Area 1: Exercise solutions

Exercise 1.1.1

1 a) 250 m on a bearing of 015°
  b) 200 m on a bearing of 123°
  c) 430 m on a bearing of 245°

2 a) d = 3700 m, s = 1000 m at 195°
  b) d = 3850 m, s = 0 m
  c) d = 1900 m, s = 1900 m at 129°

3 4·46 km

Exercise 1.1.2

1 a) 5 ms^{-1} b) 10 ms^{-1} c) 72 m
  d) 16·7 s e) 74·6 s

2 21·4 mph

3 25 ms^{-1}

4 a) 10·38 ms^{-1}
  b) 37·4 km/hr

5 24 000 s

6 a) 1032 b) 1103
  c) 1153 d) 1412

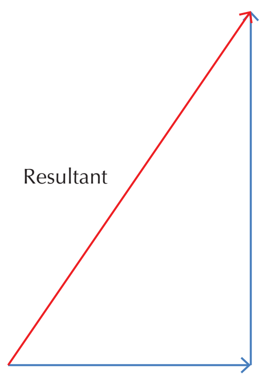
7 Measure distance with trundle wheel, time with stopclock, and use d = vt.

8 a) 2 hours
  b) no

9 4·5 ms^{-1}

Exercise 1.1.3

1



2 24 km, 4 km N

3 1200 yards, 400 yards W

4 45 miles, 15 miles 045°

5 440 m, 40 m N

6 150 miles, 110 miles 027°

7 1100 m, 854 m 249°

8 540 miles, 502 miles 355°

9 390 mph N

10 42 ms^{-1} in direction of travel

11 16·6 ms^{-1} 058°

12 a) 32 ms^{-1} 110°
  b) 9600 m 110°

Exercise 1.1.4

1 0·25 ms^{-1}, 1 ms^{-1}, 0·2 ms^{-1}, 37·5 ms^{-1}

2 Use a light gate to measure time, measure the length of the bobsleigh and use d = vt.

3 V = 27 ms^{-1} therefore the car was speeding.

4 a) 5·6 ms^{-1}
  b) 20·16 km/hr
  c) The average speed depends upon the distance moved in different directions conforming to the landscape/access/roads etc., and therefore will be greater than the average velocity which requires the displacement, which is a straight line between the two points 'X' to be used.

Exercise 1.1.5

1 15·8 mph due west

2 412·5 miles on 280°

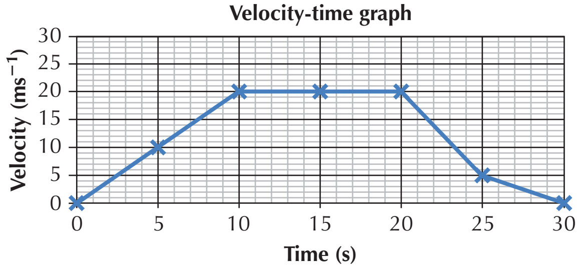
3 1·6 ms^{-1} on 070°

4 a) 4 km on 094°
  b) 2 km/hr on 094°
  c) Speed does not take direction into account.

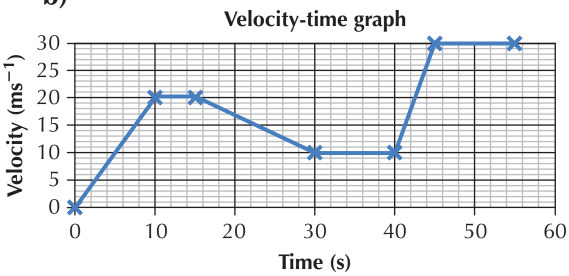
5 a) (i) d = 900 m, s = 600 m on 093°
  (ii) Average speed = 0·88 ms^{-1}
  Average velocity = 0·6 ms^{-1} on 093°
  b) (i) d = 600 m, s = 600 m on 093°
  (ii) Unsolvable

Exercise 1.2.1

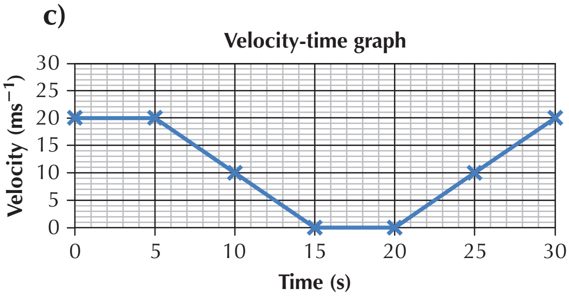
a)



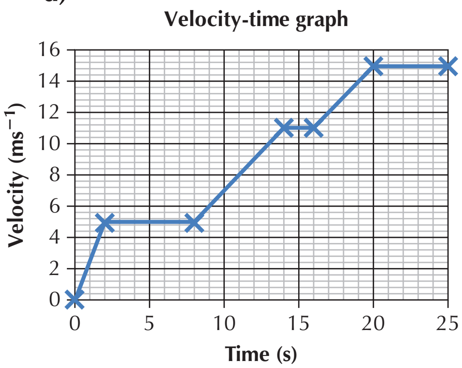
b)



