number of electrons = total charge ÷ charge on one electron = 48×10^{-3} C ÷ 1.6×10^{-19} C = 3.0×10^{17}

10

Quantity	Symbol used in equations	SI unit	Symbol for unit
charge	Q	coulomb	C
electric current	**I**	**ampere**	A
potential difference	**V**	**volt**	**V**
resistance	R	**ohm**	Ω

11 potential difference = current × resistance ($V = IR$)

12 $V = IR = 2.5 \times 82 = 205$ V

13 $V = IR$; $60 = I \times 1200$; so, $I = 60 \div 1200 = 0.05$ A

Exam-style questions

14–1 *Correct symbol for resistor* [1] *Correct symbol for ammeter placed in series* [1], *correct symbol for voltmeter placed in parallel with resistor* [1]. *Some power supply/battery placed in series with resistor* [1].

14–2 *Use of* $V = IR$ [1] *to calculate resistances* [1] *to give 2.48 Ω* [1]

14–3 The temperature of the resistor had increased [1] due to heating by the current [1].

15–1 Resistance of the wire [1]

15–2 Length of the wire [1]

15–3 *Any* [1] *mark from:* temperature of wire [1]; diameter of wire [1]; material of wire [1]

15–4 *Method should include: Way to calculate resistance (V = IR)* [1]*; Varying of length in sensible units (such as every 5 cm)* [1]*; Control of current with variable resistor* [1]*; Measurement of current with ammeter and/or voltage with voltmeter* [1].

15–5 *Even scale for current* [1]*; Even scale for p.d.* [1]*; Accurate plotting of all points* [1].

15–6 Resistance is directly proportional [1] to the length of the wire [1] OR As the length of the wire increases, the resistance increases in proportion to it [1], each increase in length has the same increase in resistance [1].

15–7 Still a straight line (proportional) [1] but the gradient would be greater/steeper [1].

16–1 *Circuit should include: Power supply/ battery* [1]*; Ammeter in series with component [1]; Voltmeter in parallel* [1]*; Method of varying current (such as a variable resistor)* [1].

16–2 At low current the resistance is constant [1]. At higher current, the resistance increases with the size of the current [1] due to a temperature increase and increased vibration of metal ions [1]. The resistance is independent of current direction [1].

16–3 $V = IR$; $2.5 = 0.35 \times R$; so, $R = 2.5 \div 0.35 = 7.1\,\Omega$ [1]

16–4 *Straight line [1] passing through the origin [1].*

16–5 A wire or resistor at constant temperature [1].

17–1 Thermometer [1]; 1 °C [1]

17–2 *Even temperature scale* [1]*; Even resistance scale* [1]*; Accurate plotting of points* [1]*; Line of best fit* [1].

17–3 Resistance decreases as temperature increases [1]; non-linear [1].

17–4 *Accept between 600 and 650 °C.* [1]

17–5 Water boils at 100 °C [1].

18–1 Non-ohmic [1]; The current is not proportional to the potential difference [1] (the resistance is not constant).

18–2 0.6-0.7 V [1]

18–3 The resistance is very high [1] and so there is (almost) no current through it [1].

18–4 (*from graph*) $V = 0.85$ V [1]; $V = IR$ [1]; $0.85 = 0.1 \times R$; so, $R = 0.85 \div 0.1$ [1] $= 8.5\,\Omega$ [1]

19–1 250 mA [1]

19–2 $V = IR$; $1.5 = 250 \times 10^{-3} \times R$ [1]; so, $R = 1.5 \div 250 \times 10^{-3} = 6.0\,\Omega$ [1]

19–3 $Q = It$; $Q = 250 \times 10^{-3}\text{ A} \times 25\text{ s}$ [1] $= 6.25$ C [1]

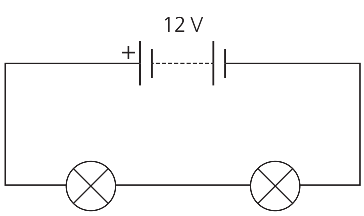
19–4 number of electrons $= 6.25 \div 1.6 \times 10^{-19}$ C [1] $= 3.9 \times 10^{19}$ [1]

19–5 There is no current [1] because the diode only conducts in one direction [1].

Series and parallel circuits (p.15)

Quick questions

1



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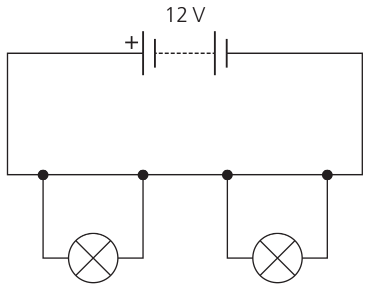


3 (*moving down the column*) S, P, S, S, P, S, P, B

4 60 Ω

5 $V = IR$; $6.0 = I \times 60\,\Omega$; so, $I = 6.0 \div 60 = 0.1$ A

Exam-style questions

6–1 $V = IR$ [1]; $12 = 0.08 \times R$ [1]; so, $R = 12 \div 0.08 = 150\,\Omega$ [1]

6–2 $R_{TOT} = 100\,\Omega + R_{LDR}$ [1]; $R_{LDR} = 150\,\Omega - 100\,\Omega = 50\,\Omega$ [1]

6–3 The resistance of the LDR decreases [1] so the total resistance of the circuit decreases [1] and so the current increases [1].

7–1 $V = IR$; $6.0 = I \times 20$ [1]; so, $I = 6.0 \div 20 = 0.30$ A [1]

7–2 $V = IR$; $6.0 = 0.060 \times R$ [1]; so, $R = 6.0 \div 0.060 = 100\,\Omega$ [1]

7–3 $R_{TOT} = R_{RES} + R_{LED}$ [1]; $100\,\Omega = 80\,\Omega + R_{LED}$; $R_{LED} = 20\,\Omega$ [1]

7–4 To check that the battery is charged [1] (The LED will be lit if the battery is operating correctly.)

8–1 The brightness of the lamp decreases [1] because the current through it decreases [1]; the current causes the lamp/filament to heat up which makes the lamp emit light (glow) [1].

8–2 $R_{TOT} = R_{RES} + R_{LAMP}$ [1]; $R_{TOT} = 60\,\Omega + 30\,\Omega = 90\,\Omega$ [1]

8–3 Maximum current is when resistance is smallest [1]. Smallest resistance is $20 + 30 = 50\,\Omega$ [1]. $V = IR$; $9.0 = I_{MAX} \times 50$ [1]; so, $I_{MAX} = 9.0 \div 50$ [1] $= 0.18$ A [1]

Domestic uses and safety (p.17)

Quick questions

1 50 Hz; 230 V

2 A: earth wire; B: fuse; C: live wire; D: neutral wire; E: cable grip; F: cable

3 earth = green and yellow; live = brown; neutral = blue

4 Fuse breaks the circuit by melting if the current is too high.

5 If there is a short circuit, the earth wire will carry the current from the case preventing electrocution.

Exam-style questions

6–1 In an a.c. supply, the potential difference changes [1] and the current changes direction [1]. In a d.c. supply, the current is always in the same direction [1] and usually remains constant [1].

6–2 The p.d of the live wire increases and decreases [1] (between +230 V and −230 V) with a period of 50 Hz [1].

6–3 The p.d.of the neutral wire remains constant (at 0 V) [1]

6–4 Electrons in the circuit transfer energy [1] when they move in either direction [1].

Energy transfers (p.18)

Quick questions

1 power = potential difference × current ($P = VI$)

2 $P = VI = 12 \times 4.5 = 54$ W

3 If resistance is doubled: The power doubles (according to $P = I^2R$)
If current is doubled: The power increases by a factor of four (according to $P = I^2R$)

4 The time the device operates for; The power rating of the device

5

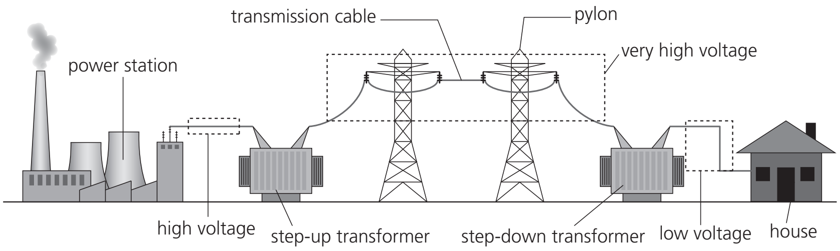
Power in W	Current in A	Potential difference in V	Resistance in Ω
18	1.5	12	2.83
24	**4.0**	6.0	1.50
45	3.0	**15**	5.0
120	**0.48**	250	520

6 $E = QV$; $E = 0.40 \times 1.5 = 0.60$ J

7 High voltages allow much higher efficiency.
Lower voltages are safer (although 230 V is still very dangerous).

8 There are two types. A step-up transformer is used to increase the voltage of the a.c. supply while a step-down transformer is used to decrease the voltage.

9



Exam-style questions

10–1 $P = VI = 230 \times 4.5$ [1] $= 1.0\,\text{kW}$ [1] (1035 W)

10–2 $P = I^2R$ [1]; $1035 = 4.5^2 \times R$ [1]; so, $R = 1035 \div 4.5^2 = 51\,\Omega$ [1]

10–3 *Any* [3] *marks from:*
The total current would be 18 A which is too large for an extension cord to carry [1]; The fuse in the cord is likely to melt [1] and cut off the circuit [1]; The high current may cause a fire [1].

10–4 The power provided to the kettle is much less in the USA than in the UK [1] because the voltage is less than half of the UK voltage. Less power means less energy transfer to the water each second [1].

11–1 $E = VQ$ [1]; $25\,000 = 5.0 \times Q$ [1]; so, $Q = 25\,000 \div 5.0 = 5000\,\text{C}$ [1]

11–2 $Q = It$ [1]; $5000 = 0.5 \times t$ [1]; so, $t = 5000 \div 0.5 = 10\,000\,\text{s}$ [1]

11–3 $E = Pt$ [1]; $25\,000 = P \times 10\,000$ [1]; so, $P = 25\,000 \div 10\,000 = 2.5\,\text{W}$ [1]

11–4 $P = I^2R$ [1]; $2.5 = 0.5^2 \times R$ [1]; so, $R = 2.5 \div 0.5^2 = 10\,\Omega$ [1]

12–1 *Maximum [6] marks from:*
The national grid is the set of power stations, transformers and cables [1] which provide us with our mains electrical supply [1]. The power stations produce alternating current at high voltages (e.g. 10 000 V) [1], this is sent to step-up transformers [1] which increase the voltage much more (to over 100 000 V) [1] so that the energy can be transferred with very low losses through pylon cables [1] over long distances. Near our houses step-down transformers reduce the voltage [1] to 230 V which is much safer to use in homes [1].

12–2 $P = I^2R$; $25 = I^2 \times 5$ [1]; so, $I^2 = 25 \div 5$ [1] $= 5$; $I = 2.2\,\text{A}$ [1]

12–3 The power loss would increase by a factor of 4 (to 100 W) [1] as power loss is proportional to the square of the current [1].

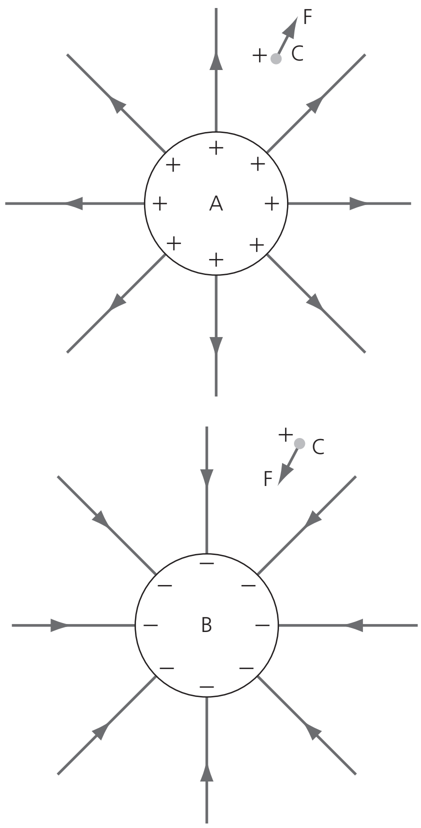
Static electricity (p.20)

Quick questions

1 repel; repel; negative

2 A charged object will create an electric field around itself; The greater the charge on the object, the stronger its electric field will be.

3



Exam-style questions

4–1 Rub the rod with the cloth [1].

4–2 Electrons have left the rod [1] and entered the cloth [1] leaving the cloth negative and the rod positively charged [1].

4–3 A current is passing through the air between the dome and the teacher. [1] Electrons are travelling from the teacher towards the dome. [1]

4–4 The field strength is greater the closer to the dome the finger is [1]. When it is close enough the field strength is great enough to pull electrons through the air (ionising it) [1].

5–1 Attractive [1]

5–2 The force increases [1].

5–3 The electric field strength increases [1].

5–4 The electric field strength increases [1].

5–5 Electrons are transferred from the negative sphere to the positive one [1]. This reduces the overall positive charge on the positive sphere [1] and the overall negative charge on the negative sphere [1]. *Accept that all the charge cancels out, do not accept charge transfer in opposite direction.*

Electricity topic review (p.22)

1–1 $V = IR$; $12 = I \times 30$ [1]; so, $I = 12 \div 30 = 0.40\,\text{A}$ [1]

1–2 $Q = It$; $Q = 0.40 \times 180$ [1] $= 72\,\text{C}$ [1]

1–3 $E = QV$; $E = 72\,\text{C} \times 12\,\text{V}$ [1] $= 864\,\text{J}$ [1]

1–4 $P = IV$; $P = 0.4 \times 12$ [1] $= 4.8\,\text{W}$ [1]

1–5 The p.d. across each resistor would be the same (12 V) [1] and the current through each would be 0.4 A [1] which means there would be twice the power output [1].

2–1 $P = I^2R$ [1]; $1380 = 3.0^2 \times R$ [1]; so, $R = 1380 \div 3.0^2 = 150\,\Omega$ [1]

2–2 $P = IV$ [1]; $1380 = 3.0 \times V$ [1]; so, $V = 1380 \div 3 = 460\,\text{V}$ [1]

2–3 It decreases [1].

2–4 It increases [1] by a factor of 12 [1].

2–5 They will continue to operate normally [1] as they are in parallel and so there is no break in their circuits [1].

3–1 $P = VI$ [1] $= 230 \times 24 = 5.5\,\text{kW}$ (5520 W) [1]

3–2 $E = Pt$ [1] $= 5520 \times 4 \times 60 \times 60 = 79.5\,\text{MJ}$ [1]

3–3 $V = IR$ [1]; $96 = 900 \times R$; so, $R = 96 \div 900 = 0.1\,\Omega$ [1]

3–4 An electric current has a heating effect [1]. The larger the current the greater the heating [1] and during acceleration the current is very large [1] so has a great heating effect [1].

4–1 Electrons [1]

4–2 The head of the doll and all of the hairs have the same charge [1] (negative) and so repel each other [1].

4–3 Electrons leave the hair [1] and so they are neutral [1] and do not repel any longer.

4–4 $Q = It$ [1]; $2.5 \times 10^{-3} = I \times 0.05$ [1]; so, $I = 2.5 \times 10^{-3} \div 0.05 = 0.05\,\text{A}$ [1]

4–5 A larger charge would produce a larger current [1] which can cause burns [1].

5–1 *Maximum [6] marks from:*
Construct the circuit in the picture [1]. Connect the circuit to 50 cm

length of wire and measure the current with an ammeter [1] and the p.d. with a voltmeter [1]. Use $V = IR$ to calculate the resistance of that length of wire [1]. Repeat with different lengths of wire in 5 cm increments until you have got at least five resistances [1]. If the current gets too high reduce it with the variable resistor and make sure you only have the circuit connected for a very short time [1].

5–2 $V = IR$; $6.0 = 0.75 \times R$ [1]; so, $R = 6.0 \div 0.75 = 8.0\,\Omega$ [1]

5–3 The short wire has a low resistance so has a high current in it [1]. This caused a heating effect which increases its resistance [1].

Changes of state and the particle model (p.24)

Quick questions

1 Density is a measure of the amount of mass contained in a certain volume of material; the mass per unit volume.

2 $\text{density} = \dfrac{\text{mass}}{\text{volume}}$ or $\rho = \dfrac{m}{V}$

3

Sample	Mass in kg	Volume in m³	Density in kg/m³
A rock	40.00	0.015	**2700**
A solid gold crown	1.06	**5.5 × 10⁻⁵**	19 300
Expanded polystyrene	**7.5**	0.50	15.0

4 Volume: $V = \frac{4}{3}\pi r^2 = \frac{4}{3}\pi(20\times10^{-3})^2 = 1.68\times10^{-3}\ \text{m}^3$

Density: $\rho = \dfrac{m}{V} = \dfrac{2.7\times10^{-3}}{1.68\times10^{-3}} = 1.6\,\text{kg/m}^3$

5 0–20 cm; 0.1 mm

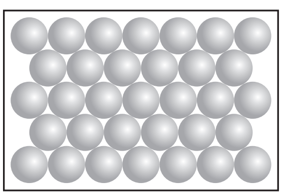
6 apparatus: top pan balance, displacement can, measuring cylinder, water

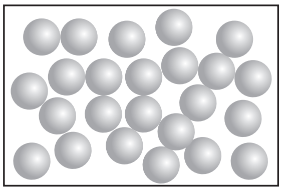
7 (top to bottom): melt; condense; evaporate (or boil); freeze; sublimate

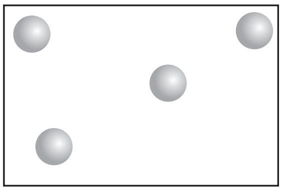
8 The total number of atoms in the sample; The total mass of the sample.

