PHYSICS

UNIT 1 ANSWERS

CHAPTER 1

1 ▶ 8 m/s

2 ▶ a 10 500 m (10.5 km)

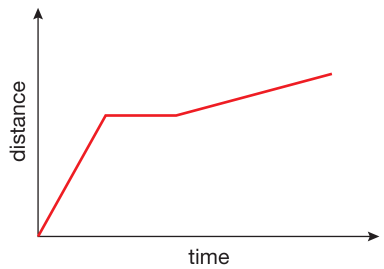
b 105 000 m (105 km)

c 630 000 m (630 km)

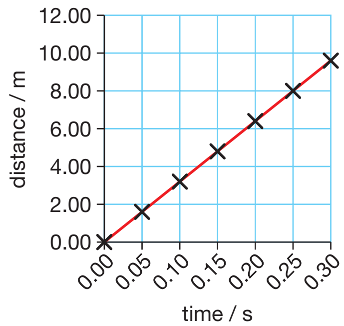
3 ▶ 4000 s

4 ▶ a C **b** A **c** B

5 ▶



6 ▶

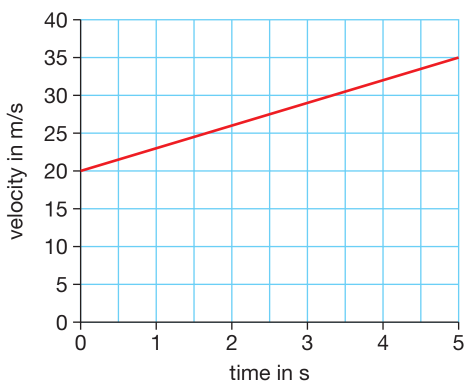


$$\text{gradient} = \frac{\text{distance}}{\text{time}} = \frac{8\,\text{m}}{0.25\,\text{s}} = 32\,\text{m/s}$$

7 ▶ a The car is moving at constant velocity (speed).

b Time interval between first and seventh drip is 15 s (6 × 2.5 s) so average speed is 135 m ÷ 15 s = 9 m/s.

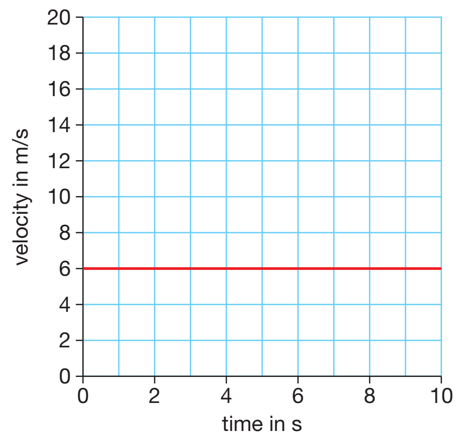
8 ▶ a



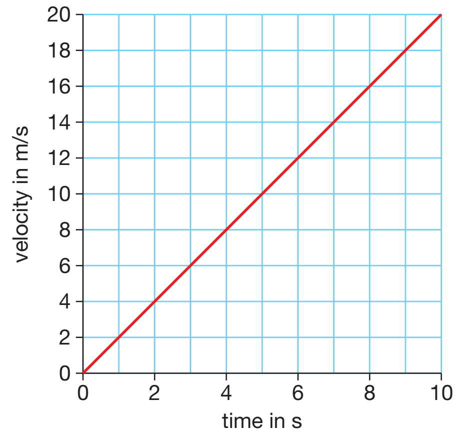
b Distance travelled is given by the area under the graph. (Divide area into a rectangle and a triangle.) = (5 s × 20 m/s) + (0.5 × 5 s × 15 m/s) = 137.5 m

9 ▶ 4 m/s²

10 ▶ a



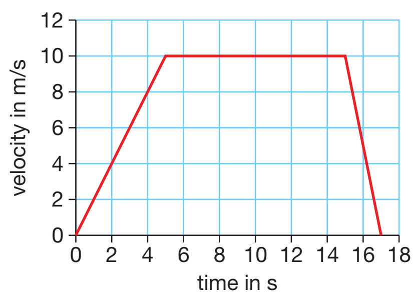
b



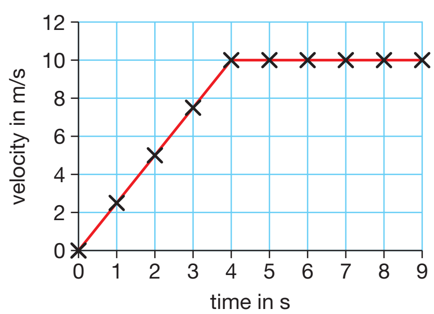
11 ▶ a 3 m/s **b** 15 m/s **c** 75 m/s

12 ▶ a B **b** A **c** D **d** C

13 ▶



14 ▶ a



b 2.5 m/s²

c i 20 m **ii** 50 m

d average speed = $\frac{\text{total distance travelled}}{\text{time taken}}$

$= \frac{70\,\text{m}}{9\,\text{s}}$

$= 7.78\,\text{m/s}$

15 ▶ The total distance travelled increases with the square of the time from the start, 0.5 m after 1 s, 2.0 m after 2 s, 4.5 m after 3 s, etc. Calculating the average velocity over each 1 s time interval (between the drips) and then plotting a graph of average velocity against time allows the acceleration to be calculated from the gradient of the graph. The acceleration is 1 m/s^2.

16 ▶ **a** The student must measure a short distance at each point on the slope with a metre rule and time how long it takes for the ball to cover each measured distance. The average velocity for each position is found by dividing the distance travelled by the time taken.

b The student must also time how long it takes for the ball to travel from position A to position B. The acceleration can then be calculated by finding the increase in velocity from position A to position B and dividing this by the time to travel between A and B.

c By taking repeated timings and taking an average for all the timings made

d The ball will accelerate at a greater rate and this will make the time taken to travel the measured distances at A and B (and the time to travel from A to B) shorter. This makes the reaction time taken to start and stop the stopwatch more significant.

CHAPTER 2

1 ▶ **a** Gravity **b** Friction

c Normal reaction or contact force

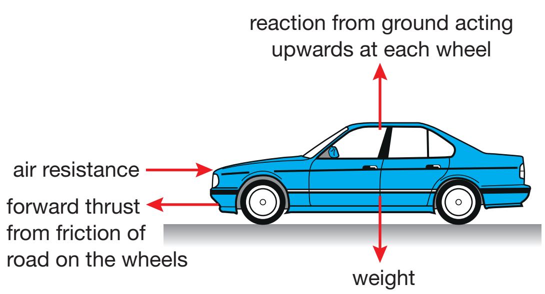
d A magnetic force

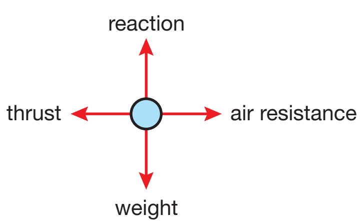
e An electrostatic force

2 ▶ Friction and air resistance (or viscous drag)

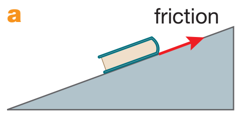
3 ▶ **a** 1200 N **b** 1250 N **c** 50 N **d** red

4 ▶

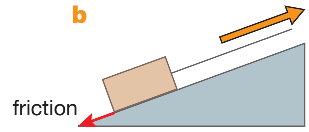




5 ▶ **a**



b



6 ▶ **a** When the slope is small the car comes to a halt. The car experiences an unbalanced force acting up the slope (against the direction of motion) because friction is greater than the force of gravity acting down the slope.

b When the slope is steep the car accelerates. This is because there is an unbalanced force acting down the slope.

c At a very specific slope the force of friction up the slope balances the force of gravity acting down the slope so the car will continue to move down the slope at constant speed.