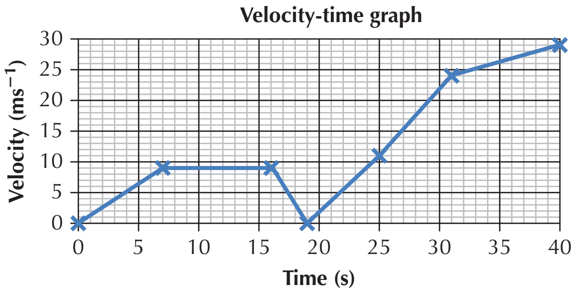
c)



d)



e)



Exercise 1.2.2

1 **a)** 175 m
b) 700 m
c) 195 m
d) 67 m
2 31·25 m
3 **a)** 0·2 s
b) 24 m

Exercise 1.3.1

1 **a)** 2 ms^{-2} **b)** 2·6 ms^{-2} **c)** 4·7 s
d) 4 ms^{-1} **e)** 4·4 ms^{-1}
2 126 ms^{-1}
3 **a)** 27·8 ms^{-1}
b) A = 3·56 ms^{-2} B = 2·36 ms^{-2}
C = 6·04 ms^{-2}
4 **a)** 1·5 ms^{-2}
b) –1 ms^{-2}
5 10·6 ms^{-2}
6 7·9 s
7 6·3 ms^{-1}
8 **a)** 0·12 ms^{-1} and 0·63 ms^{-1}
b) 0·085 ms^{-2}
9 **a)** 10 ms^{-2}
b) Use a double mask.
10 15·68 ms^{-1}
11 8·3 s

Exercise 1.3.2

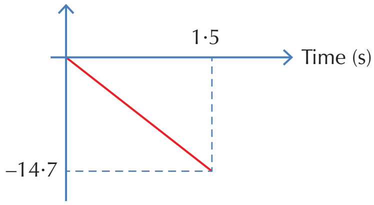
1 **a)** 2 ms^{-2}
b) 0·5 ms^{-2}
c) 2 ms^{-2} and –3 ms^{-2}
d) 2·5 ms^{-2} and –5 ms^{-2}
2 2 ms^{-2} and 1 ms^{-2}

Exercise 1.3.3

1 **a)** 6 s
b) 45 m
c) –10 ms^{-2}

2 **a)** 14·7 ms^{-1}

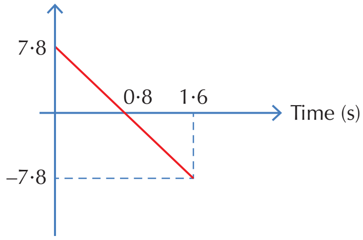
b) Velocity (m/s)



c) 11 m

3 **a)** 7·84 ms^{-1}

b) Velocity (m/s)



c) 3·1 m

4 **a)** 0·8 s

b) –8 ms^{-1}

c) 3·2 m

d) 7 ms^{-1}

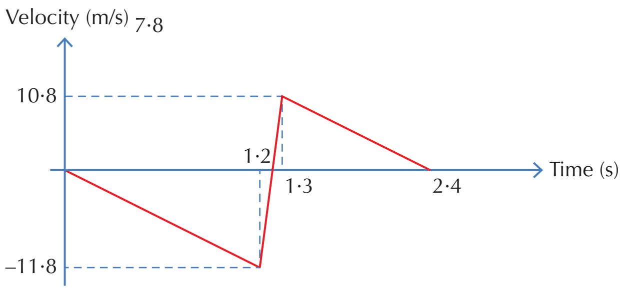
e) 2·5 m

f) Energy loss

5 **a)** –11·76 ms^{-1}

b) 10·78 ms^{-1}

c)



d) (i) 7·1m

(ii) 5·9 m

Exercise 1.4.1

1 Diagrams (a) (c) and (e)

2 24 N

3 40 000 N

Exercise 1.4.2

1 An object will remain at rest or move at a constant velocity unless acted upon by an external force.

2 **a)** No motion

b) Motion away from the team with the slip.

3 Parachute increases air resistance.

Exercise 1.4.3

1 Student's own answers

2 **a)** 10 N

b) 9·8 N

c) 6 ms^{-2}

d) 1·72 ms^{-2}

e) 4·96 kg

3 3·53 ms^{-2}

4 48 N

5 49 N

6 7500 N

7 11 000 N

8 **a)** 3·75 ms^{-2}

b) 3375 N

9 **a)** 8·75 ms^{-2}

b) 70 ms^{-1}

Exercise 1.4.4

1 0·83 ms^{-2}

2 **a)** (i) 5 N (ii) 30 N (iii) 0 N

b) (i) 1 ms^{-2} (ii) 6 ms^{-2} (iii) 0 ms^{-2}

3 **a)** 16 600 N

b) 13·28 ms^{-2}

4 **a)** 40 N

b) 120 N

5 **a)** 410 kN

b) 3·42 ms^{-2}

c) 11·8 s

6 **a)** 231 N

b) 311 N

Exercise 1.4.5

1 a) 120 N
  b) 198 N
  c) 11 kg
  d) 18 kg
  e) 15 N/kg

2 a) Moon = 56 N, Earth = 343 N
  b) Moon = 2·4 N, Earth = 14·7 N
  c) Moon = 1440 N, Earth = 882 N
  d) Moon = 0·06 N, Earth = 0·34 N