Exam-style questions

9–1







One mark for each correctly drawn particle diagram.

9–2 The particles in a gas are much further apart [1] so there are fewer particles per cubic metre [1]. This means the density must be much lower [1].

9–3 $\rho = \dfrac{m}{V}$; $1.225 = m \div 60.0$ [1]; so, $m = 1.225 \times 60 = 73.5\,\text{kg}$ [1]

10–1 Thermometer [1]

10–2 Top pan balance [1]

10–3 0.01 cm³ [1]

10–4 The changes in volume are very small and would not be detected by an instrument with smaller precision [1]

10–5 *Award [1] mark for one correct and [2] marks for all correct.*

Temperature in °C	Volume in cm³	Density in g/cm³
4.0	25.00	1.000
20.0	25.05	**0.998**
40.0	25.20	**0.992**
60.0	25.43	**0.983**
80.0	25.73	**0.972**

10–6 The density of the water decreases [1] as its temperature increases [1].

10–7 The water is expanding as its temperature increases [1] because the average distance between the particles in it is increasing [1].

Internal energy and energy transfers (p.26)

Quick questions

1 The total kinetic and potential energy of the particles which make up a system.

2 Melting, increasing temperature, evaporation (or boiling), increasing the internal energy stored

3 The specific heat capacity of a substance is the amount of energy required to raise the temperature of one kilogram of the substance by one degree Celsius.

4 Specific heat capacity is measured in J/kg °C.

5 $E = mc\Delta\theta = 0.20 \times 240 \times 50 = 2400\,\text{J}$

6 Sand: temperature change = 40 °C

Vegetable oil: specific heat capacity = 200 J/kg °C

Glass: mass = 1.2 kg

7 The temperature does not change during melting.

8 The specific latent heat of a substance is the amount of energy required to change the state of one kilogram of the substance with no change in temperature.

9 Specific latent heat is measured in J/kg.

10 The specific latent heat of fusion is the energy required to change 1 kg of a solid to a liquid. The specific latent heat of vaporisation is the energy to change 1 kg of a liquid into a gas.

11 $E = mL = 4.5 \times 272\,\text{kJ/kg} = 1.22\,\text{MJ}$ (1224 kJ)

Exam-style questions

12–1 Internal energy [1]

12–2 It stays constant [1]

12–3 The particles are in fixed positions [1], packed closely together [1] and vibrating [1].

13–1 Joulemeter [1]; *accept voltmeter, ammeter and stopwatch combination.*

13–2 0 °C [1]

13–3 energy for a change of state = mass × specific latent heat [1]

13–4 $34.10 \times 0.106 \times L$ [1]; so, $L = 34.10 \div 0.106 = 322\,\text{kJ/kg}$ [1]

13–5 Room temperature was above 0 °C, so the ice will be heated by / absorb energy from the surroundings [1].

13–6 Measure the mass of water produced by the ice when it is not heated [1] and subtract this from the mass which has been melted from the heater [1].

14–1 mass of gold = 19 × 15 g = 0.285 kg [1]; temperature change = 1060 − 24 = 1036 °C [1]; $E = mc\Delta\theta = 0.285 \times 129 \times 1036$ [1] = 38.1 kJ [1]

14–2 The particles/atoms need additional energy to break the bonds holding them together [1].

14–3 $E = mL$ [1] = 0.285 × 63 [1] = 18.0 kJ [1]

15–1 Temperature change = 8 °C; $E = mc\Delta\theta$ [1] = 0.10 × 2100 × 8 [1] = 1680 J [1]

15–2 $E = mL$ [1] = 0.10 × 330 [1] = 33 kJ [1]

15–3 33 000 J + 1680 J = 34 680 J = 34.7 kJ [1]

15–4 Temperature change of bowl = 80 °C; $34.7 \times 10^3 = 0.50 \times c \times 80$ [1]; $34.7 \times 10^3 = c \times 40$ [1], so, $c = 22.7 \times 10^3 \div 40$ [1] = 867 J/kg °C [1] (*unit not required for mark*)

15–5 The bowl seems to have required less energy to heat up than it needed (it has a lower experimental specific heat capacity than the accepted one) [1] and so energy must have been absorbed from the environment (heated by the room) [1].

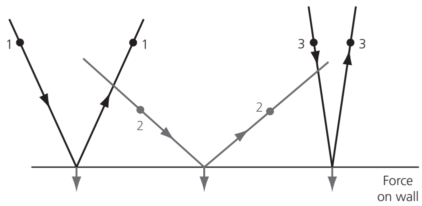
Particle model and pressure (p.29)

Quick questions

1 The particles are moving around quickly and randomly.

2 The particles speed up.

3 The particles move quickly and collide with the wall. Each particle produces a small force as it bounces off and these all add up to produce a larger force acting over the area. This force acting over an area is a pressure.



4 The mass of gas and the temperature need to stay the same.

5 The pressure doubles because there are twice the number of collisions with the surface every second.

6 The pressure decreases. The particles in the gas are hitting the wall of the syringe less often (they are travelling further between collisions) and so there are fewer collisions per second.

7 When the gas is being compressed there is work being done on it. The work increases the internal energy of the gas, so its temperature rises.
If it is inflated slowly then the gas can lose energy to the surroundings, so its temperature does not increase as much.

Exam-style questions

8–1 *Maximum [6] marks from:*
The particles in a gas are moving rapidly [1] in all directions [1]. When they collide with the walls of the container, they produce a force [1]. Millions of particles all hitting the walls produces a force on all of the surfaces which causes a pressure [1].
If the container was smaller, the particles would hit the wall more often because they don't have to go as far [1]. This would increase the pressure [1].
If the temperature was increased, then the particles would move faster [1] and cause more collisions per second, which would increase the pressure [1].

8–2 $pV = constant = 300 \times 10^3 \times 20.0$ [1] = 600×10^4 [1]; After gas has been compressed: $pV = constant$; $500 \times 10^3 \times V = 600 \times 10^4$ [1]; so, $V = 600 \times 10^4 \div 500 \times 10^3 = 12\ \text{cm}^3$ [1]

9–1 The particles in the gas are moving quickly [1] and can spread out because there are very weak forces pulling them together [1].

9–2 $pV = constant = 2.20 \times 10^7 \times 0.03$ [1] = 660 000 [1]; After gas has expanded: $pV = constant$; $p \times 4.00$ = 660 000 [1]; so, p = 660 000 ÷ 4.00 = 165 kPa [1]

9–3 *Any* [4] *marks from*:
Pressure is caused on the walls due to the collisions of the gas particles with the wall [1]. Each collision causes a small force (or change in momentum) on the surface [1] and the many (millions or billions of) particles [1] cause a pressure all over the surface [1] creating a pressure in all directions [1].

Particle model topic review (p.31)

1–1 The methanol is flammable and could catch light near a naked flame [1].

1–2 $\rho = \frac{m}{V}$ [1]; $0.792 = \frac{m}{25.0}$ [1]; so, $m = 0.792 \times 25.0 = 19.8$ g (0.020 kg) [1]

1–3 temperature increase = 64.7 − 20.0 = 44.7 °C [1]; $E = mc\Delta\theta$ [1] = 0.0198 × 2533 × 44.7 [1] = 2.24 kJ [1]

1–4 Evaporation (or boiling) [1]

1–5 Particles close together in liquid [1] but able to flow past each other [1]. Particles are much further apart in a gas [1] and moving rapidly [1] with very weak forces acting between them [1].

2–1 $\rho = \frac{m}{V}$ [1]; $1.4 = \frac{m}{0.25}$; so, $m = 1.4 \times 0.25$ [1] = 0.35 kg [1]

2–2 The pressure increases [1] because there are more particles of gas hitting the walls of the container each second [1].

2–3 $E = mc\Delta\theta$ [1]; $2900 = 0.40 \times c \times 7.0$ [1]; so, $c = 2900 \div (0.4 \times 7.0)$ = 1.0 [1] kJ/kg °C [1]

2–4 *Any* [2] *marks from:*
No energy was lost to the surrounding [1]; All the work done caused heating of the air [1]; The specific heat capacity for air is independent of temperature [1].

Atoms and isotopes (p.32)

Quick questions

1

Component	Electric charge	Location	Symbol
proton	positive	in the nucleus	p
neutron	none	in the nucleus	n
electron	negative	surrounding the nucleus	e

2 239 is the mass number, 94 is the atomic number, Pu is the atomic symbol

3 Atoms of carbon-12 and carbon-14 contain the same number of protons (6), the same number of electrons but a different number of neutrons.

4 $^{23}_{11}$Na : atomic number 11, mass number 23, 11 electrons, 12 neutrons.
$^{206}_{82}$Pb : atomic number 82, mass number 206, 82 electrons, 124 neutrons
$^{208}_{82}$Pb : atomic number 82, mass number 208, 82 electrons, 126 neutrons
$^{65}_{29}$Cu : atomic number 29, mass number 65, 29 electrons, 36 neutrons

5 Both have positive electrical charge

6 The positive charges repel each other so the alpha particle is deflected away from the nucleus.

7 The small particles are negative electrons. The grey area is positively charged 'sponge'.

Exam-style questions

8–1 Atoms have no overall electrical charge [1] and atoms have an equal number of protons and electrons [1].

8–2 1×10^{-10} m [1]

8–3 In orbit/energy levels/shells around the nucleus [1].

8–4 1/10 000th [1]

9–1 (Niels) Bohr [1]

9–2 Electrons move to higher energy levels when they absorb radiation [1].

9–3 Electrons release radiation (a photon) when they drop down into a lower energy level [1].

9–4 A positive ion. [1]

9–5 (James) Chadwick [1]

10–1 17 [1]

10–2 Isotopes are atoms of the same element because they have the same number of protons [1] but they have different numbers of neutrons [1].

10–3 19 [1]

10–4 17 [1]

10–5 An electron absorbs enough radiation/energy [1] to completely escape the atom [1] leaving an overall positive charge, [1] as there are more protons than electrons left.

11–1 Electrons are in energy levels/orbit around the nucleus [1] and protons are in the nucleus [1].

11–2 1/10 000th [1]

11–3 *Maximum [6] marks from:* Geiger and Marsden fired a beam of alpha particles [1] at a very thin gold foil [1] inside a vacuum chamber [1] and observed how the alpha particles were deflected. Most of the alpha particles passed through with no deflection at all [1] showing that most of the atom was totally empty space [1]. Some of the alpha particles were deflected slightly because they passed near a small positively charged nucleus [1]. A tiny fraction were deflected back by the nucleus [1] showing that it was positively charged and small compared with the size of the atom as a whole [1].

Atoms and nuclear radiation (p.35)

Quick questions

1 Unstable nuclei decay/emit radiation

2 The number of decays per second. Measured in becquerel (Bq)

3 The count rate is the number of radioactive decays detected per second while the activity is the number of decays which actually happen per second. Count rate is usually proportional to activity. Geiger counter

4 alpha decay, a pair of protons and neutrons, α, loses two protons and two neutrons. Atomic number decreases by 2 and mass number by 4.
beta decay, fast-moving electron, β, a neutron is replaced by a proton and an electron which is ejected. Atomic number increases by 1 and mass number is unchanged.
gamma decay, electromagnetic radiation, γ, becomes more stable. Atomic number and mass number unchanged.
neutron decay, a neutron, n, loses a single neutron. Mass number decreases by one and atomic number stays the same.

5 ${}^{4}_{2}\text{He}$ ${}^{0}_{-1}\text{e}$

6 ${}^{230}_{90}\text{Thorium} \rightarrow {}^{226}_{88}\text{Radon} + {}^{4}_{2}He$

${}^{234}_{90}\text{Thorium} \rightarrow {}^{234}_{91}\text{Paladium} + {}^{0}_{-1}\text{e}$

7 There are no changes to the particles in the nucleus.

8 The behaviour of the individual particles cannot be predicted. We do not know when a particular atom will decay.

9 The time it takes for the number of nuclei of the isotope in a sample to halve; The time it takes for the count rate (or activity) of a sample to fall to half of its initial value

10 2000 Bq; 4 days; Look for when the activity has halved (reached 4000) and read the time,

11 Irradiation: Radiation affects you from outside the body; You don't become radioactive; It can be used to kill bacteria on food.
Contamination: Can continue to cause damage when you move away from the original source; Radioactive material gets inside your body; You become radioactive due to it; It's much more dangerous.

12 Peer review is when other scientists in the specialist area read the paper and check the techniques/results to see if the conclusions are justified. Peer review improves the quality and reliability of publications by eliminating weak science or unjustified conclusions.

Exam-style questions

13–1 *(to the right of the source)* gamma radiation travels most distance [1], beta radiation medium distance [1], alpha radiation least distance [1].
(to the left of the source) alpha radiation blocked by paper [1], beta by aluminium [1], gamma reduced (or stopped) by lead [1].

13–2 alpha radiation [1]

14–1 *Maximum* [6] *marks from:* The teacher should use the sources for as short a time as possible [1] as this will reduce their exposure [1]. The sources should be handled with tongs [1] to increase the distance between the teacher and the source [1] as this will reduce the dose absorbed [1]. The sources should be pointed away from the teacher and students [1] as the shielding around the sources will block the alpha and beta radiation [1] in most directions.
Students must not be allowed close to the sources or to handle them at all [1] because they are still growing and more likely to be damaged by exposure [1].

14–2 *One mark for each missing number*:
${}^{241}_{95}\text{Am} \rightarrow {}^{237}_{93}\text{Np} + {}^{4}_{2}\text{He}$

14–3 Alpha particles have very limited range in air [1] and many are absorbed by the front cover of the detector tube [1].

15–1 7.5 ÷ 1.5 [1] = 5 [1]

15–2 Five half-lives means the fraction left is $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$ [1] = $\frac{1}{32}$ [1]

15–3 Becquerel (Bq) [1]

15–4 $\frac{1}{32}$ [1]

16–1 *One mark for each missing number*:
${}^{235}_{92}\text{U} \rightarrow {}^{231}_{90}\text{Th} + {}^{4}_{2}\text{He}$

16–2 *One mark for each missing number*:
${}^{40}_{19}\text{K} \rightarrow {}^{40}_{20}\text{Ca} + {}^{0}_{-1}\text{e}$

16–3 A (slightly) increased chance [1] of developing cancer [1].

16–4 Death [1] due to massive cell damage [1]

17–1 [1] *mark each for 238 and 93,* [1] *mark for* +He, [1] *mark for 4 AND 2*:
${}^{242}_{95}\text{Am} \rightarrow {}^{238}_{93}\text{Np} + {}^{4}_{2}He$

17–2 The beta particle is emitted from the nucleus [1] when a neutron converts to a proton and electron [1].

17–3 Alpha particles have a very short range in air [1] because they are easily absorbed [1].

17–4 Some beta particles are absorbed by the air [1] and fewer beta particles would pass through the detector at a greater distance [1].

17–5 All the alpha particles would be absorbed [1] so the count for the alpha particles would be zero [1]. Most/all of the beta particles would be absorbed [1] so the count would be zero/much lower [1].

18–1 Sample B [1]

18–2 *Accept an answer between 3.2 and 3.5 days* [1].

18–3 *Evidence of use of graph* [1] *to give eight days* [1]

18–4 *Any* [2] *marks from:* Use for limited time [1], keep distance/leave room [1], use shielding [1]

18–5 When radioactive material is absorbed by or deposited on something [1]. The material will be in close contact so can give a high dose [1] and keep causing irritation until it is removed [1].

Hazards and uses of radioactive emissions and background radiation (p.39)

Quick questions

1 Man-made: fallout from weapons testing, nuclear accidents
Natural: cosmic rays from space, radon gas released from rocks

2 Doctor: Handles radioactive materials during medical treatments of patients e.g. radiotherapy, radioactive tracers, X-ray machines
Transatlantic aircraft crew: Increased exposure to cosmic rays due to being high in the atmosphere, which protects people at ground level.
Miner: Increased exposure to radioactive gases (radon) released from rocks and/or radiation emitted from rocks which will surround them when they are underground.

3 *Any two from:*
- Medical treatment – gamma beams for treatment of cancer, sterilisation of equipment
- Medical diagnosis – radioactive tracers, gamma cameras
- Industrial tracers – monitoring the flow of a fluid/to detect leaks
- Industrial control – such as thickness of paper
- Radiocarbon dating

Exam-style questions

4–1 *Maximum* [3] *marks from:*
Gamma radiation can penetrate the body [1] to be detected outside. It is less ionising [1] so causes less damage. Beta radiation would be undetectable outside the body [1] because it is absorbed by the tissue.

4–2 To reduce irradiation of other people from gamma decay [1] to reduce contamination through sweat, and so on [1].

4–3 The half-life of technetium is short [1] so the amount left in the patient's body after 24 hours will be much lower [1].

5–1 time = 25 kSv ÷ 1600 Sv [1] = 16 hours (15.6 hours) [1]

5–2 Move the source closer to the instruments (or vice versa) [1] so that they will absorb more radiation (per second) [1].

5–3 The instruments do not come into contact with the source [1] so do not get covered in any radioactive material [1].