(It is sufficient to name the two forces acting on the car in the plane of the slope just once in the answer.)

7 ▶ The body may speed up (accelerate) or slow down (decelerate). The direction that the body is travelling in may change. The unbalanced force may cause the shape of the body to change.

CHAPTER 3

1 ▶ A force that is not balanced by a force in the opposite direction. An accelerating car has an unbalanced force when the forwards force from the engine is bigger than the backwards force from air resistance.

2 ▶ From the equation force = mass × acceleration ($F = ma$) we can see that if F, the thrust force of the rocket engines, is constant and m, the mass of the rocket, decreases then the acceleration must increase.

3 ▶ **a** $F = ma$, where mass = 0.5 kg and acceleration = 4 m/s^2

So $F = 0.5\,\text{kg} \times 4\,\text{m/s}^2 = 2\,\text{N}$

b $m = \frac{F}{a}$, where force = 200 N and acceleration = 0.8 m/s^2

So $m = \frac{200\,\text{N}}{0.8\,\text{m/s}^2} = 250\,\text{kg}$

c Use $a = \frac{F}{m}$, where force = 250 N and mass = 25 kg

So $a = \frac{250\,\text{N}}{25\,\text{kg}} = 10\,\text{m/s}^2$

4 ▶ **a** Thinking distance is the distance a car travels after the driver has seen a hazard but *before* the driver applies the brakes; during this period the car is not decelerating.

b The braking distance is the distance travelled by the car *after* the driver has started braking and the car is decelerating to rest.

c The overall stopping distance is the sum of the thinking distance and the braking distance.

5 ▶ The braking distance of a car depends on the speed at which the car is travelling and the braking force that can be applied without the car skidding (as skidding means the car is out of control). The maximum braking force will be limited by factors that affect the friction between the car tyres and the road surface – for example, the condition of the tyres and the road surface. If the road surface is wet, icy or oily, friction will be reduced. The braking distance is greater if the speed of the car is higher or the maximum safe braking force is reduced.

6 ▶ a 0.75 s (the period during which the velocity of the car is constant at 24 m/s)

b 18 m (given by the area under the velocity–time graph during the first 0.75 s)

c 2.5 s (the period during which the velocity of the car is decreasing to zero)

d 48 m (the sum of the thinking distance and the braking distance – the total area under the graph)

7 ▶ a Use *weight* = *mass* × *gravity*

mass of apple in kg = 0.1 kg

strength of gravity on the Earth is approximately 10 N/kg

weight of apple on the Earth = 0.1 kg × 10 N/kg = 1 N

b Use *weight* = *mass* × *gravity*

mass of apple in kg = 0.1 kg

strength of gravity on the Moon is approximately 1.6 N/kg

weight of apple on the Moon = 0.1 kg × 1.6 N/kg = 0.16 N

8 ▶ *Force* = *mass* × *acceleration* and

$$\textit{acceleration} = \frac{\textit{change in speed}}{\textit{time taken for the change in speed}}$$

The mass of the egg is not something that can be changed so solutions must either: reduce the change in speed or increase the time that it takes for the egg to be brought to a halt or both, but tackling one or the other is enough here.

To reduce the speed that the egg is travelling when it hits the ground can be achieved by devising some sort of parachute; or

To lengthen the time it takes for the egg to come to rest can be achieved by encasing it in material that will crumple when it hits the ground.

Note: Passengers in cars are less likely to suffer injury if the cars are not travelling at high speed when they meet an obstacle and if the cars are designed with crumple zones!

UNIT 1 EXAM PRACTICE

1 ▶ A (1)

2 ▶ C (1)

3 ▶ B (1)

4 ▶ a $v = at$, $v = 10\ \text{m/s}^2 \times 3\ \text{s}$ (1 evidence of use of correct formula) = 30 m/s (1)

b average speed = (30 + 0) / 2 (1 evidence of use of correct formula) = 15 m/s (1)

c distance = average speed × time, 15 m/s × 3 s (1 evidence of use of correct formula) = 45 m (1)

5 ▶ a $F = ma$, $F = 10^8\ \text{kg} \times 0.2\ \text{m/s}^2$ (1 evidence of use of correct formula) = 2×10^7 N (1)

b $t = \frac{v}{a}$, $t = \frac{5\ \text{m/s}}{0.2\ \text{m/s}^2}$ (1 evidence of use of correc formula) = 25 s (1)

6 ▶ a At A (when the ball is released 20 m above the ground) (1); at C (when it hits the ground) (1) and E (when the ball reaches its maximum rebound height) (1).

b At B (when it is on the point of hitting the ground) (1)

c Between A and B (while the ball is falling and the only force acting on it is gravity/its weight) (1); between D and E (after the ball has rebounded from the ground) (1).

d At A (1)

e Between B and D (Accept any of B, C or D) (1)

f At B (1)

g At D (1)

h At E (its maximum height after the first rebound) (1)

i At C (when the ball is squashed most) (1)

UNIT 2 ANSWERS

CHAPTER 4

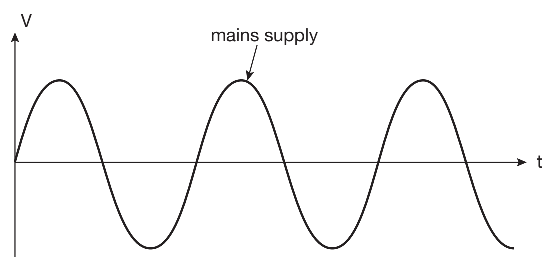
1 ▶ a 3 W b 50 V c 0.26 A

2 ▶ a The kettle is designed for a voltage of 230 V. At this voltage, 1.5 kJ of electrical energy is transferred into heat energy each second.

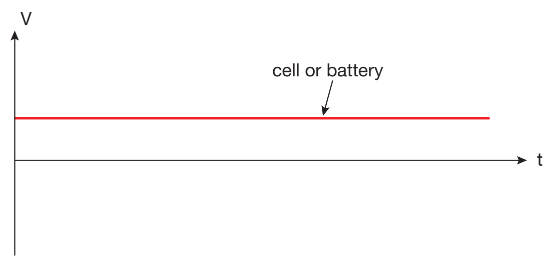
b $I = \frac{P}{V} = \frac{1500\ \text{W}}{230\ \text{V}} = 6.52\ \text{A}$

c Electrical energy is being transferred at a rate of 100 J/s in the 100 W bulb but only at 60 J/s in the 60 W bulb.

3 ▶ a i



ii



b The voltage from the mains increases and then decreases and then does the same again but in the opposite direction, the graph looks like a wave.

Cells and batteries provide voltages that are always in the same direction and have the same value. The graph is a straight horizontal line.

4 ▶ The power ratings of most appliances are shown on the appliance itself.

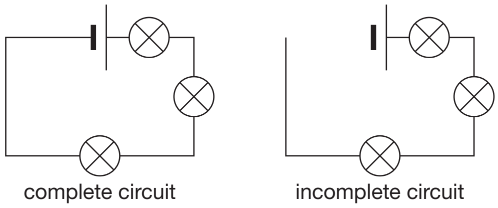
CHAPTER 5

1 ▶ a Electrons

b There are many free charge carriers (free electrons) in metals, but very few in a plastic.

2 ▶ a i Charge can travel all the way around a complete circuit. An incomplete circuit has gaps, so charge cannot travel all the way around it.

ii



b S1 open: bulbs, A, B and C will go out.

S2 open: bulbs A, B and C will go out.

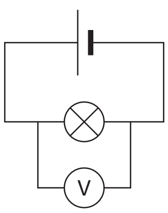
c All the bulbs will glow with equal brightness.

d It is a series circuit; therefore the current through all bulbs is the same.

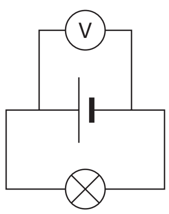
e The brightness of each of the four bulbs will be less than the brightest of the three bulbs.

f The energy carried by charges is now shared between four bulbs instead of three.

3 ▶ a



b



4 ▶ a Radio, tv, computer, electric kettle, toaster, etc.

b Less energy is needed to make an LED glow

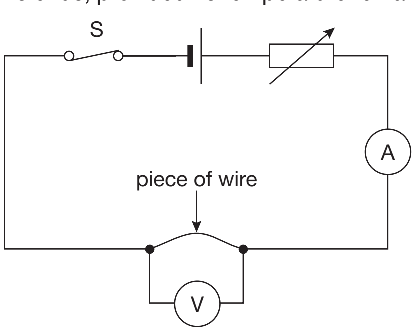
5 ▶ If all parts of the cooker are connected in series, turning one part on will turn on all the other parts as well.

CHAPTER 6

1 ▶ C

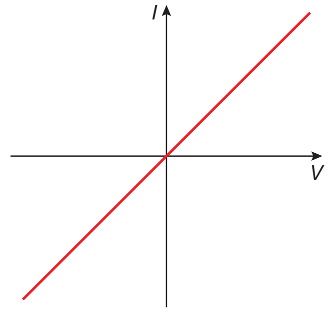
2 ▶ a The current that flows through a conductor is directly proportional to the potential difference (or voltage) across its ends, provided its temperature remains constant.

b

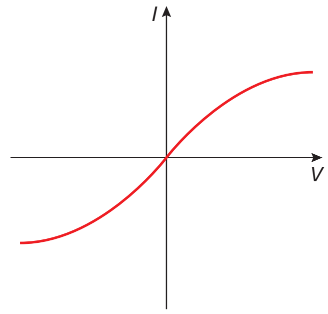


c Close the switch and record the readings on the ammeter and voltmeter. Use the variable resistor to change the resistance and take new readings. Repeat this at least six times. A graph of *I* against *V* should show a straight line passing through the origin, confirming Ohm's law.

d i A straight line graph passing through the origin, indicating a constant resistance.

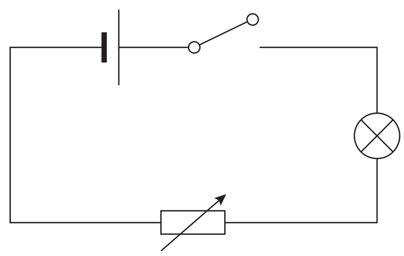


ii As the current increases, the filament gets hotter and its resistance increases.



3 ▶ a 4 Ω **b** 0.24 A **c** 30 V

4 ▶ a



b When the switch is closed, the circuit is complete and the bulb will glow. If the resistance of the variable resistor is increased the bulb will become dimmer. If it is decreased the bulb will glow more brightly.

c A dimmer light switch in a house.

UNIT 2 EXAM PRACTICE

1 ▶ a B (1) **b** B (1) **c** B (1)

2 ▶ a Y is an ammeter (1); Z is a voltmeter (1)

b Variable resistor (1)

c It can be used to change the current. (1)

d 2.5 A (1)

e 4.0 V (1)

f $R = \frac{4.0\text{ V}}{2.0\text{ A}}$ (1)

$= 2.0\ \Omega$ (1)

g It increases. (1)

3 ▶ a $I = \frac{V}{R}$ (1)

$= \frac{12\text{ V}}{10\ \Omega} = 1.2\text{ A}$ (1)

b total resistance (R) = 10 Ω + 10 Ω = 20 Ω (1).

$I = \frac{V}{R} = \frac{12\,V}{20\,\Omega} = 0.6$ A (1)

4 ▶ a $I = \frac{P}{V}$ (1)

$= \frac{2300\,W}{230\,V}$ (1)

= 8.7 A (1)

b $R = \frac{V}{I}$ (1) $= \frac{230\,V}{8.7\,A}$ (1) = 26.4 Ω (1)

5 ▶ a 10 V (2) b 2 V (2) c 12 V (1)

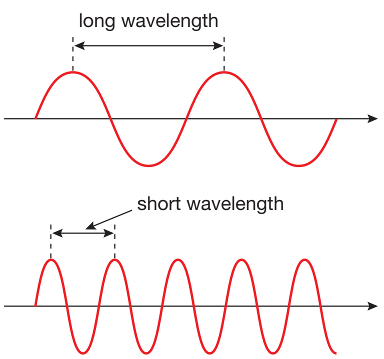
UNIT 3 ANSWERS

CHAPTER 7

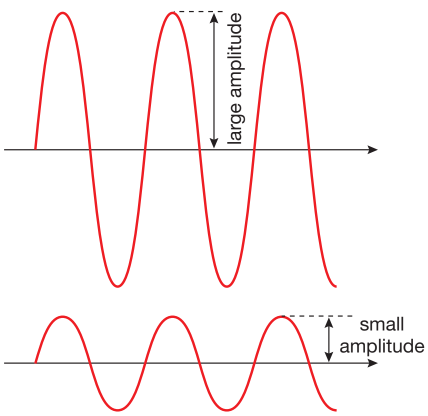
1 ▶ A

2 ▶ a Energy

b



c



3 ▶ a 0.4 s b 2.5 Hz

4 ▶ $f = \frac{v}{\lambda} = \frac{1500\,m/s}{1.5\,m} = 1000$ Hz

5 ▶ Wavelength = 0.68 m

6 ▶ Rays of light from the fish have been refracted at the surface of the water so the hunter does not see the real position of the fish.

CHAPTER 8

1 ▶ a They all: transfer energy; are transverse waves; travel at the same speed through a vacuum; can be reflected, refracted and diffracted.

b Light, microwaves and radio waves

c Microwaves and infra-red waves

d Gamma rays

e Infra-red

f Microwaves

2 ▶ a Water molecules within the food absorb the microwaves and become hot, so the food cooks throughout, not just from the outside as in the case of a normal oven.

b X-rays pass easily through soft body tissue but cannot travel through bones. Therefore bones leave ‘shadows’ on x-ray photographs, which show the shape of the bone and can show if bones have been broken.

c The Earth’s ozone layer absorbs large quantities of the Sun’s UV radiation. If this layer is damaged, more UV light will reach the surface of the Earth. UV light is harmful to human eyes and can cause skin cancer.

d Exposure to gamma radiation kills the micro-organisms that cause food to decay.

3 ▶ a i Wear lead-lined clothes, stand behind a lead screen

ii Wear clothing, use sunblock

b X-rays: overexposure can cause cancer.

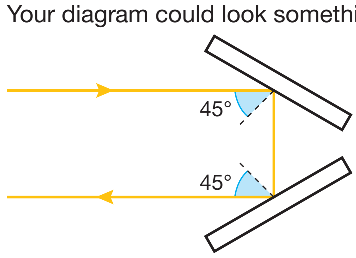
Ultraviolet: overexposure can be harmful to human eyes and can cause skin damage such as sunburn and/or blistering.