Nuclear fission and fusion (p.40)

Quick questions

1 Uranium or plutonium

2 The nucleus splits producing two smaller nuclei and a few neutrons.

3 The initial fission will release a small amount of energy and some neutrons. These neutrons will go on to split several more nuclei giving even more neutrons and energy. The reaction rate will increase rapidly giving out a huge amount of energy within a fraction of a second.

4 Nuclear fusion is the joining of small nuclei to make large ones.

5 Very small nuclei like hydrogen and helium isotopes.

6 In the core of a star.

Exam-style questions

7–1 (nuclear) <u>fission</u> [1]

7–2 *Maximum* [6] *marks from:*
The isotope uranium-235 [1] is used in fuel rods inside the reactor core [1]. A neutron hits one of the uranium nuclei [1] and causes it to split; this is called induced fission [1].
The split nuclei release more neutrons [1] which go on to cause more splits; this causes further splits, and so on, in a chain reaction [1]. Each split releases some energy which heats the coolant surrounding the reactor core [1].
The reaction rate is controlled by control rods [1] which can be inserted or withdrawn from the core. These absorb some neutrons and keep the reaction happening at a steady rate [1].

7–3 *Accept any hydrogen isotope or helium, lithium.*

Atomic structure topic review (p.42)

1–1 [1] *mark each for 219 and 86,* [1] *mark for* +He, *and* [1] *mark for 4 AND 2.*

$$^{223}_{88}\text{Radium} \rightarrow {}^{219}_{86}\text{Radon} + {}^{4}_{2}He$$

1–2 Radium-233 produces alpha particles during decay. Alpha particles can only penetrate very short distances [1] and cause large amounts of ionisation [1] in this region.

1–3 *Maximum* [6] *marks from:*
All of the medical personnel must use <u>gloves</u> [1] to protect their hands from the alpha particles emitted from the radium. These cannot <u>penetrate</u> the rubber of the gloves [1] because the particles are not very penetrating. The radium source chemical should be kept in <u>metal syringes</u> [1] to reduce how much dose the doctor <u>absorbs</u> when handling the syringe. The clothes the patient and the gloves the doctors are wearing should be disposed of carefully [1] in case they are <u>contaminated</u> and direct contact with the radium on them would give a lot of <u>ionisation</u> [1] and damage. They must make sure it isn't possible to breathe in the radium [1], so don't spray it anywhere, just inject it directly. The radium should not be handled by the doctor for <u>a long time</u> [1] because the longer the source is out the more radiation they will absorb. Also <u>do not touch the patient</u> for a few days afterwards [1] because they are contaminated, and their <u>sweat is radioactive</u> [1].

2–1 Carbon-14 will decay [1] meaning there are fewer carbon-14 atoms in the sample over time [1] so the number decaying per second (activity) will decrease [1].

2–2 *Evidence of use of graph* [1] *to give 5600 years (allow range 5500 to 5700)* [1]

2–3 Two half-lives ÷ 2 × answer to question 2–2 [1] = 11 200 years [1]

2–4 One mark for each number:
$$^{14}_{6}\text{Carbon} \rightarrow {}^{14}_{7}\text{Nitrogen} + {}^{0}_{-1}\text{e}$$

3–1 Becquerel [1]

3–2 The detector does not detect all of the radiation passing through it [1] and most of the radiation would be emitted in directions which do not pass through the container [1].

3–3 Contamination means that some radioactive material remains on the container [1] and this material would give off increased radiation increasing the activity [1].
Irradiation does not leave radioactive material behind [1] so the activity of the container would not be increased [1].

3–4 *One mark each for 135 and 56, and one for 0 AND −1:*
$$^{135}_{55}\text{Cs} \rightarrow {}^{135}_{56}\text{Ba} + {}^{0}_{-1}\text{e}$$

3–5 Four half-lives used [1] to give 120 years [1].

Forces and their interactions (p.44)

Quick questions

1 Scalar: A quantity with magnitude/size only. It has no direction.
Vector: A quantity with magnitude/size and direction.

2 The magnitude (size) is shown by the length of the arrow. The direction is shown by which way the arrow points.
3 Newton/N
4 Contact: Any two of the following: friction, air resistance, tension, drag, normal contact force
Non-contact: Any two of the following: gravitational force, electrostatic force, magnetic force
5 weight = mass × gravitational field strength / $W = mg$
6 Newtons per kilogram / N/kg (m/s^2 also acceptable)
7 Centre of mass is where the weight force is said to act from.
8 The single force that has the same effect as all the forces acting on an object together.

Exam-style questions

9–1 Time [1]; Energy [1]

9–2 Distance is a scalar quantity OR distance has a magnitude only [1] and displacement is the vector quantity of distance OR displacement has a magnitude and direction [1].

9–3 Rocket A is travelling with a greater velocity than rocket B [1], rockets A and B are travelling in the same direction [1].

10–1 Forces can change the speed of an object [1], change the shape of an object [1] or change the direction that an object moves in [1].

10–2 *Arrow pointing left should be labelled 'air resistance' (or 'drag')* [1]; *label pointing down should be labelled 'weight'* [1]

10–3 The forces will slow down the javelin [1] and they will change the direction that the javelin moves. [1]

11–1 They are directly proportional. [1]

11–2 weight = mass × gravitational field strength. [1]; Substitution and answer: weight = 80 × 9.8 = 784 N [1]; Answer to 2 significant figures = 780 N [1]

11–3 gravitational field strength = weight ÷ mass [1] = 128 ÷ 80 [1] = 1.6 N/kg [1]

12–1 resultant force = 700 – 300 = 400 N [1]

12–2 700 N [1]

12–3 *Weight force should be shown and labelled as a downwards arrow and air resistance shown and labelled as an upwards arrow.* [1]; *Both forces should act from the same point on the object.* [1]; *Both arrows should be the same length as determined by eye.* [1]

13–1 A newtonmeter OR a calibrated spring balance [1]

13–2 mass = weight ÷ gravitational field strength [1] = 7.8 ÷ 9.8 [1] = 0.80 kg OR 0.796 kg [1]

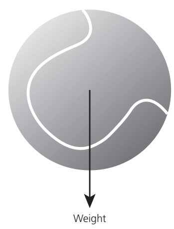
13–3 *Any* [1] *mark from:*
Read the newtonmeter at eye level to avoid parallax error [1] Hold the newtonmeter at a sensible height so that neither part touches the floor or table [1]

14–1 Arrow 1 = air resistance OR drag OR frictional forces [1]; Arrow 2 = normal contact force [1]

14–2 resultant forces in the vertical direction = 0 N [1]; resultant forces acting in the horizontal direction = 500 – 250 = 250 N [1]; So, overall resultant force is 250 N to the right [1] *Direction is needed to gain the final mark.*

14–3 The car will speed up [1] because the resultant force acts in the same direction as the velocity [1].

15–1 *Arrow should act from the centre of the tennis ball* [1] *and should be shown in the downwards direction clearly labelled as weight.* [1]

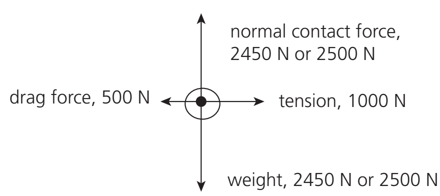


15–2 57 g = 0.057 kg [1]; 0.057 × 9.8 [1] = 0.5586 N [1] *answer must be seen to at least 2 significant figures.*

15–3 *Air resistance arrow should be labelled upwards from the object, starting at the centre* [1]; *Weight arrow should be labelled downwards from the object, starting at the centre* [1]; *The air resistance arrow should be approximately half the length of the weight arrow, as checked by eye* [1]

16–1 weight = mass × gravitational field strength, weight = 250 × 9.8 [1] = 2450 N [1] *Answer must be shown to 3 significant figures to gain the second mark.*

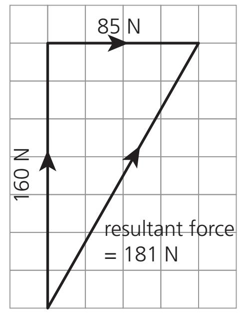
16–2 [1] *mark for each correct force arrow. Each arrow must include name of the force, size of the force and must have the correct scale.*



16–3 vertical forces are balanced [1]; horizontal forces = 1000 – 500 = 500 N to the right [1]. *Direction needed for mark.*

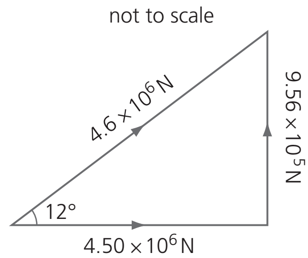
16–4 This will cause the trailer to speed up [1] as the resultant force is in the same direction as the velocity [1].

17–1 *Scale diagram seen, showing the vertical and horizontal components of the force [1]; Correct scale used [1]; Resultant force seen to be between 180 and 182 N [1]*



17–2 Angle measured from the vertical 28°, accept between 27° and 29° [1]

18–1 *Diagonal arrow shown with label* 4.6×10^6 *N to appropriate scale* [1]; *Diagonal arrow is found at 12° to the horizontal* [1]; *Scaled measurement of horizontal force, found to be* 4.5×10^6 *N* [1]; *Scaled measurement of vertical force found to be* 9.6×10^5 *N, which can be rounded to* 1×10^6 *N* [1]

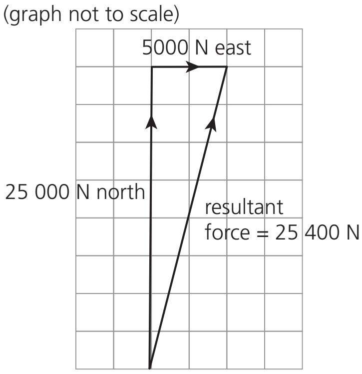


18–2 resultant force in vertical direction = 9.6×10^5 – 323 500 = 636 500 N OR resultant force in vertical direction = 1×10^6 – 323 500 = 676 500 N [1]

18–3 mass of aeroplane = weight ÷ gravitational field strength = 323 500 ÷ 9.8 [1] = 33 010 kg OR 33 000 kg [1]

18–4 *Scale diagram showing the vertical and horizontal components of the force* [1]; *Correct scale used* [1]; *Resultant force seen to be between 25 300 and 25 600 N* [1]; *Angle measured from north to be 11°, allow between 10° and 12°* [1].

(graph not to scale)



Work done and energy transfer (p.47)

Quick questions

1 Joule (J) or newton metre (Nm)

2 work done = force applied × distance moved in the direction of the force.

3 Joule (J)

Exam-style questions

4–1 work done = force × distance = 735 × 10 [1] = 7350 J or Nm [1]

4–2 The second firefighter may have a lower mass [1]. *Allow lower weight as an alternative.*

4–3 work done = 0 J or Nm [1]; No work is done OR work done is 0 because the door doesn't move even though a force is applied [1].

5–1 work done = force × distance; so, distance = work done ÷ force [1] = 240 ÷ 12 [1] = 20 m [1]

5–2 80 cm = 0.8 m [1]; 78 × 0.8 [1] = 62.4 J OR Nm [1] = 62 J or Nm to 2 significant figures [1].

5–3 The first worker is correct because the work done to push the box is greater than the work done to lift the box [1]. This means that more energy is being transferred by the first worker [1].

6–1 250 mN = 0.250 N [1]; 0.250 × 3.6 [1] = 0.9 Nm [1]

6–2 0.9 Joules or J [1]

6–3 Friction acts against the tennis ball [1]. Work must be done to overcome the frictional forces [1] resulting in some energy being transferred by heating [1] so, the ball doesn't roll as far.

Force and elasticity (p.48)

Quick questions

1 force = spring constant × extension OR $F = ke$

2 N/cm

3 Elastic deformation: when an object is stretched but will return to its original shape when the force is removed.

Inelastic deformation: when an object is stretched and will not return to its original shape when the force is removed.

4 It will not return to its original shape as the object is permanently deformed.

5 elastic potential energy = $\frac{1}{2}$ × spring constant × extension² or $E = \frac{1}{2}ke^2$

Exam-style questions

6–1 force = spring constant × extension; $F = 5.3 \times 4.0$ [1] = 21.2 N [1] *The answer must be shown to more than 2 significant figures.*

6–2 The new force is now 21.2 + 2 = 23.2 N [1] *Allow 23 N*; 23.2 ÷ 5.3 = *e* OR 23 ÷ 5.3 = *e* = 4.4 cm [1] OR 4.3 cm if 23N is used.

6–3 The spring has gone past the limit of proportionality [1] and so the spring has undergone inelastic deformation [1].

7–1 Two forces must be acting on the spring [1], they will be equal but opposite for the spring to remain stationary [1].

7–2 force = spring constant × extension; 4.2 = *k* × 1.3; so, *k* = 4.2 ÷ 1.3 [1] = 3.2 [1] N/mm [1]; *Also allow,* 3230 [1] N/m [1] *if e = 0.0013 m is used or* 32.3 [1] N/cm [1] *if 0.13 cm is used.*

7–3 *Any* [1] *mark from:*
The shoelace has not passed the limit of proportionality [1]; The shoelace extends with elastic deformation [1]; The force applied is proportional to the extension [1].

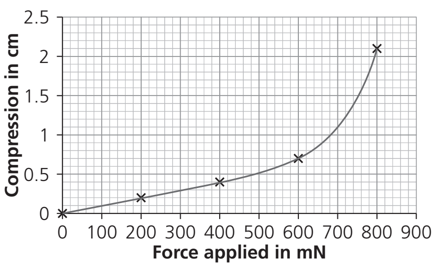
7–4 55 mm = 0.055m [1]; $E = \frac{1}{2} \times 450 \times 0.055^2$ [1] = 0.68 J [1]

7–5 work done stretching the shoelace = elastic potential energy; work done = 0.68 J [1]

8–1 *One mark* [1] *for each correct answer.*

Force applied in mN	Height of the can in cm	Compression in cm
0	*13.3*	**0**
200	*13.1*	**0.2**
400	*12.9*	**0.4**
600	*12.6*	**0.7**
800	*11.2*	**2.1**

8–2



Scale: the data points should cover at least half of the graph paper in each axes [1]*; Axis labels: the x-axis should be labelled Force (applied) in mN and the y-axis Compression in cm* [1]*; Points plotted correctly: lose* [1] *for each incorrectly plotted point, up to a maximum of 2 marks.*

8–3 *A sensible smooth line of best fit is seen, as above.* [1]

8–4 After 400 mN or 0.4 N the graph becomes non-linear [1]. The limit of proportionality must be between 0.4 N and 0.6 N [1], therefore the can will have elastic deformation up to 0.35 N [1]. This means the manufacturer's claim is correct [1].

8–5 This is not possible because the can has inelastic behaviour at 800 mN [1]. This means the elastic potential energy stored cannot be calculated [1] because work has been done to deform the can OR move the atoms to make a new shape [1].

9–1 First, attach a spring to retort (clamp) stand and measure the initial length of the spring [1] using a ruler. Add 1 N weight to the spring and measure the new length of the spring [1]. Calculate the extension: new length of the spring – original length of the spring [1]. Continue to add weight in 1 N intervals and measure the extension of the spring [1]. Take at least five readings. Plot a graph of weight applied (mass × *g*) and extension [1].
Marks can be awarded for any of the points above seen on a diagram.
Any [1] *mark from:*
Wear safety glasses [1]; Attach the clamp stand to the desk with a G-clamp [1].

9–2 As the force increases the extension increases [1]. The relationship is linear [1].
OR It is directly proportional [2]

9–3 *Gradient method seen on graph* [1]; Example calculation: (180 – 0) ÷ (6–0) = 180 ÷ 6 = 30 mm/N; spring constant = 1 ÷ gradient = 1 ÷ 30 [1] = 0.033 N/mm [1] = 33 N/m [1]
OR
Gradient method seen on graph [1]; Conversion of extension units of measure [1]; Example calculation: (0.18 – 0) ÷ (6–0) = 0.18 ÷ 6 = 0.030 m/N; spring constant = 1 ÷ gradient = 1 ÷ 0.030 [1]; Answer: 33 N/m[1]

9–4 *Any* [1] *mark from*:
Attach ruler to the clamp stand [1]; Check that the ruler is vertical using a set square or other sensible method [1]; Read the length measurements at eye level to avoid parallax error [1].

9–5 *From reading the extension from the graph at 1 N*: at 1 N the extension is 32 mm *(allow +/– 4 mm)* [1]; Conversion of units; 32 mm = 0.032 m [1]; Using spring constant in question 9–3, $E = \frac{1}{2} \times 33 \times 0.032^2$ [1]; 0.017 J [1] *Accept answers in range 0.013 J to 0.21 J*

Moments, levers and gears (p.50)

Quick questions

1 moment = force × perpendicular distance from the pivot, $M = Fd$

2 The clockwise moments must equal the anticlockwise moments and the resultant force acting on the object should be zero.

3 Gears are designed to increase or decrease the rotational effects of a force.

Exam-style questions

4–1 This increases the moment or turning effect of the force [1] as moment = force × distance OR so the tin is easier to open with less force applied [1].

4–2 moment = force × distance; 6.6 = 30 × d [1]; d = 6.6 ÷ 30 [1] = 0.22 m [1] *To gain the mark this answer must be seen, not just approximately 0.2 m*; 0.22 m is equal to 22 cm [1]

5–1 moment = force × distance = 350 × 2 [1] = 700 [1] Nm [1]

5–2 The principle of moments is when the total clockwise moments equals the total anticlockwise moments [1] when a system is balanced. [1]

5–3 moment = 700 Nm, so, 700 = 400 × d [1]; d = 700 ÷ 400 [1] = 1.75 m [1] = 1.8 m to 2 significant figures [1].