4 ▶

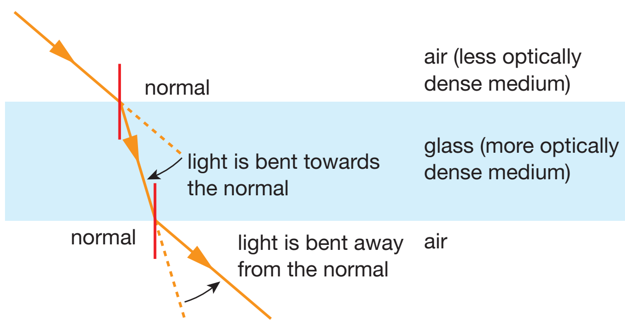
Type of radiation	Possible harm	Precautions
x-rays	cancer	lead screening
microwaves	cancer	metal screening
infra-red	skin burns	avoid over-exposure
ultraviolet	cancer/skin damage	glasses, sunblock
gamma rays	cancer	lead screening

CHAPTER 9

1 ▶ Your diagram could look something like this:

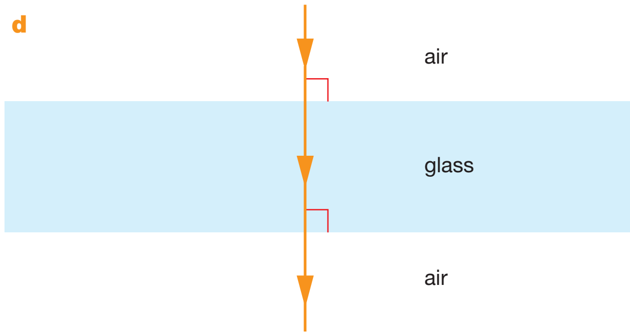


2 ▶ a and b



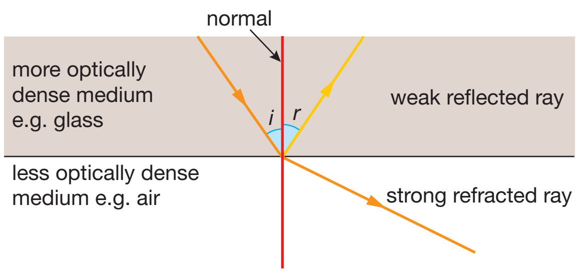
c As the ray of light enters the glass block, it slows down and is refracted towards the normal. As the ray leaves the glass block, its speed increases and it is refracted away from the normal.

d

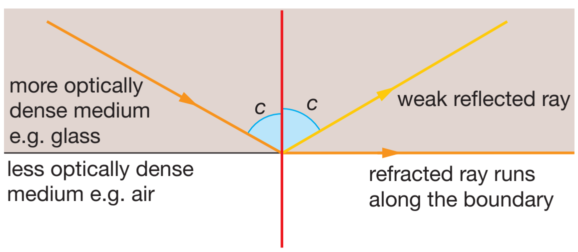


3 ▶ Sound waves are emitted downwards from the ship. The time it takes the reflected waves to return to the ship is measured. From this the depth of the water below the ship can be calculated.

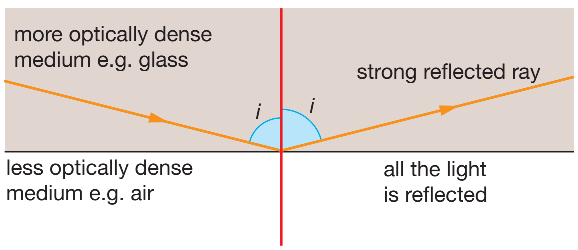
4 ▶ a



b

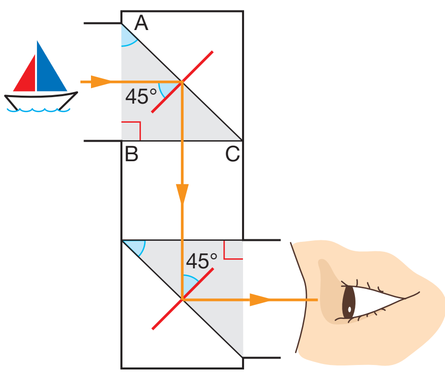


c



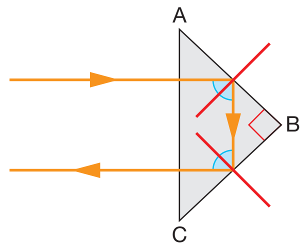
5 ▶ a If a ray of light travelling from glass or water to air strikes the boundary between the two at an angle greater than the critical angle, the ray is reflected by the boundary and is not refracted. This phenomenon is called total internal reflection.

b



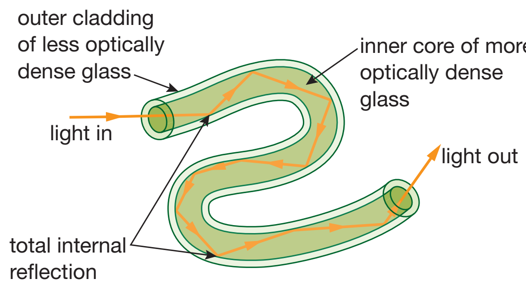
c The final image created by a prismatic periscope is likely to be sharper and brighter than that produced by a periscope which uses mirrors.

d



Bicycle reflectors and binoculars use prisms to turn light through 180°.

6 ▶ a



As the fibres are very narrow, light entering the inner core always strikes the boundary of the two glasses at an angle that is greater than the critical angle. This means that all the light is reflected (total internal reflection).

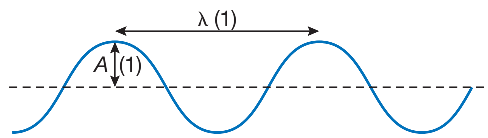
b Optical fibres are used in the construction of endoscopes. Bundles of optical fibres carry light into and out of a patient's body. Images of the inside of the body can be created from the reflected light.

c Telecommunications

UNIT 3 EXAM PRACTICE

1 ▶ a A (1) **b** A (1)

2 ▶ a



b $f = \frac{v}{\lambda}$ (1)

$= \frac{20\,\text{m/s}}{2.5\,\text{s}}$ (1)

$= 8\,\text{Hz}$ (1)

3 ▶ a A is a glass with a higher refractive index (higher optical density). (1)

b B is a glass with a lower refractive index (lower optical density). (1)

c The light strikes the boundary at an angle greater than the critical angle (1) so total internal reflection takes place (1).

d Optical fibres are used in endoscopes. These allow doctors / surgeons to see inside the body, and make keyhole surgery possible. (1)

4 ▶ a To improve the accuracy of the experiment. (1)

b

Experiment	Time in seconds	Speed of sound in m/s
1	2.95	339
2	3.00	333
3	2.90	345
4	3.20	313
5	2.95	339

(1 mark for each row of table completed)

Average speed of sound from experiment = 334 m/s (1)

c No (1). The effect of any wind is cancelled out as the sound travels in one direction as it approaches the building, and in the opposite direction as it returns. (1)

5 ▶ a Radio waves, microwaves, infra-red waves, visible spectrum, ultraviolet waves, x-rays, gamma rays. (2 marks for all correct; lose 1 mark for each wave in the wrong position (no negative marks))

b All these waves transfer energy (1), are transverse waves (1), travel at the speed of light in a vacuum (1), can be reflected, refracted and diffracted (1).

c Radio waves – communication (1); microwaves – communication / cooking (1); infra-red waves – cooker / heater / remote control / night vision (1); visible light – seeing / communication (1); ultraviolet waves – fluorescent tubes / tanning lamps (1); x-rays – x-radiography (1); gamma rays – sterilising food or equipment / radiotherapy (1)

d Gamma rays (1), x-rays (1) and ultraviolet waves (1)

e Radio waves (1), microwaves (1) and visible light (1)

6 ▶ a Periscope (1) **b** Binoculars (1)

c Endoscope (1) **d** Car reflectors (1)

UNIT 4 ANSWERS

CHAPTER 10

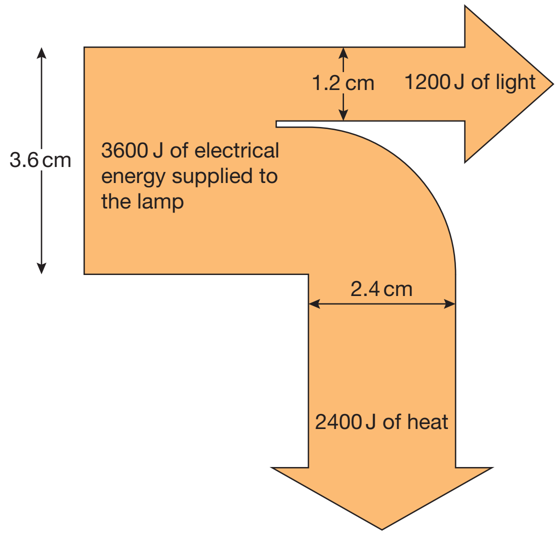
1 ▶ a Stored chemical energy in the battery → electrical energy in the circuit → heat and light in the lamp filament

b Stored chemical energy in the paraffin wax → heat and light as the candle burns

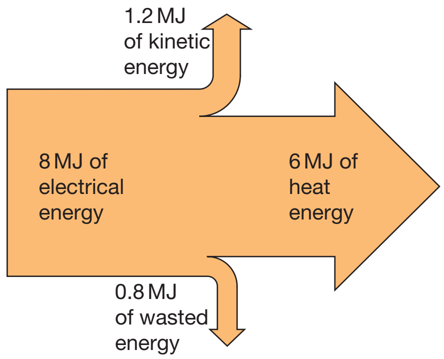
c Kinetic energy of moving hands → heat energy

d Stored energy in the stretched elastic of the trampoline → kinetic energy of the trampolinist moving upwards → gravitational potential energy as the trampolinist slows to a halt at the top of the bounce

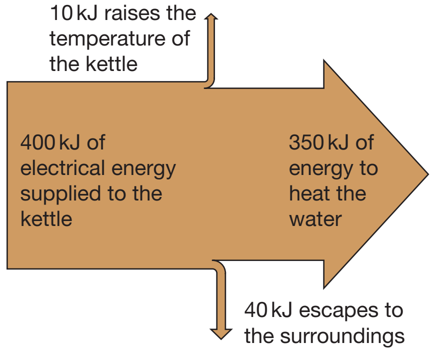
2 ▶ a



b



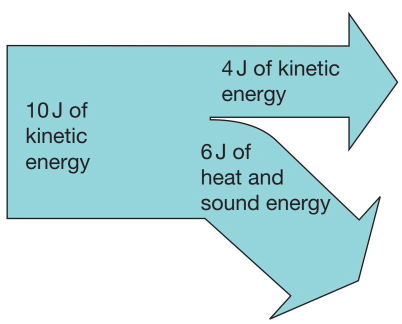
3 ▶ a



b Efficiency = $\frac{350}{400}$ = 0.875

4 ▶ a 6 J of energy is converted to heat in the ball and the ground and to sound.

b



CHAPTER 11

1 ▶ a A wide range of answers possible, e.g. rubbing hands to warm them.

b Heat water to produce steam, which is then used to rotate a turbine. The turbine can then raise a weight.

2 ▶ a Joule

b The joule is the amount of work done when a force of 1 N is applied through a distance of 1 m in the direction of the force.

c For each, use: work done = force × distance

i $W = 6 \times 1\,\text{N} \times 0.8\,\text{m} = 4.8\,\text{J}$

ii $W = 100\,000\,\text{N} \times 200\,\text{m} = 20\,\text{MJ}$

iii $W = (60\,\text{kg} \times 10\,\text{N/kg}) \times 2.8\,\text{m} = 1680\,\text{J}$

iv $W = (350\,\text{kg} \times 10\,\text{N/kg}) \times 45\,\text{m} = 157.5\,\text{kJ}$

3 ▶ Use gravitational potential energy = mgh

GPE = 200 000 000 kg × 10 N/kg × 800 m = 160 000 MJ

4 ▶ a Use the formula KE = $\frac{1}{2}mv^2$ where m is the mass of the moving object in kg and v is its velocity in m/s to give the KE in joules.

b i KE = $\frac{1}{2} \times 80\,\text{kg} \times (9\,\text{m/s})^2 = 3240\,\text{J}$

ii KE = $\frac{1}{2} \times 0.0002\,\text{kg} \times (50\,\text{m/s})^2 = 0.25\,\text{J}$

iii KE = $\frac{1}{2} \times 0.06\,\text{kg} \times (24\,\text{m/s})^2 = 17.28\,\text{J}$

5 ▶ At the top of the stone's flight, all of its initial KE is converted to GPE, so 48 J = mgh, where m = 0.04 kg and

g = 10 N/kg. Hence: $h = \dfrac{48\,\text{J}}{0.04\,\text{kg} \times 10\,\text{N/kg}} = 120\,\text{m}$

6 ▶ The initial GPE that the coin has is completely converted to KE when it reaches the ground, so $mgh = \frac{1}{2}mv^2$.

As mass, m, is common to both sides of the equation, it cancels to give $gh = \frac{1}{2}v^2$.

Rearranging, we can calculate the velocity $v = \sqrt{(2gh)}$,

so $v = \sqrt{(2 \times 10\,\text{N/kg} \times 80\,\text{m})} = 40\,\text{m/s}$.

Assumption: air resistance has little effect.

7 ▶ Power is the rate of doing work (or the rate of converting energy) and can be calculated using:

$$\text{power} = \frac{\text{work done in J}}{\text{time taken in s}}$$

The unit of power is the watt.

8 ▶ a Weight = mass × gravitational field strength, so the person weighs 400 N

b Total height = height of one step × number of steps = 4 m

c Work done = force × distance = 1600 J

d Power = $\dfrac{\text{work done}}{\text{time taken}}$ so the person's power output is 133 W

9 ▶ a i 144 km/h × 1000 = 144 000 m/h

ii $\dfrac{144\,000\,\text{m/h}}{3600} = 40\,\text{m/s}$

b KE = $\frac{1}{2} \times 500\,\text{kg} \times (40\,\text{m/s})^2 = 400\,000\,\text{J}$

c Assuming no energy is converted to other forms than movement (impossible in reality), the average power developed by the engine is: $\dfrac{400\,000\,\text{J}}{5\,\text{s}} = 80\,000\,\text{W}$

UNIT 4 EXAM PRACTICE

1 ▶ a D (1) **2** C (1) **3** D (1)

4 ▶ a Work done = force × distance (1)

= 800 N × 30 m (1)

= 24 000 J (1)

b Power = $\dfrac{\text{energy transferred}}{\text{time taken}}$

$= \dfrac{24\,000\,\text{J}}{16\,\text{s}}$ (1)

= 1500 W (1)

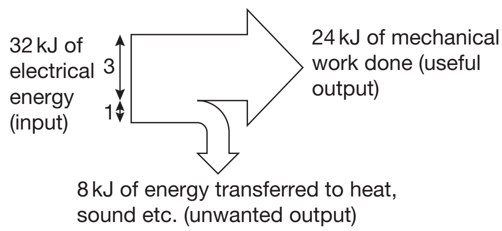
c i This means that only 75% of the electrical power supplied to the motor is transferred usefully in raising the load. (2)

ii Efficiency = $\dfrac{\text{useful power transferred}}{\text{total electrical power supplied}}$

Total electrical power supplied = $\dfrac{1500}{75/100}$ (1)

Total electrical power supplied = 2000 W = 2 kW (1)

d



(3)

5 ▶ a B (1)

b Once the rocket has left the launcher, it loses speed as KE is transferred to GPE. (1)

At the top of the flight, the rocket comes to a stop: KE is zero, GPE is maximum. (1)

The rocket then falls and gains speed as GPE is transferred to KE. (1)

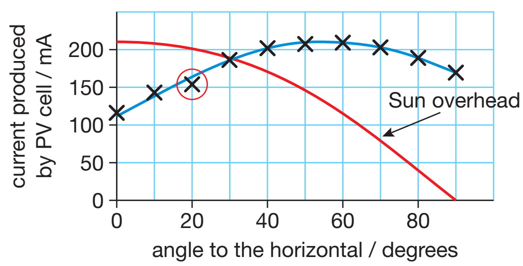
It hits the ground with max KE, which is then transferred to heat, sound etc. (1)