6–1 12 kNm = 12 000 Nm [1]; 12000 = F × 8 [1]; F = 12 000 ÷ 8 [1] = 1500 N [1]

6–2 750 N [1] The moment that the crane can safely withstand will remain the same [1]. Therefore, if the distance doubles, the force must halve [1].

6–3 48 ÷ 12 [1]; The turning effect will be four times greater on the output shaft [1].

6–4 radius of the input shaft is 12 cm ÷ 2 = 6 cm; turning moment = 300 × 6 [1] = 1800 Ncm OR 1.8 Nm [1]

Pressure and pressure differences in fluids (p.51)

Quick questions

1 Pascal or Pa

2 pressure = force ÷ area

3 Liquids and gases.

4 The density decreases.

5 Height of the column is measured in metres or m, density of the liquid is measured in kg/m³ and gravitational field strength is measured in N/kg.

6 Upthrust is the resultant force upwards exerted by a fluid on an object.

Exam-style questions

7–1 pressure = force ÷ area [1]

7–2 area of the pool = 50 × 25 = 1250 m² [1]; pressure = 25 000 000 ÷ 1250 [1] = 20 000 Pa [1]

7–3 pressure = density × g × height; so, 20 000 = 1000 × 9.8 × height [1]; height = 20 000 ÷ 9800 [1] = 2.04 m which is approximately 2.00 m. *To gain the final mark 2.04 m must be seen rather than just 2.0 m.*

8–1 pressure = force ÷ area; pressure = 120 ÷ 5 × 10^{-5} [1] = 2 400 000 Pa [1] = 2400 kPa [1]

8–2 pressure = force ÷ area; pressure = 2 400 000 = force exerted ÷ 0.00125 [1] = 2 400 000 × 0.00125 [1] = 3000 N [1]

8–3 Liquids can change shape [1] but they do not change volume when compressed [1].

9–1 The air molecules collide with the surface many times a second [1] and exert a force [1]. This creates a pressure as pressure = force ÷ area [1].

9–2 As the aeroplane travels away from the Earth's surface the atmospheric pressure will decrease. [1]. This happens because the density of the air is lower further away from the surface of the Earth [1], so there are fewer collisions of the air molecules with the surface of the aeroplane [1].

9–3 pressure = force ÷ area; 27 500 = force exerted ÷ 360 [1], so force exerted = 27 500 × 360 [1] = 9 900 000 N OR 9.9 × 10^6 N [1]

9–4 101 kPa = 101 000 Pa [1]; pressure = force ÷ area; 101 000 = force ÷ 360 [1]; so force = 101 000 × 360 [1] = 36 360 000 N which is approximately 3.6 × 10^7 N [1]

9–5 3.6 × 10^7 N – 9.9 × 10^6 N [1] = 2.61 × 10^7 N [1] *Allow error carried forward from an incorrect answer in question 9–3.*

10–1 pressure = density × g × height; pressure = 1000 × 9.8 × 14 [1] = 137 200 Pa [1] = 137.2 kPa [1]; *Accept 137 kPa.*

10–2 height of water above the fish = 14 – 5 = 9 m [1]; pressure = 1000 × 9.8 × 9 [1] = 88 200 Pa or 88.2 kPa [1]

10–3 The pressure is greatest at the bottom of the reservoir [1] due to there being the greatest depth of water here. This means the greatest force acts at the bottom of the reservoir, requiring thicker walls to support the water [1].

11–1 Upthrust is exerted as there is difference in pressure between the top and bottom of the oil drum [1]. The bottom of the drum has a greater force acting on it than the top of the drum [1]. This creates a resultant upward force on the drum [1].

11–2 50 cm = 0.5 m OR 101 kPa = 101 000 Pa [1] *Mark is for a correct unit conversion.*
liquid pressure = density × g × height of water = 1020 × 9.8 × 0.5 [1] = 4998 Pa [1]
total pressure = atmospheric pressure + liquid pressure = 101 000 + 4998 = 105 998 Pa [1] *Answer must have at least 3 significant figures.*

11–3 Total depth of water = 0.5 + 1.5 = 2.0m [1]
liquid pressure = 1020 × 9.8 × 2.0 = 19992 Pa OR new liquid pressure is 4 × greater than original liquid pressure, i.e. 4 × 4998 Pa [1]
total pressure = 101 000 + 19 992 = 120 992 Pa [1] = 121 000 Pa to 3 significant figures OR 121 kPa [1]

11–4 The pressure difference is 121 kPa – 106 kPa = 15 kPa OR 15 000 Pa. [1]

11–5 If the oil drum is floating then the density must be equal to the water and be 1020 kg/m³ [1]. This is because the weight of the water displaced must equal the weight of the oil drum [1].

Describing motion along a line (p.54)

Quick questions

1 Distance is a scalar quantity (only has a magnitude), whereas displacement is a vector quantity (has magnitude and direction).

2 The gradient.

3 Velocity is the speed in a given direction.

4 acceleration = change in velocity ÷ time

5 Deceleration is when an object slows down.

6 The gradient.

7 The distance travelled is found by calculating the area under a straight line, or by using a counting squares method for a curved line.

8 Terminal velocity is when an object moves through a gas or liquid at constant speed because there is no resultant force acting on it.

Exam-style questions

9–1 3.0 m/s *Allow between 3.0 and 6.0 m/s* [1]

9–2 *Any* [1] *mark from*: age, terrain, distance travelled, fitness [1].

9–3 33.5 minutes = 33.5 × 60 = 2010 seconds OR 5.5 km = 5500 m [1] *First mark is for a correct conversion*. speed = distance ÷ time; so, speed = 5500 ÷ 2010 [1] = 2.74 m/s [1]

9–4 The jogger may not have been running in a straight line or the jogger may have run in a loop [1].

10–1 30 m/s [1]

10–2 A and B [1] gradient [1]

10–3 The car is stationary between 3 and 5 seconds [1]; the car travels with a slow constant speed between 5 and 8 seconds [1].

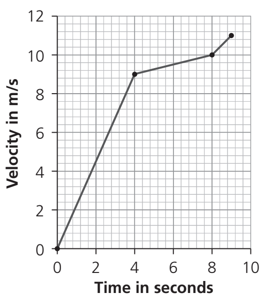
10–4 average speed = total distance ÷ time taken = 100 ÷ 8 [1] = 12.5 m/s [1]

10–5 *Gradient method must be seen to be used*. [1]
gradient = (100 – 80) ÷ (8 – 5) = 20 ÷ 3 [1]; speed = gradient = 6.67 m/s [1]

11–1 acceleration = change in velocity ÷ time, acceleration [1] = (9 – 0) ÷ 4 [1] = 2.25 m/s² [1] *Answer must not be rounded to 2 m/s²*.

11–2 *Answer can use 2 m/s² or* 2.25 m/s²
$v^2 - u^2 = 2as$; $9^2 - 0^2 = 2 \times 2.25 \times s$ OR $9^2 - 0^2 = 2 \times 2 \times s$ [1] ; so, $s = 81 \div 4.5$ OR $s = 81 \div 4$ [1]; $d = 18$ m OR 20.25 m [1]

11–3 *The data points should cover at least half of the graph paper in each axis* [1]*; the x–axis should be labelled* Time in seconds *and the y–axis* Velocity in m/s [1]*; Check plotting of points, lose one mark for each incorrect plot, up to a maximum of 2 marks*.



11–4 *Area under the graph method seen*. [1]
Any area correctly calculated.
4–8 seconds area = (4 × 9) + (4 × 1 ÷ 2) = 38 m OR 8–9 seconds area = (1 × 10) + (1 × 1 ÷ 2) = 10.5 m [1]
total area = total distance travelled = 18 m (from 11-2) + 38 + 10.5 = 66.5 m [1]

12–1 $v^2 - u^2 = 2as$; $31^2 - 0^2 = 2 \times a \times 50$ [1]; so, $a = 961 \div 100 = a$ [1] = 9.61 m/s² [1] *Final answer must not be rounded to 9.6 m/s²*

12–2 acceleration = change in velocity ÷ time; 9.61 = 31 ÷ t [1]; so, t = 31 ÷ 9.61 [1] = 3.23 seconds [1]

12–3 12 seconds [1]

12–4 The weight force balances the air resistance [1], so there is no resultant force [1].

12–5 The parachute opens [1]. This results in a large increase in air resistance [1]. The resultant force is in the opposite direction to the motion [1].

12–6 *Counting squares method is seen* [1]; Total of approximately 19 squares of 10 × 4 [1] *accept range between 18 and 20;* Total area = 19 × 40 = 760 m [1] *accept range between 720 m and 800 m*

13–1 *Maximum* [6] *marks from:*
Measure the diameter of the cupcake cases [1] with a ruler [1]. Measure a fixed height to drop the cupcake cases at e.g. 2.0 m [1], time how long it takes for the cupcake case to fall through this height when dropped [1] using a stop clock [1]. Repeat the time measurement at least three times for reliability [1]. Take a mean average of the time measured [1], and calculate the average speed using the equation average speed = total distance / total time taken [1]. Repeat for different diameter cupcake cases [1].

13–2 10 cm [1]. Between 2 and 4 seconds the cupcake case is falling the same distance each second OR between 2 and 4 seconds the cupcake case is falling at the same speed [1], it has reached terminal velocity [1].

13–3 *A tangent seen* [1]*; A gradient seen of tangent* [1]*; Gradient = (195 – 110) ÷ (1.5 – 0) = 85 ÷ 1.5* [1]*; gradient = speed = 56.7 cm/s* [1]*; Conversion of units to m/s 56.7 cm/s = 0.567 m/s* [1]

Forces, accelerations and Newton's laws of motion (p.57)

Quick questions

1 There must be zero resultant force acting on it, or the forces acting on it must be balanced.

2 The acceleration of an object is proportional to the resultant force acting on the object or the acceleration of an object is inversely proportional to the mass of the object.

3 $F = ma$, resultant force = mass × acceleration

4 Resultant force is measured in N, mass is measured in kg, and acceleration is measured in m/s².

5 ∝ = proportional to; ~ = approximately

6 Whenever two objects interact, the forces they exert on each other are equal and opposite.

7 Inertial mass is a measure of how difficult it is to change the velocity/accelerate an object OR force ÷ acceleration.

Exam-style questions

8–1 $F = ma$ = 10 000 × 0.5 [1] = 5000 N [1]

8–2 The acceleration will increase, [1] this is because $F = ma$ and the mass has decreased OR this is because according to Newton's Second Law, acceleration is inversely proportional to the mass [1].

8–3 *Any* [3] *marks from:*
There will be a driving force in the direction of the motion [1] and resistive forces [1] in the opposite direction [1]. These two forces must be equal. [1]

9–1 *Any* [5] *marks from:*
Place the trolley approximately 1m (*or other sensible distance*) from the light gate [1] and the hanging masses the same distance above the ground. Calculate the accelerating force by using weight = mass × g [1]. Release the trolley from rest [1] and time how long it takes for the trolley card to pass through the light gate [1]. Record the velocity from the light gate and data logger [1]. Calculate the acceleration using acceleration = change in velocity ÷ time taken [1]. Remove a mass from the trolley and place it on the hanging masses [1], to keep the total mass constant [1] and repeat the experiment. Plot a graph of *acceleration* against *force* [1].

9–2 The hanging masses may fall and land on student's toes [1]. Use a sand box or impact mat to absorb impact or do not stand underneath the hanging masses [1].

9–3 $F \propto a$

9–4 Straight line OR linear [1] passing through the origin of the graph [1].

10–1 zero [1], weight [1], normal contact force [1], magnitude OR size [1], first [1].

10–2 $F = ma$; so $1.57 \times 10^7 = m \times 5.25$ [1]; so $m = 1.57 \times 10^7 \div 5.25$ [1] 2 990 476 kg [1] = 2 990 000 kg to 3 significant figures [1].

10–3 As the fuel is burnt the mass of the rocket decreases [1], due to $F = ma$ the acceleration must increase or due to the acceleration being inversely proportional to the mass the acceleration must increase [1].

10–4 *Any* [2] *marks from:*
They act on two separate bodies [1]; They are the same type of force [1]; They are of the same magnitude or size [1]; They act in opposite directions [1]; They act in the same plane or along the same line [1]

11–1 The force must be 30 N [1] and in the opposite direction to the force that the fisherman exerts on the boat [1]

11–2 $F = ma = 85 \times 0.2$ [1] = 17 N [1]

11–3 30 – 17 = 13 N [1]

11–4 $F = ma = 85 \times 0.33$ [1] = 28 OR 28.05 N [1]

11–5 This statement is not true [1] as the boat and the fisherman have different resultant forces acting on them [1] so different accelerations would be expected for the same inertial mass [1].

Forces and braking (p.59)

Quick questions

1 The distance that a vehicle travels while the driver reacts OR The distance that a vehicle travels before applying the brakes.

2 The distance that a vehicle travels while the car is stopped by the brakes OR the distance the vehicle travels under the braking force.

3 stopping distance = thinking distance + braking distance

4 0.2–0.9 seconds

5 greater

Exam-style questions

6–1 *Any* [2] *marks from:*
size of the braking force [1]; weather conditions [1]; conditions of the tyres or brakes [1]; road surface [1]; speed of the car

6–2 Thinking distance = 23 – 14 = 9 m [1]

6–3 The thinking distance would increase [1], the braking distance would increase [1] so the stopping distance would increase [1].

7–1 *Any* [4] *marks from:*
Hold the bottom end of a ruler between the fingers of a partner's hand [1], Without telling them, drop the ruler [1]. The other student must catch the ruler as fast as possible [1]. Measure the distance that the ruler fell before it was caught [1]. Use $v^2 - u^2 = 2as$ and $a = (\Delta v \div t)$ to calculate their reaction time. [1]

7–2 Repeat this experiment and take a mean average of the results [1].

7–3 he was tired [1]; he was chatting to his friend [1].

7–4 As the speed increases, so does the thinking distance [1] a linear relationship [1] OR directly proportional [2]

7–5 The line should be drawn straight [1] above the line already shown on the graph [1].

8–1 As the speed increases so does the braking distance [1] it is non-linear [1].

8–2 If the mass increased the thinking distance line would remain the same [1], but the braking distance line would be above the original line, for example, a greater braking distance would be measured [1].

8–3 If the brakes were poorly maintained, they would produce a smaller braking force [1], due to work done = force × distance [1]. This means that the braking distance would increase [1].

8–4 From the graph: braking distance = 4.0 m, thinking distance = 2.0 m [1]; so, stopping distance = 4.0 + 2.0 = 6.0 m [1]

8–5 *Any* [3] *marks from:*
The stopping distance at 8 m/s is 20 m [1], this is 14.0 m longer [1]. The thinking distance is twice as large as the thinking distance at 2.0 m [1] but the braking distance is 4 × larger than the braking distance at 4 m/s [1].

9–1 *Any* [5] *marks from:*
Rainy and icy weather conditions will increase the braking distances of cars [1] and so will increase the stopping distances of cars [1]. These weather conditions are unlikely to affect the thinking distance of cars, unless they affect visibility [1]. Reducing the speed that cars travel at will decrease the thinking distance, braking distance and stopping distances of cars [1]. Reducing the speed limit when it is rainy and icy will go some way in counteracting the increase to braking distance in these conditions [1]. The reduction in speed limits is sensible [1] because this will reduce the likelihood of accidents and injury [1].

9–2 *Any* [3] *marks from:*
When the brakes are applied, work is done [1] by the friction force between the brakes and the wheels [1]. This transfers the kinetic energy of the car [1] mechanically [1] to thermal energy in the brakes [1].

9–3 The large braking forces result in a large deceleration [1]. This can result in the brakes overheating [1] or in the driver losing control of the lorry [1].

9–4 For the initial situation, assuming constant deceleration, the average speed = (14 + 0) ÷ 2 = 7 m/s. This means that the time taken is 25 m ÷ 7 m/s = 3.57 seconds, and the deceleration is = 14 ÷ 3.57 = 3.92 m/s^2 for a braking force of 9800 N.
For the new situation, the average speed = (28 + 0) ÷ 2 = 14 m/s. The time taken is 50 ÷ 14 = 3.57 seconds OR the time taken is the same [1]. The deceleration is 28 ÷ 3.57 = 7.84 m/s^2 OR double [1]. So, the braking force is double [1] because the acceleration is proportional to force assuming constant mass [1].
braking force = 19 600 N [1]; *Accept estimated answers between 18 000 N and 20 000 N.*

Momentum (p.61)

Quick questions

1 momentum = mass × velocity

2 Vector

3 kgm/s

4 In a closed system, the initial total momentum equals the final total momentum.

5 change in velocity.

Exam-style questions

6–1 momentum = mass × velocity, momentum = 0.4 × 8 [1] = 3.2 [1] kgm/s [1]

6–2 force = change in momentum ÷ time taken; 50 = 3.2 ÷ t [1]; so t = 3.2 ÷ 50 [1] = 0.064 seconds [1]

6–3 force = change in momentum ÷ time taken = 3.2 ÷ 14 [1] = 0.2286 N [1] = 0.23 N to 2 significant figures [1]

7–1 momentum = mass × velocity; 760 = 20 × v [1]; so, v = 760 ÷ 20 [1] = 38 m/s [1]

7–2 *Any* [3] *marks from:*
Momentum of the closed system is conserved [1]. The initial momentum of the system is 0 kgm/s [1] so when the cannonball is released the cannon must have equal and opposite momentum to the cannonball. [1] This means that the cannon will move/have velocity, in the opposite direction to the cannonball [1].