6 ▶ a i The current through the load (1)

ii The angle between the plane of the PV cell and the horizontal (1)

iii Any one from: the distance between the lamp and the PV cell (1); the brightness of the lamp (1); the brightness of other lighting in the room (1), etc.

b



All points plotted correctly (2)

Sensible scales (1)

Scales labelled (1)

Smooth best fit line (1)

c i Anomalous result ringed in red (1)

ii Peak between 50° and 60° (1)

d **i** By raising the lamp, keeping the stand position where it is (and re-angling the lamp to keep the PV cell in the beam (1)

ii See red graph line:
Peak at 0° (any magnitude, likely to be greater than for original graph) (1)
Curves downwards (1)
To a very low level at 90° (1)

7 ▶ a Power = Energy transferred / Time taken (1)
so, Time taken = Energy transferred / Power (1)
= 300 kJ / 2.4 kW
= 125 s (1)

b It takes longer because not all the energy is transferred to the water (1), some energy is also transferred to the surroundings and to the kettle itself (1).

c The energy transferred in 2½ minutes (150 s) is given by 2.4 W × 150 s, 360 kJ (2) so, the useful energy transferred = 300 kJ and 60 kJ is the energy that is wasted heating other things.

$$\text{Efficiency} = \frac{\text{Useful energy transferred}}{\text{Total energy transferred}} \times 100\% \text{ (1)}$$
$$= \frac{300\text{ kJ}}{360\text{ kJ}} \times 100\%$$
$$= 83.3\% \text{ (1)}$$

UNIT 5 ANSWERS

CHAPTER 12

1 ▶ a The person's weight will be spread out over the area of the ladder, so the pressure on the roof will be less.

b Area of one boot = 0.021 m^2

$$\text{Pressure} = \frac{\text{force}}{\text{area}} = \frac{850\text{ N}}{0.021\text{ m}^2} = 40\,476\text{ Pa}$$

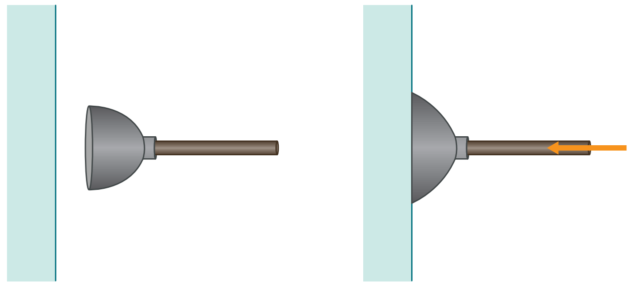
c Force = 850 N + 70 N = 920 N

$$\text{Pressure} = \frac{920\text{ N}}{0.3\text{ m}^2} = 3067\text{ Pa}$$

2 ▶ a The particles in a gas are in continuous random movement. When the particles bump into the walls of the container they exert a force on the wall as they rebound. As there are large numbers of particles moving around rapidly, the total amount of force acting on any area of the wall remains constant on average, so the force per unit area remains constant.

b Removing some air from the container reduces the number of particles, and so the number of particles colliding with any part of the wall in a given time goes down. This means that the average force exerted on the container walls goes down and so, therefore, does the pressure.

3 ▶ As the rubber sucker is pushed against the smooth surface air is pushed out of the sucker and so, the pressure on the inside of the sucker is smaller than the pressure of the air outside the sucker. The difference in pressure holds the sucker in place and prevents the air getting back inside the sucker.



CHAPTER 13

1 ▶ As a substance is cooled, the pressure it exerts becomes smaller as the particles move more slowly. Absolute zero is the temperature at which the particles are not moving / the gas is exerting zero pressure.

2 ▶ a **i** 273 K **ii** 373 K **iii** 293 K
b **i** −23 °C **ii** −4 °C **iii** 32 °C

3 ▶ a The piston moves out. The air particles will move faster when they are heated, so there will be more, and harder, collisions with the walls of the container and the piston, increasing the pressure. The increased force on the piston will make it move outwards.

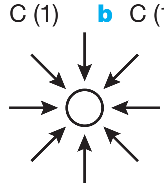
b As the beaker is pushed down, pressure from the water will tend to compress the air trapped in the beaker, so the particles in the air will be closer together.

c As the container is heated, the air particles inside will move faster. The pressure will increase, and may increase enough to force the cork out of the opening.

UNIT 5 EXAM PRACTICE

1 ▶ a C (1) **b** C (1) **c** D (1)

2 ▶ a



(2)

b The pressure on the bubble decreases as it rises towards the surface of the cola (1)
so the bubble gets bigger (1)
because pressure × volume is constant (for a fixed mass of gas at constant temperature) (1).

3 ▶ a The temperature of a gas is proportional to the mean kinetic energy (1) of the gas molecules. Transferring energy to the gas increases the movement energy stored by the molecules. (1)

b Cooling a gas means that energy is being transferred away from the gas (1) and therefore the mean kinetic energy of the gas molecules decreases (1). The more energy that is transferred from the gas the slower the gas molecules move (1). The gas temperature would become zero when all the kinetic energy of the gas molecules has been removed. (1)

4 ▶ a 200 K (1) and 400 K (1)

b The pressure exerted by a fixed amount of gas kept at constant volume is proportional to its absolute (Kelvin) temperature (1) so doubling the temperature will cause the pressure of the gas to double. (1).

c If the container could expand the rate at which collisions between the gas molecules and the container walls occurred would decrease (1) and the area of the walls would increase (1), so the pressure exerted by the gas would decrease. (1)

5 ▶ Pumping more air into the tyre means that there are more air molecules in the tyre (1). This means that there are more collisions between the air molecules and the tyre walls per second (1). The average force on the tyre walls therefore increases (1) and so too does the pressure inside the tyre. (1)

UNIT 6 ANSWERS

CHAPTER 14

1 ▶ B

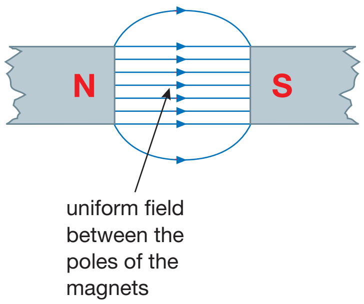
2 ▶ D

3 ▶ The two magnetic fields overlap creating a new magnetic field.

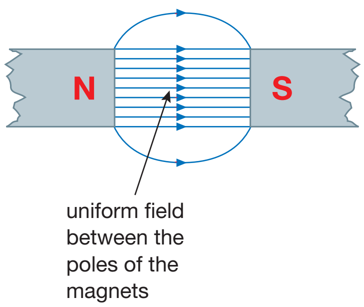
4 ▶ a Shape, strength and direction

b A field that has the same strength everywhere.

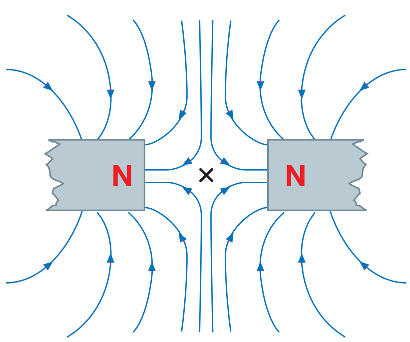
c



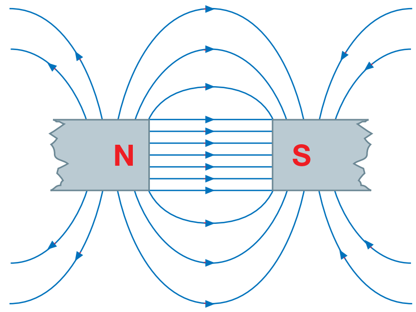
d



5 ▶ a



b



6 ▶ a When current passed through the wire, a magnetic field was created around it.

b From right to left. The magnetic field around the wire is circular, with the wire at its centre. The field is therefore in opposite directions on opposite sides of the wire.

c No. If the current flowing through the wire is reversed, the direction of the magnetic field around the wire will also be reversed.