7–3 initial momentum = final momentum [1]; $0 = 760 + (700 \times v)$ [1]; so $v = 760 \div 700$ [1] = 1.09 OR 1.1 m/s [1]

7–4 4 ms = 0.004 seconds [1]; force = change in momentum ÷ time taken = 760 ÷ 0.004 [1] = 190 000 N [1]

8–1 *Any* [5] *marks from:*
The teacher should measure the masses of the carts [1] using a mass balance [1]. The teacher should then label the carts A and B, and place cart B close to the second light gate and stationary [1]. The teacher should then apply a small force to cart A to make it travel along the frictionless track, until it collides with cart B and they should stick together [1]. The first light gate should measure the initial speed of cart A [1] and the final light gate should measure the final speed of cart A and B stuck together [1]. The teacher should then find the momentum of cart A, cart B and the two carts stuck together [1]. If momentum is conserved, then the momentum of cart A + momentum of cart B will equal the final momentum of the two carts stuck together [1].

8–2 This would increase the velocities of the carts [1] and cause a systematic error [1].

8–3 initial momentum = final momentum [1]; $(3 \times 4) + (2 \times 2)$ = initial momentum [1]; so, initial momentum = 16 kgm/s = final momentum = $5 \times v$ [1]; final velocity = 16 ÷ 5 = 3.2 m/s [1]

9–1 momentum = mass × velocity = 1000 × 10 [1] = 10 000 kgm/s [1]

9–2 initial momentum = final momentum [1]; initial momentum = 10000 + (500 × –30) = 10000 – 15000 [1] = –5000 kgm/s [1]; final momentum = –5000 kgm/s = 1500 × v [1]; so, v = –5000 ÷ 1500 = –3.33 m /s; so 3.33 m/s to the left [1]

9–3 blue car momentum = 15 000 kgm/s and final momentum = 0 kgm/s; 15 000 + (1000 × v) = 0 [1]; so, v = –15 000 ÷ 1000 [1] = –15 m/s OR 15 m/s [1] *The negative sign is not required.*

9–4 The crumple zone collapses upon impact increasing the time of impact [1]. Because force = change of momentum ÷ time taken [1] this will decrease the force of the collision [1]. As there is less force, there are likely to be fewer injuries [1].

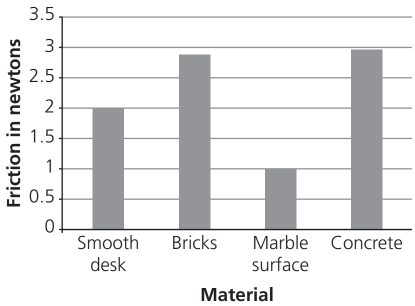
Forces topic review (p.63)

1–1 Moves [1] contact force [1]

1–2 force 1 = weight [1], force 2 = normal contact force [1] and force 3 = friction [1]

1–3 The material is discrete data [1]

1–4 *Scale, the data points should cover at least half of the graph paper in each axis* [1]*; Axis labels, the x-axis should be labelled* Material *and the y-axis* Friction in newtons [1]*; Check plotting of points* [2], *lose* [1] *for each incorrect plot, up to a maximum of 2 marks.*



1–5 At constant speed the resultant force is zero [1]. This means that the force pulling the newtonmeter will equal the friction force [1], so the newtonmeter reading is the value of the friction.

2–1 The motorcyclist travels with constant speed between A and B [1], and then the motorcyclist is stationary between B and C [1].

2–2 *Attempt to use gradient* [1]
(8 – 3) ÷ (7 – 5) = 5 ÷ 2 [1] = 2.5 km/minute [1]

2–3 12 minutes in seconds = 12 × 60 = 720 seconds [1]; average speed = total distance ÷ total time = 14 000 ÷ 720 [1] = 19.4 m/s [1]

2–4 *Any* [2] *marks from:*
the road conditions [1];
the weather conditions [1]; the condition of the tyres [1];
the condition of the brakes [1];
the speed of the car [1]

2–5 resultant force = mass × acceleration OR $F = ma$ [1]

2–6 resultant force = 410 × 6.8 [1]; F = 2788 N [1] = 2800 N *to 2 significant figures* [1]

3–1 work done = force × distance [1]

3–2 One joule is the energy required to move an object with a force of 1 N a distance of 1 m [1]

3–3 Nm [1]

3–4 total weight = 12 × 2.45 = 29.4 N [1]; work done = 29.4 × 1.8 [1] = 52.92 J [1]

3–5 $v^2 - u^2 = 2as$; $v^2 - 0^2 = 2 \times 9.8 \times 1.8$ [1]; v^2 =35.28 [1]; v = 5.94 m/s [1]

4–1 Measure the original length of the glass rod with a ruler [1]. Apply a weight and then measure the new length of the glass rod [1]. The extension is the new length minus the original length [1].

4–2 weight = mass × gravitational field strength OR $W = mg$ [1]

4–3 conversion, 100 g = 0.1 kg [1]; weight = mass × g = 0.1 × 9.8 [1] = 0.98 N [1]

4–4 The anomalous point is at 2.5 N and 2.5 mm extension [1]

4–5 *Attempt to use gradient* [1]
gradient = (10 – 0) ÷ (20 – 0) = 10 ÷ 20 [1]; spring constant = 0.5 [1]

4–6 N/mm [1]

4–7 Elastic deformation means that the object will return to its original length [1] when the force is removed [1]

5–1 clockwise moments = anticlockwise moments [1]

5–2 moment of a force = force × distance [1]

5–3 10 cm in metres = 0.1 m; distance from pivot = 1 – 0.1 = 0.9 m [1]; moment of a force = 2 × 0.9 [1] = 1.8 [1] Nm [1]

5–4 anticlockwise moments = clockwise moments; anticlockwise moments = 1.8 Nm = clockwise moment [1]; moment = force × distance; 1.8 = 3 × distance [1]; so, distance from pivot = 1.8 ÷ 3 [1] = 0.6 m [1]

6–1 acceleration = change in velocity ÷ time taken OR $a = \Delta v \div t$ [1]

6–2 acceleration = 45 ÷ 0.03 [1] = 1500 [1] m/s² [1]

6–3 conversion, 145 g = 0.145 kg [1];
$F = \frac{m\Delta v}{\Delta t}$ = 0.145 × 45 ÷ 0.03 [1] = 217.5 N [1]

6–4 A weight force will act downwards on the ball [1] and a drag force due to air resistance will act in the opposite direction to the baseball's motion [1].
If a comment about throwing force or force from pitcher is seen deduct [1] *mark.*

6–5 *Any* [4] *marks from:*
The helmet has cushioning inside to protect the wearer [1]. The cushioning increases the time taken for the collision [1]. While the change of momentum is constant [1] this means that the force exerted decreases, as the rate of change of momentum is smaller [1] reducing injury [1].

7–1 Measure the circumference of the circular ice rink [1] using a long tape measure or a trundle wheel

[1]. Measure the time taken for the ice skater to travel around the circumference of the ice rink 5 times (at least) [1] using a stopwatch [1]. Find the time taken for one lap, by dividing the time measured by the number of laps [1]. Calculate the average speed using speed = distance ÷ time [1]

7–2 Speed is a scalar quantity, but velocity is vector [1]. The speed can be constant, but travel is in a different direction [1] resulting in a different velocity.

7–3 *Any [2] marks from:* same size force [1]; acting in opposite directions [1]; same type of force [1]; acting in the same line [1].

7–4 *Vertical arrow upwards and horizontal arrow to the right* [1]; *Horizontal arrow longer than the vertical arrow* [1].

7–5 momentum = mass × velocity OR $p = mv$ [1]

7–6 momentum = 70 × 12 [1] = 840 kg m/s [1]

7–7 *Attempt for conservation of momentum* [1] (70 × 12) + (75 × 0) = (4 × 70) + (75 × v) [1]; 840 = 280 + (75 × v), 75v = 560 [1]; so, v = 7.5 m/s *or answers that round to this value* [1]

Waves in air, fluids and solids (p.68)

Quick questions

1 A wave that transfers energy perpendicular to the direction of vibration.

2 A wave that transfers energy parallel to the direction of vibration.

3 The maximum displacement of a wave from its undisturbed position.

4 The distance from one point on a wave to the equivalent point on the next wave.

5 wave speed = frequency × wavelength

6 Hz or hertz

7 angle of incidence = angle of reflection

8 An image formed by light rays that appear to diverge from a point.

9 20–20 000 Hz

10 Sound waves with a frequency above 20 000 Hz.

11 Solids and liquids

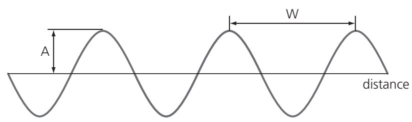
12 Solids

Exam-style questions

13–1 Light [1]; ultraviolet [1]

13–2 Transverse waves vibrate perpendicular to the direction of energy transfer [1], whereas longitudinal waves vibrate parallel to the direction of energy transfer [1].

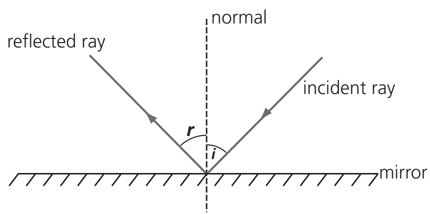
13–3



W *shown as a distance between peak to peak, trough to trough or any other equivalent point on two separate waves* [1].

13–4 *See image above*; A *shown as distance between the undisturbed position (dotted line in the middle) and the peak or trough of a wave* [1].

14–1



incident ray with directional arrow [1]; *reflected ray with directional arrow* [1]; *the normal* [1]; *angle of incidence, i* [1]; *angle of reflection, r* [1]

14–2 90° [1] normal [1] normal [1] equals OR is the same as [1]

14–3 The light is absorbed [1] as the paper doesn't allow the light to pass through it [1].

15–1 An echo is a sound wave [1] that reflects from a surface such as large object or building [1].

15–2 mean = (2.36 + 2.45 + 2.46) ÷ 3 = 2.42 seconds [1]

15–3 2.46 – 2.36 = 0.10 seconds [1]; uncertainty = 0.10 ÷ 2 = 0.05 seconds [1]

15–4 distance travelled = 40 × 2 (for echo) × 10 (repeats) = 800 m [1]; speed of sound = distance travelled ÷ time taken = 800 ÷ 2.42 [1] = 331 m/s [1]

15–5 Random error [1]

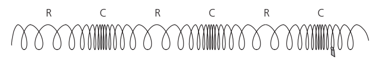
15–6 microphone [1]

15–7 *Any [2] marks from the points below to set up the equipment:* Connect the loudspeaker to a signal generator and place this 20 cm away from the microphones and oscilloscope [1]. Two microphones are connected to the oscilloscope. Measure the distance between them with a ruler [1] and ensure that the microphones are placed 40 cm away from each other *award the mark for any sensible distance seen* [1].

Any [2] marks from the points below to calculate the speed of sound: When the sound is produced on the loudspeaker the oscilloscope detects the sound as it reaches each microphone [1]. Measure the time difference between these detections using the oscilloscope [1]. Calculate the speed of sound using speed = distance between microphones ÷ time difference between detection [1].

Allow [1] mark for a reliability procedure from: Repeat the experiment and take a mean average [1]. Repeat the experiment for at least three different microphone separation distances [1].

16–1



Any correct location of C [1]
Any correct location of R [1]

16–2 wave speed = frequency × wavelength = 0.5 × 0.15 [1] = 0.075 [1] m/s [1] OR wave speed = frequency × wavelength = 0.5 × 15 [1] = 7.5 [1] cm/s [1]

16–3 Wave speed is the speed at which energy [1] is transferred through the medium [1].

17–1 Calculate the speed of the wave by using speed = frequency × wavelength [1]

Any [2] *marks from the points below to measure the wavelength:* Measure the distance across the screen [1] using a ruler [1] and count the number of waves seen on the screen [1]. Divide the distance across the screen by the number of waves to find the wavelength [1].

Any [2] *marks from the points below to find the frequency:* Count the number of waves passing a point [1] in 10 seconds (or more) [1] and find the frequency by dividing the number of waves counted by the time measured [1].

Allow [1] mark for a reference to improving reliability Repeat these measurements and take a mean average [1]; Repeat the experiment using different speeds of the motor [1].

17–2 The water is always in contact with the vibrating dipper OR a vacuum doesn't form by the dipper [1].

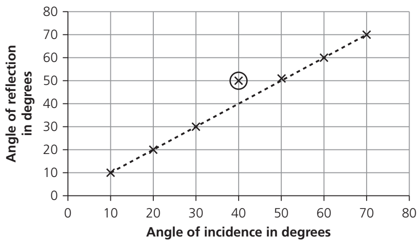
17–3 4.4 cm = 0.044 m [1] wave speed = frequency × wavelength; 0.12 = frequency × 0.044 [1]; so, frequency = 0.12 ÷ 0.044 [1] = 2.7 Hz [1] *do not allow frequency = 3 Hz*

17–4 period = $\frac{1}{\text{frequency}}$; $T = \frac{1}{2.7}$ OR $T = \frac{1}{3}$ [1]; T = 0.37 seconds OR 0.33 seconds [1]

18–1 *Any* [6] *marks from:*
Set up the mirror and ray box on paper, drawing a line around the mirror or along the boundary line. [1] Using the ray box, send an incident ray towards the mirror, and trace the path of the incident and reflected rays on the paper [1]. Remove the mirror and the ray box and draw a normal at the 90° to the boundary [1]. Measure the angle of incidence [1] and measure the angle of refraction [1]. Repeat the experiment for different angles of incidence [1]. Plot a graph of angle of incidence vs angle of reflection [1].

18–2 When measuring the angles using the protractor, misjudging the centre of the ray [1]

18–3



Scale: the data points should cover at least half of the graph paper in each axis [1]; Axis labels: the x-axis should be labelled angle of incidence in degrees and the y-axis angle of reflection in degrees [1]; Plotting of points: lose [1] for each incorrect plot, up to a maximum of 2 marks.

18–4 *The point* (40, 50) *should be circled on the graph* [1] *as seen in the diagram above.*

18–5 *A sensible smooth line of best fit is seen*. [1]

18–6 As the angle of incidence increases the angle of reflection increases [1]. It is linear [1]. OR directly proportional [2]

19–1 Sound waves can travel through a vacuum [1].

19–2 Sound waves are converted to vibrations in the ear drum [1]. These are then transferred to vibrations in the small bones in the ear [1]. These are connected to nerves (in the cochlea) and these signals are transferred to the brain [1].

19–3 This is because your ear drum and small bones are unable to vibrate at the speeds required [1] to transmit these frequencies, due to wave speed = wavelength × frequency [1].

20–1 The ultrasound is sent down into the water and is reflected off the sea bed [1]. The boat records how long it takes for the ultrasound to be emitted, reflected and received again [1]. Using speed = distance ÷ time, the distance travelled can be calculated [1]. This distance is then divided by 2 to find the depth[1].

20–2 30 kHz = 30 000 Hz [1]; wave speed = frequency × wavelength; 1500 = 30 000 × wavelength [1]; so, wavelength = 1500 ÷ 30 000 [1] = 0.05 m or 5 cm [1]

20–3 speed = distance ÷ time; 1500 = distance ÷ 0.4 [1]; so, distance = 1500 × 0.4 = 600 m [1]; depth of water = 600 ÷ 2 = 300 m [1]

20–4 Some of the ultrasound will be reflected [1] and some will be transmitted or absorbed [1].

21–1 The energy transferred by the shockwave damages the building. [1]

21–2 *Any [5] marks from points below; a comparison must be made somewhere to gain the final mark.*
P-waves can travel through solid and liquid rock [1], they can travel through the crust, mantle, inner and outer cores [1] and they change direction when their speed changes [1]. The S-waves can only travel through solids [1] and so they are only able to travel through the crust and the mantle [1], they cannot travel through the liquid outer core unlike P-waves [1]. They also change direction as their speed changes [1].

21–3 It helps us learn about the inside of the Earth and its structure (that we could not do otherwise) [1]

21–4 The different stations can then record the time at which they detected the signal [1], and as the speed of the wave is known, we can work out how far each has travelled [1] to identify the location where all the waves originated [1].

Electromagnetic waves (p.72)

Quick questions

1 *In any order:* Radio waves, microwaves, infrared, visible, ultraviolet, X-ray and gamma.

2 Visible

3 Refraction occurs when waves change speed as they enter a different substance.

4 Radiation dose is a measure of the risk of harm to the body when exposed to radiation.

5 It is a ratio.

6 convex lens: 

concave lens: 

7 The principal focus is the point at which all rays of light parallel to the principal axis converge after passing through a convex lens.

8 Red

9 Black

10 An object which light can pass through.

Exam-style questions

11–1 Electromagnetic waves are transverse [1]; Electromagnetic waves travel at the same speed through a vacuum [1]

11–2 Radio waves [1]

11–3 Treating cancers OR sterilising medical equipment [1]

11–4 They can cause mutations to genes OR they can cause cancer [1]

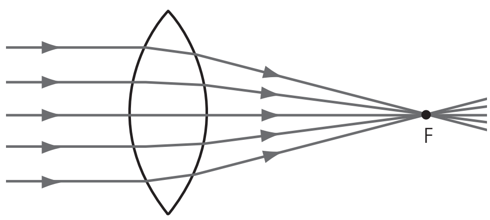
11–5 Gamma rays are produced when there are changes in the nucleus of an atom [1].

12–1 *Marks are awarded for each group in the correct placement.*
microwaves [1] visible [1] ultraviolet [1] X-rays [1]

12–2 Treating cancers – X-rays [1]; Sun tanning – ultraviolet [1]; Optical fibre communication – visible [1]; Cooking food – microwaves [1]

12–3 They can cause skin cancer OR prematurely age the skin [1]

13–1



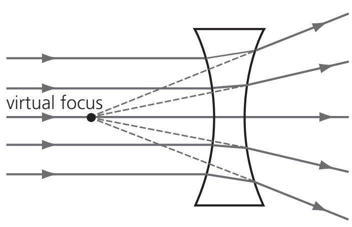
Rays seen to bend inside the lens [1]*; Rays seen to bend again to converge outside the lens* [1]*; Rays converge to a single point* [1].

13–2 F should be labelled where the focus is in the diagram above. [1]

13–3 Focal length [1]

13–4 Real images are images which can be projected onto a screen [1]

13–5



Rays bend away from each other inside the lens [1]*; Rays bend away from each other again outside the lens* [1]*; Dotted construction lines tracing backwards from the diverging rays outside the lens to a point* [1]*; The point where the dotted lines meet is labelled the virtual focus* [1].

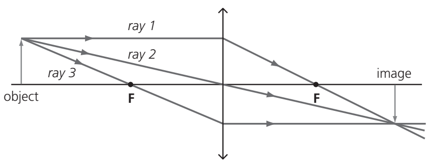
14–1 Specular reflection occurs when the light is reflected in a single direction [1] from a smooth surface [1] whereas diffuse reflection occurs when the reflected light is scattered [1] from a rough surface [1].

14–2 White light contains all wavelengths of light [1]. All wavelengths of light except red are absorbed [1]. The red light is reflected from the poppy [1].

14–3 All wavelengths of light are absorbed by the filter except the blue light [1], the blue light is transmitted [1].

14–4 Black [1] As the only light incident on the poppy is blue light [1], and the blue light will be absorbed OR no light is reflected from the poppy [1].

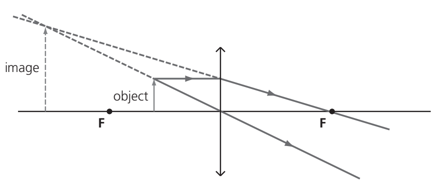
15–1



Horizontal line from the top of the object to the lens seen. This line then travels through F on the right-hand side and continues – ray 1 [1]*; Diagonal line from the top of the object through the centre of the lens seen that continues – ray 2* [1]*; Diagonal line from the top of the object through the focal point to the lens, the ray then travels horizontally from the lens – ray 3* [1]*; Image arrow shown correctly* [1].

15–2 The image is real, diminished and inverted.

15–3



Horizontal line from the top of the object to the lens seen. This line then travels through F on the right-hand side and continues. [1]*; Diagonal line from the top of the object through the centre of the lens seen that continues* [1]*; Dotted construction lines are traced backward from the two rays on the right–hand side of the lens* [1]*; Image shown where the dotted construction rays cross.* [1].

15–4 This image is virtual whereas the previous image was real [1], this image is upright, whereas the previous image was inverted [1] and this image is magnified whereas the previous image was diminished [1].

15–5 $\text{magnification} = \dfrac{\text{image height}}{\text{object height}} = \dfrac{22}{9}$

[1] = 2.44 [1]

16–1 *Any* [1] *mark from*:
remote controls [1]; optical fibres [1]; cooking [1]; heaters [1]

16–2 Absorbs means that the object does not transmit or reflect the waves [1].

16–3 Black matt tin [1]

16–4 *Any [1] mark from:*
The student should fill the three metal tins with the same volume of hot water [1] at the same temperature [1].
Plus maximum [3] marks for method:
They should measure and record the temperature using a thermometer [1]. They should cover the tins with an insulating material [1]. The tins should then be left for 15 mins (*Allow other sensible time between 10 and 30 mins)* to cool [1]. The student should then remove the lids and measure the temperature of the three tins [1].
Conclusion must be shown for final [1] *mark:*
The tin that has reduced in temperature the most will be the best emitter of infrared radiation [1].

16–5 A bar chart [1]

17–1 Radio waves and X-rays are similar as they are both transverse waves [1] that travel at the same speed in a vacuum [1]. Radio waves have a longer wavelength [1] and smaller frequency than X-rays [1]. *Allow reverse argument for final two marks.*

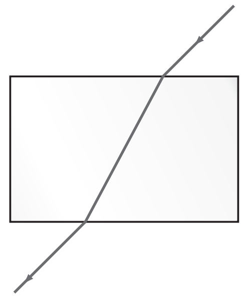
17–2 Radio waves are produced by an oscillating [1] electric current [1].

17–3 Radio waves are used for radio OR television signal transmission [1]. They are used because radio waves are reflected from the ionosphere [1] so can travel long distances [1].

17–4 They may cause mutations in genes OR they may cause cancer [1].

17–5 *Any [4] marks from:*
While any X-rays increase the risk of mutations in genes or cancer [1] the radiation dose from the chest X-ray is quite low. The annual dose from natural sources is 2 orders of magnitude [1] larger [1] and this annual exposure poses a very small risk to health [1]. The chest X-ray is a much smaller dose than a transatlantic flight [1] but is much larger than a dental X-ray [1]. The chest X-ray is probably safe and not too dangerous [1].

18–1



Ray inside the glass block bending towards the normal [1]; Ray outside the glass block bending away from the normal so that it travels parallel to the original line [1].

18–2 The light travels more slowly inside the glass [1] this makes its direction change [1].

18–3 The wavelength is longer in the deep water than in the shallow water [1]. This means that the wave is travelling faster in the deep water [1]. The change in speed results in a change in direction [1].

Black body radiation (p.76)

Quick questions

1 The wavelength decreases.

2 Intensity is the energy from the radiation per second per square metre OR the power of the radiation per square metre.

3 They partially reflect radiation.

Exam-style questions

4–1 A perfect black body will absorb all the radiation that is incident on it [1].

4–2 emitter [1] reflect [1] transmit [1] emit [1] constant [1].

4–3 The potato will absorb more [1] infrared red radiation per second [1] than it radiates [1].

5–1 The gradient of the line is steepest at the beginning [1].

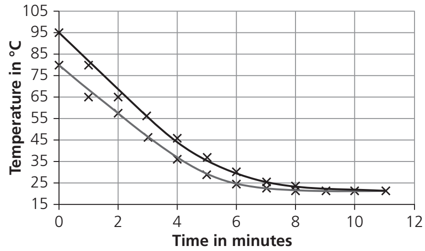
5–2 The water is hotter than its surroundings [1]. This means that it will emit more radiation per second [1] than it absorbs [1].

5–3 The water is absorbing the same amount [1] of radiation per second as it emits [1].

5–4 *Any* [2] *marks from:*

Same volume of water [1]; Same room temperature [1]; Same material beaker [1]; Same colour beaker [1]; Same surface area of water [1].

5–5



Line is below the original line on the graph [1]*; Line reaches 22 degrees (equilibrium) before the original line* [1]*; Gradient of the new line is always slightly less than the original line at the same time* [1].

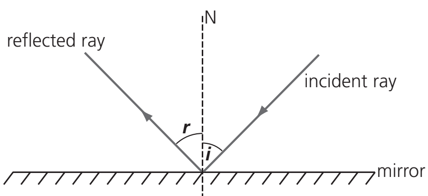
Waves topic review (p.77)

1–1 *Any part of the electromagnetic spectrum* OR water waves OR S-waves [1]

1–2 eyes [1], electromagnetic [1], energy [1], radio waves [1], ultraviolet [1], vacuum [1]

1–3 *Any* [1] *mark from:* energy efficient lamps; tanning beds; detecting forged bank notes; security markings

2–1



Mark awarded for correct line, N [1]

2–2 *See image above,* mark awarded for correct labelling of angle *i* [1] and angle *r* [1].

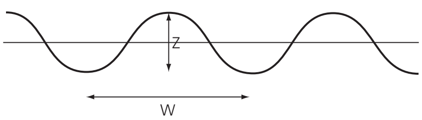
2–3 Diffuse reflection is where light is scattered [1] from a rough surface [1].

2–4 Transparent objects allow light to travel though them OR they transmit light [1].

2–5 Some of the light will be reflected [1], but most of the light will be transmitted through the block [1]. Due to the change in material the light will refract [1].

3–1 $2 \times$ the amplitude OR double the amplitude [1]

3–2



Correct labelling of W [1]

3–3 The diagram shows 2.5 waves [1]; so, wavelength = $4 \div 2.5$ m [1] = 1.6 m [1]

3–4 Hertz [1]

3–5 *Maximum* [6] *from:* Attach a string to a signal generator [1]. The frequency of the waves will be the same as the setting of the signal generator [1]. Adjust the apparatus so that a whole number of waves are present on the string [1]. Measure across as many waves as possible [1] using a ruler. The wavelength is the distance measured ÷ number of waves [1]. Use wave speed = frequency × wavelength to find the wave speed [1].

4–1 A green filter absorbs all wavelengths of light except for green [1] so the green light is transmitted [1].

4–2 The white block will appear green [1] as only green light is incident on the block and white objects reflect all colours of light [1].

4–3 The block appears black [1] as only green light is incident on the block [1] but the red block absorbs the green light [1]. No light is reflected from it [1].

4–4 *A horizontal line should be seen inside the prism* OR *a line with a smaller angle of refraction compared to the angle of incidence* [1].

4–5 This is where the infrared rays are [1].

5–1 *Any* [2] *marks from:* Ultraviolet waves and microwaves are both transverse waves [1]; they both travel at the same speed in a vacuum [1]; they both transfer energy from one place to another [1]; they both obey the equation wave speed = frequency × wavelength [1].
Plus any [2] *marks from:* Ultraviolet waves have a higher frequency than microwaves [1]; ultraviolet waves have a shorter wavelength than microwaves [1]; ultraviolet waves are more dangerous than microwaves [1].

5–2 They can increase the risk of skin cancer OR They can damage your eyes [1].

5–3 Radiation dose is a measure of the risk of harm resulting from an exposure of the body to the radiation [1].

5–4 $2.7\,\text{mSv} = 2.7 \times 10^{-3} = 0.0027\,\text{Sv}$ [1]

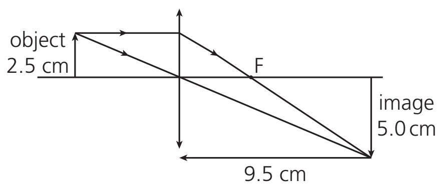
5–5 wave speed = frequency × wavelength [1]

5–6 $3.0 \times 10^{8} = f \times 3 \times 10^{-9}$ [1]; so, $f = (3.0 \times 10^{8}) \div (3 \times 10^{-9})$ [1] = 1×10^{17} Hz [1]

6–1 *Allow* [1] *mark for each correctly drawn diagram for convex and concave lenses* OR *descriptions:*. Convex lenses bend the light causing it to converge [1]; Concave lenses bend the light causing it to diverge [1].
Allow [2] *marks for comments on the images formed:* Convex lenses can produce real or virtual images [1]; Concave lenses can only produce virtual images [1]

6–2 $\text{magnification} = \dfrac{\text{image height}}{\text{object height}}$; 2 = image height ÷ 25 [1]; so, image height = 2×25 = [1] = 50 mm [1]

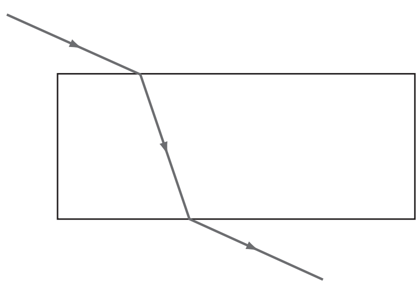
6–3



One ray seen to travel straight between the object and image through the centre of the lens [1]*; One ray seen to travel parallel from the object to the lens, and then diagonally down to the image* [1]*; Scale of object and image drawn correctly* [1]*; Scale of distance from image to lens drawn correctly* [1].

6–4 Measurement from the lens to the point where the top ray crosses the principal axis = 3.2 cm. *Allow values in the range of 3–3.4 cm* [1].

7–1



Diagonal line shown bending towards the normal inside the glass [1]*; Diagonal line shown leaving the glass block parallel to the initial ray in the air below the block* [1].

7–2 Refraction occurs when light travels into a new material [1] and it changes speed [1].

7–3 Draw around the glass block on the piece of paper and mark on the paper where the incident ray enters the block and mark on the paper where the ray leaves the block on the other side [1]. Remove the glass block and join up the two lines [1]. Draw a normal at the top surface [1], measure the angle of incidence, the angle between the normal and incident ray [1] and the angle of refraction, the angle between the normal and refracted ray [1] with a protractor [1].

7–4 *Any* [1] *mark from:*
Turn off the ray box in between readings because it will get hot [1]; Do not shine the ray box in anyone's eyes [1]; Clear away stools and unneeded equipment due to working in the dark [1].

8–1 P-waves are longitudinal, and S-waves are transverse [1], P-waves can travel through solid and liquid, but S-waves can only travel through solid rock [1].

8–2 S-waves cannot travel through liquid [1] so cannot travel through the outer core [1]. Therefore the monitoring station must be at a location far away where the S-waves cannot reach them [1].

8–3 S-waves cannot reach the shadow zones as they cannot travel through the outer core [1].

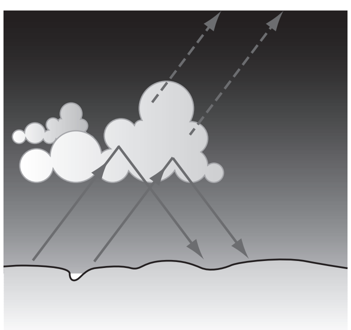
8–4 When P-waves travel into the outer core they refract [1] towards the normal [1]. This means that the waves bend towards locations directly opposite the earthquake OR bend away from the shadow zones [1].

9–1 The Sun would become redder [1].

9–2 The intensity of radiation is higher at the equator [1] due to the difference in the angle at which the radiation hits the Earth's surface [1]. This means that at the equator the Earth absorbs more radiation than it emits [1].

9–3 The clouds reflect some of the radiation away from the Earth [1]. This is shown by the reflected arrows [1] and the dotted arrows towards the Earth [1].

9–4



Arrows show the energy radiating away from the Earth [1]*; Arrows show some energy reflected from the clouds back to the Earth* [1]*; Arrows show some energy (dotted) transmitted away from the Earth* [1].

10–1 Radio waves are produced by oscillations [1] in electrical circuits [1].

10–2 An alternating [1] current in the circuit [1].

10–3 98 cm = 0.98 m [1]; wave speed = frequency × wavelength; (3.0×10^8) = frequency × 0.98 [1]; so, frequency = $(3.0 \times 10^8) \div 0.98$ [1] = 3.06×10^8 Hz = 3.1×10^8 Hz to 2 significant figures [1].

10–4 Radio waves are used for television or radio transmission [1]. They are suited because radio waves reflect off the ionosphere [1].

11–1 A longitudinal wave is a wave where the direction of vibration is parallel [1] to the direction of energy transfer [1].

11–2 20–20 000 Hz [1]

11–3 To hear, the sound waves must be transferred to vibrations in the bones in our ears [1]. This is a transfer from a gas to a solid, which only occurs at a certain frequency range [1].

11–4 Ultrasound is sound waves above 20 000 Hz [1]

11–5 Ultrasound is partially reflected [1] when it travels between different materials [1]. The time taken [1] for the ultrasound to be sent into the human, and for the reflections to be received is recorded [1] and the computer produces an image [1].

Permanent and induced magnetism, magnetic forces and fields (p.83)

Quick questions

1 two like poles = repulsion; two unlike poles = attraction

2 *Any* [3] *from:* Iron, steel, cobalt, nickel

3 A permanent magnet produces its own magnetic field and always has a north and south pole.

4 An induced magnet becomes a magnet when placed inside a magnetic field.

5 A magnetic field is the region around a magnet where a force acts on another magnet or magnetic material.

Exam-style questions

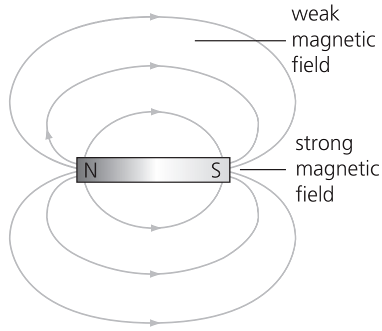
6–1 non-contact [1]; repel [1]; north [1]

6–2 The force increases [1].

6–3 Nothing, no forces are felt [1]. This is because copper is not a magnetic material [1].

6–4 The student could use a magnet to sort them [1]. The steel paperclips would be attracted to the magnet [1] but the aluminium paperclips would not [1].

7–1



General shape correct (no field lines touching) [1]*; Field lines closer together at the poles* [1].

7–2 *Arrows shown on at least two field lines showing the direction north to south* [1].

7–3 The direction of the field lines shows the direction of the force [1] that would act on a north pole at that point in the field [1].