CHAPTER 15

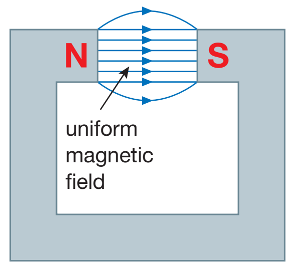
1 ▶ a The wire is pushed upwards.

b The wire is pushed downwards.

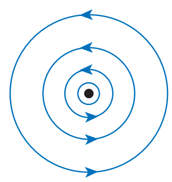
c The wire is pushed upwards.

d The wire is pushed with a larger force.

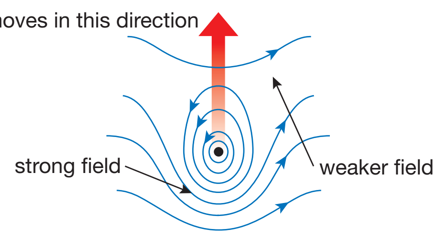
2 ▶ a



b

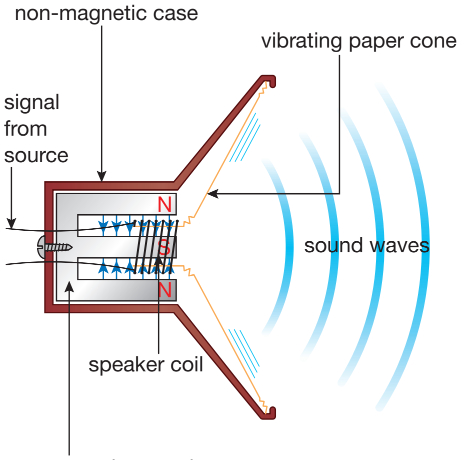


c



3 ▶ Increase the strength of the current in the wire or increase the strength of the magnetic field.

4 ▶ a

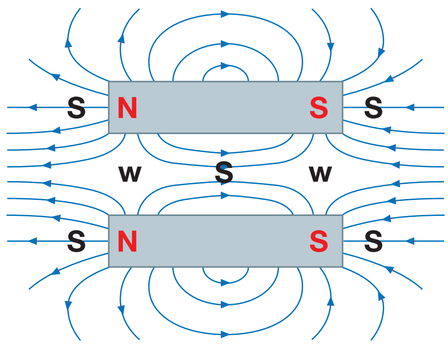


b Varying electric currents from the source create magnetic fields (around the speaker coil); the strength and direction of these fields change as the current changes. These changes make the speaker vibrate, creating the sound waves we hear.

UNIT 6 EXAM PRACTICE

1 ▶ B (1)

2 ▶



*Two **S**s placed anywhere in the diagram where the field lines are closest together (or where they **ought** to be closest together, close to the poles of the magnets) (2).*

*Two **W**s where the lines are distinctly widely spaced (2).*

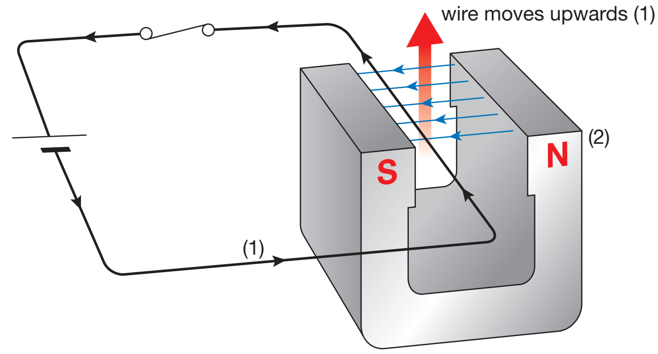
3 ▶ a The strength of the magnetic field remains the same. (1)

b A uniform magnetic field. (1)

4 ▶ (1 mark for each correct underlined word)

When current <u>passes</u> through a wire, a <u>magnetic</u> field is created around it. The field is <u>circular</u> in shape. If the direction of the current is changed the <u>direction</u> of the field <u>changes</u>. If the battery connected to the wire is removed <u>no current flows</u> and the field <u>collapses/ disappears</u>.

5 ▶ a–c



d Change the direction of either the current in the wire or the direction of the magnetic field (1).

e Increase the strength of the current flowing in the wire or increase the strength of the magnetic field (1).

UNIT 7 ANSWERS

CHAPTER 16

1 ▶

Atomic particle	Relative mass of particle	Relative charge of particle
electron	1	+1
proton	2000	–1
neutron	2000	0

2 ▶ a Neutron **b** Electron

c Proton **d** Proton

e Electron

3 ▶ a The atomic number of an atom is equal to the number of protons in the atomic nucleus. This defines the chemical element. Different chemical elements have different atomic numbers.

b The mass number of an atom is equal to the total number of protons and neutrons in the nucleus.

4 ▶

	$^{3}_{2}$He	$^{13}_{6}$C	$^{23}_{11}$Na
protons	2	6	11
neutrons	1	7	12
electrons	2	6	11

5 ▶ a Nucleons, protons, neutrons, +2

b Electron, proton, neutron

c Gamma, short

d Electromagnetic

6 ▶ Alpha radiation is stopped by card; since there is a drop in the detected radiation when a piece of card is placed between the source and the detector, the source must be emitting alpha particles.

Beta radiation is stopped by a thin sheet of aluminium; since there is no change in the detected radiation when an aluminium sheet is used, the source *cannot* be emitting beta particles.

Gamma radiation is stopped by a thick block of lead; since there is a drop in the detected radiation when a lead block is placed between the source and the detector, the source must be emitting gamma radiation.

CHAPTER 17

1 ▶ a Background radiation is radiation produced by radioactive material in the Earth and in the Earth's atmosphere. It should be measured and taken into account when measuring the activity of radiation from a particular source.

b Natural background radiation is due to the decay of naturally occurring radioactive isotopes in the Earth that were formed when the Solar System was created. Natural radiation also results from high-energy particles that bombard the Earth. Artificial background radiation comes from human-made sources, rather than from the rocks that make up the Earth.

2 ▶ a The half-life of a radioactive sample is the average time taken for half the unstable atoms in the sample to undergo radioactive decay.

b Random means that the decay of an individual atom is unpredictable; we cannot say when any particular atom will undergo decay.

3 ▶ In 8 hours the sample has halved so the activity in 8 hours is half of 240. Activity = 0.5 × 240 = 120 Bq.

4 ▶ a 70 seconds (1 minute 10 seconds)

b $1\frac{3}{4}$ minutes is three half-lives (3 × 35 seconds), so the volume of water in the burette will have halved again. The burette will be one-eighth full, containing 6.25 ml.

CHAPTER 18

1 ▶ a It has a short half-life, so its activity drops to a negligible level in a day or two.

b Beta particles and low-energy gamma rays penetrate soft tissue easily, so the progress of the isotope through the body can be monitored easily. The emitted radiation is not strongly ionising, so the risk of tissue damage is acceptably small. (It is also relatively easy to produce.)

2 ▶ a Iodine-131 is taken up by the thyroid gland in the same way as ordinary iodine. An overactive thyroid concentrates more iodine – if the concentration of I-131 is greater than normal, this can be detected by measuring the activity and comparing it with the expected take-up from a normal thyroid gland.

b I-131 is a high-energy beta-emitter. The radiation is sufficiently ionising to destroy cells in the thyroid, reducing its activity.

3 ▶ a Radioactive contamination is the accidental transfer of radioactive material onto or into an object or living organism. If safety procedures are ignored, people working with radioactive materials could be contaminated by radioactive materials.