7–4 *Any* [3] *marks from:*
Place the magnet on a piece of paper and draw around it [1]. Place a plotting compass [1] close to the north pole [1] and make a small mark on the paper in the direction that it points [1].
Plus any [3] *marks from:*
Move the plotting compass to this point [1] and repeat until the compass reaches the edge of the paper or the south pole. Join up the marks to make a field line [1]. Return the plotting compass to the north pole and repeat to get at least five field lines [1]. Add arrows to the lines to show the field direction north to south [1].

7–5 Near the poles [1].

8–1 It is an attractive, non-contact force [1].

8–2 The steel nails are made of a magnetic material [1], so they are magnetised when in the field of a permanent magnet [1]. The nails become induced magnets with their poles aligned with the permanent magnet to cause further attraction [1].

8–3 The magnetic force gets stronger [1] as the distance decreases [1].

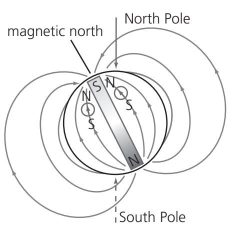
8–4 Permanent magnets produce their own magnetic field, whereas induced magnets are only magnetic when in another magnetic field [1]. Permanent magnets can attract or repel other permanent magnets [1], but induced magnets can only attract other magnets [1]. Induced magnets are temporary magnets, but permanent magnets remain magnetised unless a force is exerted on them [1].

8–5 The builder should take a known permanent magnet [1] and place it at one end of the nail [1] to see if it attracts or repels [1]. They should then place the permanent magnet at the other end of the nail [1]. If the nail attracts at one end and repels the other then it is a permanent magnet [1] but if it attracts both ends, then they have induced magnetism [1].

9–1 The compass aligns with the Earth's natural magnetic field in a north–south direction [1]. The north-seeking pole is attracted towards the geographical north pole [1] as this is a magnetic south pole [1].

9–2 *The poles should be labelled S at the top and N at the bottom* [1] *as in the image in answer 9–3*.

9–3



Shape similar to a bar magnet and at least three field lines drawn [1]*; Lines closer together at the poles* [1]*; Arrows shown from north magnetic pole to south magnetic pole* [1].

The motor effect (p.85)

Quick questions

1 A coil of wire.

2 A solenoid with an iron core.

3 A method to work out the direction of a magnetic field from the current direction in a wire.

4 This is a method to work out the direction of a force caused by the motor effect. It gives the direction of the force, the current and the magnetic field.

5 The strength of the magnetic force OR the number of lines of flux in a given area.

6 Tesla, T

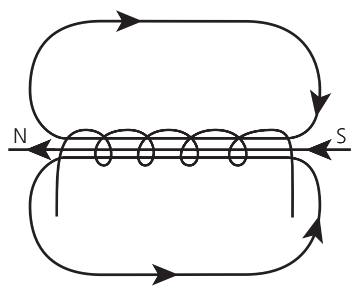
Exam-style questions

7–1 Downwards [1]

7–2 The plotting compasses will point the opposite way or anticlockwise [1].

7–3 The current [1] the distance from the wire [1].

8–1



Straight parallel lines inside the solenoid [1]*; Curved lines outside the solenoid in the same shape as a bar magnet* [1]*; Arrows shown north to south* [1]

8–2 increases [1]; uniform [1]; shape [1]

8–3 *Any [2] marks from:*
Increase the number of coils on the solenoid [1]; Use a larger current [1]; Place the turns closer together [1]

8–4 The student could use light objects made of a magnetic material, such as paperclips, which would be attracted to the end of the electromagnet [1]. The greater the number of paperclips attracted in a single long line, the greater the strength of the electromagnet [1].

9–1 Take a length of wire and coil it into a solenoid and apply a current [1]. Place a soft iron bar inside the solenoid [1].

9–2 When the switch is closed, a current will flow [1]. This will create a magnetic field around the coil of wire, creating an electromagnet [1]. This electromagnet will attract the striker which will strike the bell [1]. This will break the circuit [1]. The striker will spring back and reconnect the circuit [1].

9–3 Fewer coils mean that the strength of the magnetic field is reduced [1]. This will mean that the electromagnet cannot attract the striker fully [1].

10–1 Upwards [1]

10–2 Fleming's left-hand rule [1]

10–3 Convert 50 mT = 0.05 T [1]; $F = BIl$ = 0.05 × 1.2 × 0.2 [1] = 0.012 N [1]

10–4 The current carrying wire will produce a magnetic field around it [1]; this will interact with the magnetic field of the permanent magnets [1], creating a force.

11 *Any* [6] *marks from:*
The current in the coil of wire produces a magnetic field inside it [1], this interacts with the permanent magnetic field [1], creating a force [1]. This force causes the coil and attached paper cone to move [1]. The current is then reversed [1], and the coil moves the opposite way [1]. This happens many times a second, to produce a pressure wave, which creates a sound wave [1].

12–1 The coil rotates clockwise [1].

12–2 *Any* [4] *marks from:*
The current in the wire produces a magnetic field [1] which interacts with the permanent magnet [1]. Using Fleming's left-hand rule [1] this creates an upwards force on AB [1] and a downwards force on CD [1], which makes the coil rotate.

12–3 30 cm = 0.3 m [1]; $F = BIl$; 0.15 = B × 2.1 × 0.3; so, B = 0.15 ÷ (2.1 × 0.3) [1] = 0.238 T [1] = 0.24 T to 2 significant figures [1]

Induced potential, transformers and the National Grid (p.88)

Quick questions

1 *Any two from:*
Strength of the magnetic field, speed at which conductor moves, length of wire.

2 A direct current generator.

3 An alternating current generator.

4 Primary coil, secondary coil, iron core.

5 V_p = potential difference across the primary coil; V_s = potential difference across the secondary coil; N_p = number of turns on the primary coil; N_s = number of turns on the secondary coil.

Exam-style questions

6–1 Reverse the magnetic field OR reverse the direction of motion of the conductor [1].

6–2 The induced current increases [1].

7–1 When the axle turns, the coil turns inside the magnetic field [1]. The conducting coil cuts through the magnetic field [1] inducing a potential difference [1]. As the circuit is complete, this produces an induced current [1].

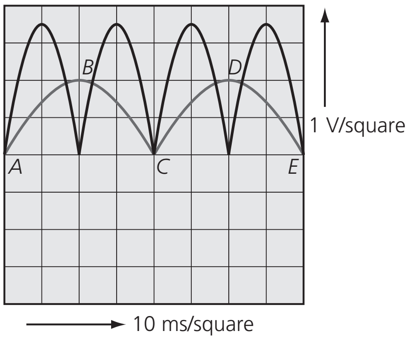
7-2 The faster the coil turns the greater the current produced [1] so the greater the magnetic field generated by the induced current [1]. This increases the resistive force / force which opposes the movement of the axle, making it harder to turn the coil [1].

8–1 Direct current [1]

8–2 The coil is vertical [1].

8–3 The coil is horizontal [1], which means that it cuts the magnetic field at the greatest rate [1].

8–4



Cycle should happen in half the time (for example, each crest is two squares wide) [1]*; The induced potential difference should be greater* [1].

9–1 Iron [1]; It is easily magnetised [1]

9–2 Yes, it is true [1] because there are fewer turns on the secondary coil [1].

9–3 *Any* [3] *marks from:*
An alternating [1] current is supplied to the primary coil [1]. This creates an alternating [1] magnetic field in the iron core [1].
Plus all [3] *marks must be seen from:*
The alternating magnetic field cuts the secondary coil [1] inducing an alternating potential difference [1], which creates an alternating current [1].

9–4 $\frac{V_p}{V_s} = \frac{N_p}{N_s}$; $\frac{50}{V_s} = \frac{140}{20}$ [1]; so,
$V_s = \frac{50 \times 20}{140}$ [1] = 7.1 V [1]

10–1 Step-up transformer [1]

10–2 $V_pI_p = V_sI_s$; 25 000 × 500 = 400 000 × I_s [1]; so, I_s = 12 500 000 ÷ 400 000 [1] = 31.25 A = 31.3 A [1]

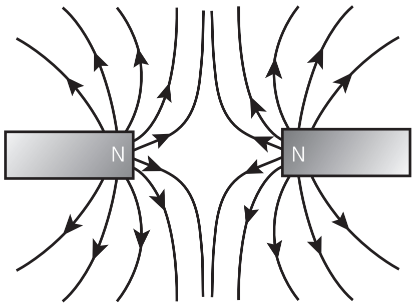
10–3 *Any* [3] *marks from:*
When a transformer is used to increase the potential difference, the current is reduced [1] to conserve power [1]. The lower current will result in fewer energy losses [1] as the wires do not heat up as much [1] due to resistive heating. [1]

Magnetism and electromagnetism topic review (p.91)

1–1

Magnetic pole 1	Magnetic pole 2	Attractive or repulsive force?
North	North	Repulsive
North	South	Attractive [1]
South	South [1]	Repulsive
South	North [1]	Attractive

1–2



Arrow seen pointing away from the left-hand North pole [1] *and arrow seen pointing away from the right-hand north pole* [1]. *Note, not all field lines need to be labelled.*

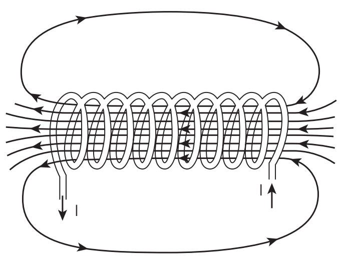
1–3 The magnetic field is a region around a magnet where a force acts on another magnet/magnetic material [1]. It gives the direction of the force exerted on a north pole in that position [1].

1–4 Place the magnets on a piece of paper, fix them in place and draw around them [1]. Place a plotting compass close to the first north pole [1] and make a small mark on the paper in the direction that it points [1]. Move the plotting compass to this point and repeat until the compass reaches the edge of the paper [1]. Join up the marks to make a field line [1]. Return the plotting compass to the other north pole and repeat to obtain at least five field lines [1].

2–1 *Field lines seen in clockwise direction* [1]*; At least three arrows seen* [1]

2–2 Place plotting compasses around the outside of the wire [1] and observe the direction that the compasses point [1].

2–3



Solenoid seen (coil of wire) [1]*; Straight parallel lines seen inside the solenoid* [1]*; Curved field lines seen outside the solenoid, similar to those expected around a bar magnet* [1]*; Ignore arrow directions.*

2–4 *Any* [2] *marks from:*
Add an iron core [1]; Increase the number of turns [1]; Increase the current [1]

2–5 *Any* [4] *marks from:*
When the ignition switch is closed current flows through the solenoid [1] creating a magnetic field [1]. The solenoid is attracted towards the heavy iron contacts [1] completing the secondary circuit [1]. The current flows through the motor [1] starting the car.

3–1 When a conductor carrying a current is placed inside a magnetic field [1], and the conductor and magnet exert a force on each other [1].

3–2 It will move upwards [1].
Plus any [3] marks from:
This is because the conductor carrying a current has a magnetic field around it [1]. The conductor's magnetic field interacts with the magnet's magnetic field [1] and this creates a force on the conductor [1]. The direction of the force can be found using left-hand rule [1].

3–3 Convert 75 mT = 0.075 T [1]; F = 0.075 × 3.2 × 0.15 [1] = 0.036 N [1]

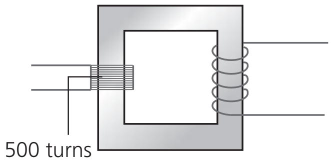
3–4 *Any* [3] *marks from:*
An alternating current [1] is applied to the solenoid/coil of wire [1]. This creates an alternating [1] magnetic field [1].
Plus any [2] *marks from:*
The magnetic field around the solenoid/coil of wire interacts with the permanent magnetic field [1] creating a force [1]. This force causes the solenoid/coil of wire to move/vibrate [1].
And any [1] *mark from:*
This movement vibrates the paper cone [1] creating a sound wave [1].

4–1 potential difference [1]; magnetic field [1]; current [1]; faster [1]; increased [1]

4–2 Reverse the direction of the magnetic field OR Reverse the direction of motion [1]

4–3 A sound wave reaches the flexible diaphragm, causing it to vibrate [1]. This moves the solenoid/coil of wire up and down [1]. This movement causes the solenoid/coil of wire to cut the permanent magnetic field [1]. This induces an alternating [1] potential difference [1] and an alternating current [1].

5–1



Soft iron core seen [1]; *Primary coil and secondary coil seen* [1]; *More coils seen on the primary coil than on the secondary coil* [1]

5–2 *Any* [4] *marks from:*
An alternating [1] current is supplied to the primary coil [1]. This creates a [1] magnetic field in the iron core [1]. The alternating magnetic field cuts the secondary coil [1] inducing an alternating potential difference [1], which creates an alternating current [1].
Plus this [1] *mark must be seen:*
As there are fewer turns on the secondary coil, a smaller potential difference is induced on the secondary coil [1].

5–3 $\frac{V_p}{V_s} = \frac{N_p}{N_s}$; $\frac{230}{45} = \frac{1000}{N_s}$ [1];

so, $N_s = \frac{1000}{\left(\frac{230}{45}\right)}$ [1] = 195.6 [1] =

196 turns [1]

5–4 $V_pI_p = V_sI_s$; $230 \times 3 = 45 \times I_s$ [1]; so $I_s = 690 \div 45$ [1] = 15.333 A [1] = 15 A to 2 significant figures [1].

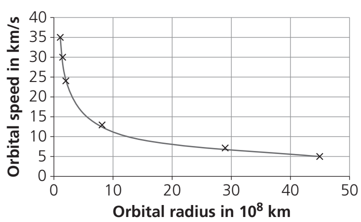
Solar System; stability of orbital motions; satellites (p.95)

Quick questions

1 8
2 Nuclear fusion
3 A large body that orbits a star.
4 The Moon OR any other moon.
5 Gravity

Exam-style questions

6–1 The Sun [1]
6–2 The Milky Way [1]
6–3 Moon [1]
6–4 Difference: Planets orbit a star, whereas moons orbit a planet [1]. Similarity: Many of the orbits of planets and moons are almost circular [1].
6–5 Dwarf planets have a smaller mass than planets [1]. A dwarf planet is an object that is large enough to be spherical like a planet OR dwarf planets and planets orbit the Sun [1].
7–1 Toliman was formed from a nebula of dust and gas [1]. The dust and gas gravitationally attracted together [1] until it was hot enough and dense enough for nuclear fusion to begin [1].
7–2 Main sequence [1]
7–3 nuclear [1]; balance [1]; hydrogen [1]; red giant [1]; white dwarf [1]
7–4 Black dwarf [1]. A black dwarf is a cold dead star that does not emit light [1].
8–1 *Any* [6] *marks from:*
Stars begin as a nebula (cloud of dust and gas) [1]. Gravitational forces bring the dust and gas together to form a protostar [1] which then becomes a main sequence star as it reaches equilibrium. As the star is large, it will quickly run out of hydrogen and begin to collapse [1]. This collapse increases the temperature which allows the fusion of heavier elements to begin [1]. The star quickly increases in size and becomes a super red giant [1]. Once no more fusion can occur, the star collapses quickly and explodes in a supernova [1]. After the supernova, the star will become either a neutron star or a black hole [1] depending on its remaining mass [1].
8–2 Fusion occurs when hydrogen nuclei [1] collide with other nuclei [1] and they combine to form helium [1]
8–3 Supernova [1]
8–4 Elements heavier than iron can only be created in a supernova [1]. On Earth there are elements heavier than iron [1].
9–1 (almost) circular [1]
9–2 The Earth travels at the same speed around the Sun, but it changes direction [1]. This means that its velocity changes, as velocity is a vector [1].
9–3



Scale: the data points should cover at least half of the graph paper in each axis [1]; *Axis labels: the x-axis should be labelled Orbital radius in* 10^8 *km and the y-axis Orbital speed in km/s* [1]; *Plotting of points: lose* [1] *for each incorrect plot, up to a maximum of* [2] *marks.*
9–4 *A sensible smooth curved line is seen* [1].
9–5 As the radius increases the orbital speed decreases [1]; it is non-linear [1].
9–6 Accept any value between 40 and 60 km/s.

Red-shift (p.96)

Quick questions

1 Wavelength
2 Big Bang theory
3 Speed at which an object is travelling relative to the observer.

Exam-style questions

4–1 The black (absorption lines) have all moved to the right by the same amount [1], showing that the wavelength has increased [1], but they are in the same pattern as before [1].
4–2 It is moving away from the Sun [1].
4–3 *The third spectrum should have lines that show the same pattern as previously* [1] *but all moved to the right of the previous star line spectrum* [1].
5–1 Extremely hot [1] and dense [1].
5–2 Red-shift shows that distant galaxies are moving away from us [1], showing that the universe is expanding [1].
5–3

Linear graph shown with constant gradient [1]; *Passing through the origin* [1]
5–4 The light from the most distant galaxies would be red-shifted the most [1], because the galaxies are moving the quickest [1]. This means that wavelengths would be the longest [1].
5–5 increasing [1] dark energy [1].

Space physics topic review (p.98)

1–1 A cloud of dust and gas [1].
1–2 The dust and gas are gravitationally attracted together [1]. This causes the temperature and pressure to rise and fusion begins [1]. The star becomes stable as the pressure from

fusion balances the gravitational collapse [1].

1–3 Main sequence [1]

1–4 *For the first* [1] *mark:*
From the protostar the star reaches equilibrium and becomes a main sequence star [1].
Plus any [2] *marks from:*
Then when hydrogen fuel runs out [1] it will turn into a red giant [1]. Red giants are very large stars [1] with a hot core [1] and a cool surface temperature [1].
And any [2] *marks from:*
When fusion finally finishes the star collapses [1] into a white dwarf [1]. White dwarfs are very small [1] and very hot [1].
And for the final [1] *mark:*
As the star cools it become a black dwarf [1].

1–5 Elements up to iron can be produced inside larger mass main sequence stars [1]. All other heavier elements must be produced inside a supernova [1].

2–1 A black hole is the most concentrated state of matter from which even light cannot escape [1].

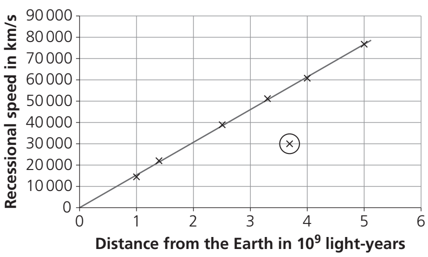
2–2 A main sequence star will expand to form a red super giant [1]. After fusion finishes [1] it will then collapse and explode as a supernova [1]. If it has a high enough mass, it will become a black hole. [1]

2–3 Supernova is a huge explosion of a massive star [1]

2–4 *Any* [3] *marks from:*
Scientists measure the wavelength of the light emitted [1]. If the star is moving away from us, its wavelength increases [1]. The amount that it increases is related to its speed [1]. The light has been red-shifted [1].

2–5 That the universe is expanding [1] at an increasing rate [1].

3–1



Scale: the data points should cover at least half of the graph paper in each axis [1]*; Axis labels: the x-axis should be labelled Distance from the Earth in* 10^9 *light-years and the y-axis Recessional speed in km/s* [1]*; Plotting of points: lose* [1] *for each incorrect plot, up to a maximum of* [2] *marks.*

3–2 Circled anomalous point at (3.7×10^9, 30 000) [1]

3–3 Sensible straight line of best fit seen [1].

3–4 As the distance from the Earth increases the recessional speed increases [1]. This is a linear graph [1]. OR directly proportional [2].

3–5 Between 68 000 km/s and 72 000 km/s [1]

3–6 Galaxies further away from the Earth are moving the fastest [1], this shows that the universe is expanding [1].

4–1 Milky Way [1]

4–2 *Any* [2] *marks from: Earth,* Mercury, Venus, Jupiter, Saturn, Uranus, Neptune.

4–3 A moon is a natural satellite [1] that orbits a planet [1].

4–4 Gravity OR gravitational force [1]

4–5 The Earth's moon is much further away from its planet [1]. It is also much larger in mass [1] and has a much greater diameter [1].

4–6 Its orbital speed [1].

4–7 The gravitational force causes the planets to travel in a circle, where their direction is constantly changing [1]. Velocity is a vector and has both speed and direction [1] so it keeps changing while the speed is constant.

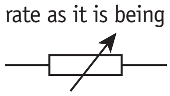
Practice exam papers

Paper 1

1–1 chemical [1]; gravitational potential [1]; thermal [1]

1–2 g.p.e. = 2500 × 9.8 × 12 [1] = 290 kJ OR 294 000 J [1]

1–3 The engine is radiating (losing) energy to the surroundings [1] at the same rate as it is being transferred [1].

2–1  [1]

2–2 0.5 A [1]

2–3 $R = \frac{V}{I} = \frac{6.0}{0.5}$ [1] = 12 Ω [1]

2–4 7.5 Ω [1]

2–5 $V = IR = 0.5 \times 4.5 = 2.3$ V (2.25) [1]

2–6 It increases [1]. The total resistance for the circuit decreases and from $V = IR \left(\text{or } I = \frac{V}{R}\right)$ the current must increase [2] OR The p.d. across the lamp increases so the current must increase [2].

3–1 Electrons have left the player [1] and moved into the pitch [1].

3–2 An electric (electrostatic) force [1] which repels [1].

3–3 Metal is a conductor [1]; electrons travel through the fence to the player [1] making them uncharged (neutral) again [1].

3–4 *Check for four approximately equally spaced lines* [1] *pointing away from the ball's surface* [1]

4–1 *Even x-axis with suitable scales* [1]*; Even y-axis with suitable scales* [1]*; Accurate plotting of four data points* [1]*; Accurate plotting of remaining points* [1].

4–2 *Selection of two data points to choose gradient* [1]*; Drawing of triangle to find* Δy *and* Δx [1]; gradient = 3.0 °C/kJ [1]

4–3 *Use of reciprocal of gradient (1 ÷ gradient)* [1]; energy required = 333 [1] J/°C [1]

4–4 change in thermal energy = mass × specific heat capacity × temperature change; 333 = 0.95 × specific heat capacity × 1 [1]; so, specific heat capacity = 333 ÷ (0.95 × 1) = 351 J/°C kg [1]

5–1 Energy can be transferred usefully, stored or dissipated, but cannot be created or destroyed [1] OR The energy within a closed system does not change [1].

5–2 g.p.e. = 0.05 × 9.8 × 0.08 = 0.39(2) J [1]

5–3 1.20 m/s [1]

5–4 kinetic energy = 0.5 × mass × $(\text{speed})^2$ [1] = 0.5 × 0.05 × $(1.20)^2$ [1] = 0.036 J [1]

5–5 The change in kinetic energy is less than the change in gravitational energy [1] so it appears that energy has not been conserved [1].

5–6 A systematic error is due to measurement results differing from the true value by a consistent amount each time [1].

5–7 The difference between the energy values is greater than the 5% possible error produced by the light gate [1] but the velocity is squared to find the kinetic energy [1] so this would make the error in the energy calculation much larger (10%) [1] meaning that the two values for energy are within the margin of error of the measuring instruments [1].

6–1 When the pressure inside the cylinder reaches atmospheric pressure [1] the gas will no longer be able to expand and leave the cylinder [1].

6–2 As the temperature increases, the average speed (or kinetic energy) of the particles would increase [1].

This would increase the rate of collisions with the cylinder walls [1] and, therefore, cause an increase in pressure in the cylinder [1].

7 Before the syringe is pushed: $pV = C$; $(2 \times 10^4) \times (6 \times 10^{-5})$ [1] = C; so, $C = 1.2$ [1]. After the syringe is pushed: $pV = C$; $p \times (3 \times 10^{-5}) = 1.2$; so, $p = 1.2 \div (3 \times 10^{-5})$ [1] = 4×10^4 Pa [1]

8–1 $W = Fd$ [1] = 550 × 2.5 = 1375 J [1] = 1400 J to 2 significant figures [1]; *Accept up to 3 significant figures, such as 1380 J; also accept answer in kJ (1.4 kJ)*

8–2 $P = \frac{E}{t}$ [1] = 1375 ÷ 15 = 92 W [1]

8–3 The current is always in the same direction for a d.c. supply or current changes direction in an a.c. supply [1].

8–4 $P = IV$ [1] = 3.5 × 230 = 805 W [1]

8–5 efficiency = useful power output ÷ total power input = 92 W ÷ 805 W [1] = 0.11 [1]

8–6 Some work is done (energy is lost) as the lift moves horizontally (as opposed to the vertical part of the motion) [1] . Energy is wasted through electrical heating effects in the motor [1].

9–1 Gamma [1]

9–2 *Maximum* [4] *marks from:*
Irradiation is the process of exposing an object to nuclear radiation [1]. This ends when the source is removed and the irradiated object does not become radioactive [1]. Contamination is the unwanted presence of materials containing radioactive atoms on other materials [1]. The hazard from contamination is due to the decay of the contaminating atoms, involves absorption of, or coming into contact with, materials which are radioactive [1] and will continue to cause exposure over time [1] even if the original source is removed.

9–3 [1] *mark each for 135 and 56, and* [1] *mark for 0 AND –1*

$$^{135}_{55}Cs \rightarrow {}^{135}_{56}Ba + {}^{0}_{-1}e$$

9–4 Activity at one-eighth after three half-lives [1]; 3 × 2.3 = 6.9 million years [1]

9–5 The half-life is very long [1] so the activity of the material will remain high for a long period [1].

10–1 *Any* [2] *marks from:*
The argument they are using is not a valid one because wood is a carbon-neutral fuel. [1] This means that it is not adding additional carbon to the atmosphere [1] when it is burned, as the wood absorbs carbon dioxide when it grows. [1]
Plus any [4] *marks from:*
Wood is also renewable [1] but fossil fuels are non-renewable [1] so using it is not depleting natural resources. The fossil fuels may need to be brought from long distances away which adds to transport costs [1], but the wood is grown locally [1]. Burning fossil fuels contributes significantly to climate change [1] due to increasing the amount of carbon dioxide in the atmosphere [1].

10–2 efficiency = 4.6 MJ ÷ 15.5 MJ = 0.30 [1]

11–1 Non-ohmic [1]. The resistance depends on the p.d. across (or current in) the diode [1].

11–2 20 mA [1]

11–3 $V = IR$ [1]; 0.8 = 0.02 × R [1]; so, R = 0.8 ÷ 0.02 = 40 Ω [1]

11–4 potential difference (p.d.) across the resistor = p.d. across the battery – p.d. across the diode; 6.0 – 0.8 = 5.2 V [1]

11–5 $P = I^2R$ [1] = $0.02^2 \times 260$ = 0.10(4) W [1] OR $P = IV$ [1] = 0.02 × 5.2 = 0.10(4) W [1])

11–6 $E = 1.6 \times 10^{-19} \times 0.8 = 1.3 \times 10^{-19}$ J [1]

Paper 2

1–1 *Any* [1] *mark from:*
Drinking alcohol [1]; Taking drugs [1]; Being tired [1]; Too many distractions [1]

1–2 A car with worn tyres has a smaller frictional force between the car and the road. [1] This means that a greater distance will be travelled to reduce the speed of the car [1].

1–3 *Any* [2] *marks from:*
Work done by the friction force between the brakes and the wheel [1] is transferred mechanically [1] to reduce the kinetic energy of the car [1] and increase the thermal energy in the brakes [1].

2–1 *Any* [2] *marks from:*
All electromagnetic waves travel at the same speed in a vacuum [1]; They transfer energy from the source of the waves to an absorber [1]; They obey the equation $v = f\lambda$ [1]; They can travel in a vacuum [1].

2–2 Detecting forged bank notes [1]

2–3 X-rays OR Gamma waves [1]

2–4 scatter graph OR line graph [1]

2–5 The black container [1] because it has the greatest temperature increase [1]

2–6 *Any* [1] *mark from:*
Start the containers at the same temperature [1], measure the temperatures for longer [1], measure the temperature more frequently, such as every 30 seconds [1]. Repeat the experiment to check for anomalous results [1].

2–7 *Any* [1] *mark from:*
The temperature outside the containers [1], the material of the containers [1], the volume of water [1], the surface area of the containers [1].

3–1 Transparent objects allow light to pass through them [1].

3–2 14 cm = 0.14 m [1]; $p = h\rho g$ = 0.14 × 1000 × 9.8 [1] = 1372 Pa [1]

3–3 *Any* [1] *mark from:*
When the cork is submerged there is a greater pressure at the bottom of the cork than at the top of the cork [1]. This creates an upthrust force [1]. The upthrust force is greater than the weight of the cork [1] so it rises. The cork is less dense than water [1].

3–4 Transverse [1]

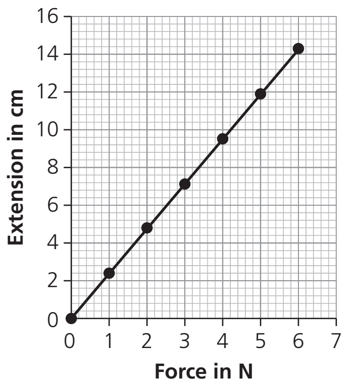
3–5 The cork bobs / moves up and down [1]; it does not move horizontally across the container [1].

4–1

Force in N	Length of spring in cm	Extension in cm
0	6.0	0
1	8.4	2.4
2	10.8	**4.8 [1]**
3	13.1	7.1
4	**15.5 [1]**	9.5
5	17.9	**11.9 [1]**
6	20.3	14.3

4–2 *Any* [3] *marks from:*
Measure the original length of the spring [1] with a ruler [1]. Attach a weight of 1 N to the spring and measure the new length [1]. Continue to attach weights in 1 N intervals and measure the new length [1]. Calculate the extension by subtracting the original length from the measured length [1].
Plus any [2] *marks from:*
Remove the weights 1 N at a time and remeasure the length of the spring [1] to check that it hasn't reached its elastic limit [1]. Plot the results on a graph [1] and find the gradient of the line [1].
And any [1] *mark from:*
Make sure to wear safety glasses [1] in case the spring breaks. Make sure to clamp the clamp stand to the lab bench [1] so that it doesn't fall over.

4–3



Scale: the data points should cover at least half of the graph paper in each axis [1]*; Axis labels: the x-axis should be labelled Force in N and the y-axis Extension in cm* [1]*; Plotting of points: lose* [1] *for each incorrect plot, up to a maximum of* [2] *marks.*

4–4 *A smooth straight line is seen* [1].

4–5 *Attempt at calculating the gradient is seen* [1]; gradient = (12.8 – 0) ÷ (5.4 – 0). *Points must be seen to be on the line not just from the table*. [1]; gradient = 12.8 ÷ 5.4 = 2.4 cm/N [1]; spring constant = 1 ÷ gradient = 1 ÷ 2.4 = 0.42 N/cm [1] *Accept answers in the range of* 0.4–0.45 N/cm

4–6 Yes, the manufacturer's claim is correct [1] As the spring constant measured is very close to the quoted value [1]. If the student's spring constant is calculated incorrectly, allow any correct evaluation using their values.

4–7 There would be no change [1]. The values of length would all be different by the same amount and so the gradient would not change [1].

5–1 The Sun was formed from a cloud/nebula of dust and gas [1] which was pulled together by gravitational forces [1].

5–2 Main sequence [1]

5–3 At the end of the main sequence the star will swell to become a red giant (as its hydrogen runs out) [1]. It will then completely run out of fuel for fusion and collapse to become a white dwarf [1]. Eventually it will cool to become a black dwarf [1].

5–4 The Milky Way [1]

5–5 *Any* [3] *marks from:*
The wavelength of light from other galaxies is seen to increase [1] showing that they are moving away from us [1]. The wavelength of light from the furthest galaxies is increased the most [1] showing that they are moving away the fastest [1].
Plus the following must be seen for final mark:
This provides evidence that the universe is expanding [1].

5–6 *Any* [2] *marks from:*
When a new model is proposed, scientists will need to collect evidence to support the new model [1]. It will then be published in journals [1] and other scientists will peer review it for validity [1].

6–1 The copper wire moves to the right OR in towards the magnet [1].

6–2 62 mT = 0.062 T [1]; $F = BIl$; 0.0091 = 0.062 × 2.1 × l [1]; so, l = 0.0091 ÷ (0.062 × 2.1) [1] = 0.06989 m [1] = 0.070 m to 2 significant figures [1].

6–3 *Any* [4] *marks from:*
The current passing through the coil of wire induces a magnetic field [1]. This magnetic field interacts with the permanent magnetic field [1] and creates a force [1] moving the coil and paper cone [1]. The current is then reversed, and the coil and paper cone move in the opposite direction [1]. This repeated motion creates a pressure wave/sound wave [1].

6–4 wave speed = frequency × wavelength [1]

6–5 16.5 cm = 0.165 m [1]; wave speed = frequency × wavelength; 330 = f × 0.165 [1]; so, f = 330 ÷ 0.165 [1] = 2000 Hz [1]

6–6 Human hearing is between 20 and 20 000 Hz [1], so yes humans can hear the sound [1].

7–1 The gaps between the dots are increasing in length [1], showing the ball is travelling a greater distance during each time interval OR showing an increasing velocity [1].

7–2 $v^2 - u^2 = 2as$; $v^2 - 0^2 = 2 \times 9.8 \times 1.2$ [1]; so, $v^2 = 23.52 + 0^2$ [1] = 4.8497 m/s [1] = 4.8 m/s to 2 significant figures [1].

7–3 As the ball falls, its velocity increases, increasing air resistance [1]. This reduces the resultant force acting on the ball [1] and so decreases the acceleration [1].

7–4 resultant force = mass × acceleration [1]

7–5 240 g = 0.240 kg [1]; $F = ma$ = 0.240 × 6 = 1.44 N [1]; weight of the ball = $m \times g$ = 0.240 × 9.8 [1] = 2.35 N [1]; F = 2.35 N – air resistance; so, air resistance = 2.35 – 1.44 = 0.91 N [1]

8–1 The magnetic field around the magnet cuts the solenoid [1]. This induces a potential difference [1]. As the circuit is complete a current flows [1].

8–2 *Any* [1] *mark from:*
Move the magnet faster [1]; Use a stronger magnet [1]; Add more coils to the solenoid [1]

8–3 An alternating current is needed so that the magnetic field produced is also alternating [1]. This means that the magnetic field will cut the secondary coil to produce a potential difference [1].

8–4 $\frac{V_p}{V_s} = \frac{N_p}{N_s}$; $\frac{12}{V_s} = \frac{10}{75}$ [1];

so, $V_s = \frac{12}{\left(\frac{10}{75}\right)}$ [1] = 90 V [1]

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