Irradiation is the deliberate exposure to ionising radiation, such as gamma rays or x-rays. The irradiation lasts for a controlled period of time and is then turned off.

b Irradiation is used to sterilise surgical instruments. The instruments are sealed into wrappers and then irradiated with ionising radiation. The radiation passes through the wrapper, destroying any organisms on the instrument; the instrument then remains sterile within its wrapper. The process does not contaminate the instruments with radioactive material.

4 ▶ a β radiation is used. It can pass through paper (unlike α particles) but the thicker the paper, the greater the amount of β radiation absorbed.

b A β-emitting source is placed above the paper as it emerges from the rollers used to press it to the required thickness. A detector is placed beneath the paper in line with the source. The count rate will decrease if the thickness of the paper passing between the emitter and the detector increases.

c To ensure accuracy, the background radiation count should be measured regularly so that the reading from the detector can be corrected. The half-life of the β-emitting source needs to be quite long, so the count rate does not fall significantly over short intervals. The apparatus will need to be recalibrated regularly using paper of known thickness.

d Care should be taken to ensure workers cannot come within range of the radiation from the source. The source must be stored in a secure container that is lined with lead to ensure no ionising radiation can escape. The storage area and the part of the paper-making works in which the radiation source is being used should be clearly identified with standard signs. The source must be selected and screened to ensure that it emits only β radiation.

5 ▶ a Alpha radiation has a very limited range. After alpha particles have travelled only a few centimetres in air, they have lost most of their kinetic energy and thus their ionising power. Alpha particles are stopped completely by quite thin layers of material, even if the material is not very dense. Thus alpha radiation is not particularly dangerous to living cells unless the source is very close to living tissue. If a source is very close to the skin it may, if the exposure is prolonged, cause burns and other tissue damage. The greatest danger is when alpha-emitting material is absorbed into the body. Inside the body, cells do not have the protection of a layer of skin and fat, so they are readily affected by the highly ionising alpha particles. This will result in cell destruction or mutation.

b Radon-220 is an alpha-emitter. It is a dense gas and therefore accumulates in the lower parts of buildings, etc. As it is a gas, it is readily inhaled and thus comes into close contact with internal cells. As described above, this is the most hazardous condition for alpha sources.

6 ▶ a Beta radiation. Alpha radiation is unsuitable because it is blocked by thin paper. Gamma radiation is unsuitable because it passes through paper without being affected. Beta radiation passes through paper but the amount that passes through decreases as the paper thickness increases.

b If the half-life of the isotope is short the amount of radiation detected will change over time as the isotope decays. This will mean that the control system would need to be continuously adjusted or the isotope used would need to be replaced on an hourly basis.

CHAPTER 19

1 ▶ a The nuclei of its atoms can be split apart by a nucleus.

b A chain reaction is a reaction that produces further reactions. When a U-235 nucleus splits apart, the neutrons produced can cause further nuclei to split, and so on.

2 ▶ Advantages: virtually inexhaustible supply of energy; does not produce ‘greenhouse’ gases.

Disadvantages: produces waste that remains extremely dangerous for thousands of years; very high set-up and decommissioning costs.

3 ▶ a Shielding prevents radiation from escaping.

b The shielding is a 5 metre thick layer of concrete.

4 ▶ Nuclear fission is the splitting of large unstable atoms of isotopes of elements, like uranium, into smaller atoms and other particles, producing large amounts of energy.

Nuclear fusion occurs when atoms of light elements, such as hydrogen, are brought together with enough energy to make them combine to form heavier atoms such as helium.

UNIT 7 EXAM PRACTICE

1 ▶ D (1) 2 C (1) 3 C (1)

4 ▶ a E (1) b D (1) c C (1) d B (1)

5 ▶ a i Nuclear fission is the splitting of large unstable atoms of isotopes of elements, such as uranium, into smaller atoms and other particles producing large amounts of energy. (4)

ii Nuclear fusion occurs when atoms of light elements, such as hydrogen, are brought together with enough energy to make them combine to form heavier atoms, such as helium. (4)

b A chain reaction occurs when neutrons emitted from a nucleus of a fissile material (such as U-235) collide with further unstable nuclei, causing them to decay and emit further neutrons. If each decay triggers more than one further decay, the reaction will accelerate, causing a huge release of energy in a nuclear explosion. (4)

6 ▶ a A is the atomic mass of the element, equal to the number of nucleons (protons and neutrons) in the nucleus (1). Z is the atomic number, equal to the number of protons in the nucleus (1).

b i D (1) ii B (1) iii A (1) iv C (1)

7 ▶ a Gamma (1) b Beta (1) c Alpha (1)
d Gamma (1) e Alpha (1) f Beta (1)
g Beta (1)

UNIT 8 ANSWERS

CHAPTER 20

1 ▶ a Gravitational forces

b The mass and diameter of the planet

c The orbit of Mercury is much more curved than the orbit of Neptune because the gravitational forces between the Sun and Mercury are much stronger than those between Neptune and the Sun.

d The closer a comet is to the Sun, the faster it travels.

2 ▶ Moons orbit planets. Planets and comets orbit the Sun. The orbits of moons are circular. The orbits of planets are a little elongated (squashed circles or ellipses). The orbits of most comets are very elongated.

3 ▶ a Any suitable answer, e.g. the moon.

b Any suitable answer, e.g. the International Space Station.

4 ▶ a Jupiter

b Jupiter

c Venus

CHAPTER 21

1 ▶ A

2 ▶ a A galaxy

b Attractive gravitational forces pull them together

c The Milky Way

d Billions

3 ▶ a B class stars have a surface temperature of 33 000–10 000 K and a lot of the light they emit is in the blue part of the visible spectrum. K class stars have a surface temperature of 5200–3700 K and emit a lot of light in the orange / yellow part of the visible spectrum.

b M class

c F or G class

d 5200–7500 K

4 ▶ The distance the star is from the Earth and the luminosity of the star (the rate the star is emitting energy).

5 ▶ Clouds of particles are pulled together so strongly by gravity that nuclear reactions begin: the star is born. Forces of expansion due to the nuclear reactions and forces of contraction due to gravitational forces become balanced. The star is in its stable period. As the nuclear reactions between hydrogen nuclei become rarer, the forces become unbalanced. The star collapses and becomes very hot. New nuclear reactions begin and the star expands greatly until a new balance of forces is established. For stars as massive as our Sun, the new star is called a red giant. In the core of the star, new nuclear reactions can begin. The star becomes very hot and very dense, it is now a white dwarf.

6 ▶ a Nuclear reactions

b Thermal energy

UNIT 8 EXAM PRACTICE

1 ▶ a B (1) **b** A (1) **c** D (1)

2 ▶ comets (1); orbit (1); closest (1); Mercury (1); Venus (1); strongest (1); curved (1); furthest (1); Uranus (1); Neptune (1); weakest (1); curved (1); circular (1); elliptical (1); satellites (1); moons (1)

3 ▶ a $W = 80 \times 9 = 720\,\text{N}$ (3)

b $W = 80 \times 4 = 320\,\text{N}$ (3)

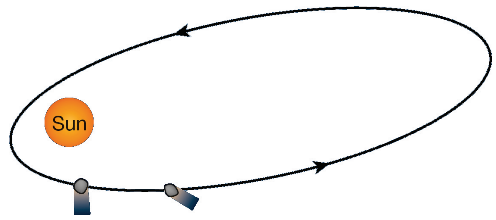
c $W = 80 \times 11 = 880\,\text{N}$ (3)

4 ▶ a Mercury, Venus and Mars (1)

b 30 years (1)

c 750 million kilometres (2)

5 ▶ a Your diagram should show an ellipse (1), with the Sun near one end of it (1):



b As a comet gets closer to the Sun, the gravitational forces acting upon it increase (1) and it speeds up (1). As it travels away from the Sun, the Sun's gravity slows it down (1) so its speed is least when it is furthest from the Sun (1).