3 2356·7 N

Exercise 1.4.6

1 a) 3920 N
  b) 10·2 ms^{-2}
  c) 19·6 s

2 a) 44 100 N
  b) 13 500 N
  c) 66 100 N

3 a) 13 720 N
  b) 2100 N
  c) 15 820 N

4 5·2 ms^{-2}

Exercise 1.4.7

1 Arrows should be at 180° to the direction of force.

2 The reaction force opposite the air being forced down out of the balloon.

3 The action of running towards the pier results in an equal and opposite reaction of the boat moving away from the pier.

4 Jumping off the skateboard results in an equal and opposite reaction of the skateboard moving away from her.

5 The gases ejected backwards result in an equal and opposite force forwards.

Exercise 1.4.8

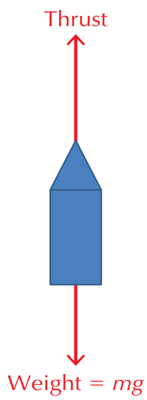
1 6·9 ms^{-2}

2 24 500 N

3 a) 1000 N
  b) 6·67 ms^{-2}
  c) 2058 N
  d) 2842 N
  e) 13·5 ms^{-2}
  f) 1715 N
  g) 2152·5 N
  h) 437·5 N
  i) 2352 N
  j) 3336 N
  k) 984 N
  l) 19 306 N
  m) 26 989 N
  n) 7683 N

4 $6{\cdot}96 \times 10^7$ N

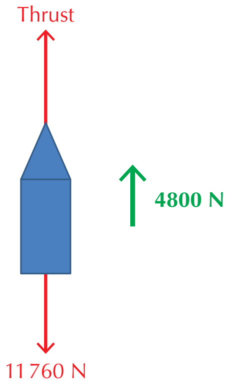
5 a)



  b) 38·2 ms^{-2}
  c) Lower gravity; less mass thus less weight (fuel burn); lower air resistance
  d) 46·4 ms^{-2}
  e) In accordance with Newton's first law, there are no resistive forces therefore the rocket continues at constant velocity.

6 a) 31 490 N
  b) 65 660 N
  c) 97 150 N
  d) 42 210 N

7 a) Water forced downwards results in equal and opposite force upwards propelling rocket into air.



b) 17·8 ms^{-2}

8 Breadalbane Power.

Exercise 1.5.1

1 a) Electrical to light
b) Electrical to sound
c) Electrical to light
d) Gravitational potential energy to kinetic

2 a) Stored energy to kinetic then kinetic to gravitational then gravitational to kinetic
b) Kinetic plus chemical stored to heat and light
c) Chemical stored to heat, light and sound
d) Electrical to light and sound
e) Electrical to light and sound

3 a) 0·2ms^{-1}
b) 10%
c) Heat (small amount through sound)

4 Heat energy (small amount of sound)

5 Electrical energy to sound energy

Exercise 1.5.2

1 a) 75%
b) 53·57%
c) 1500 J
d) 5000 J
e) 6154 J

2 70%

3 3000

4 a) A 150 J B 30 J
b) 15 J
c) 9 J
d) Values not the same. Difference of 6 J
e) Bulb B. It produces less light energy (15% efficient) so the remaining energy must be heat energy.

5 60 J

Exercise 1.5.3

1 a) Chemical stored to heat to kinetic to electrical
b) Nuclear stored to heat to kinetic to electrical
c) Gravitational to kinetic to electrical
d) Kinetic to electrical
e) Light to electrical (PV)

2 Answer must consider local topography, wind, mountains & geothermal

Exercise 1.5.4

1 520 J

2 0·72 J

3 7 N

4 3 m

5 111·76 m

6 0·0006 J

7 925 000 N

8 57 000 000 J

Exercise 1.5.5

1 a) 700 000 J
b) 700 000 J

2 16 000 J

3 a) W = Fd
b) E = mgh

4 0·04 kg

5 a) 18 000 J
b) 24 000 J

Exercise 1.5.6

1 a) 220 000 J
  b) 4 275 000 J
  c) 320 J
  d) 62·5 J
  e) 13888·89 J = 14 000 J to 2s.f.
  f) 1·02488E – 22 J = $1 \cdot 02 \times 10^{-22}$ J to 2s.f.

2 53·54 ms^{-1}

3 6 kg

Exercise 1.5.7

1 a) Bottom of swing (centre)
  b) Top – just at point pendulum swings back.
  c) 2·4 ms^{-1}
  d) Air resistance (friction)

2 7·07 ms^{-1}

3 a) 28·28 ms^{-1}
  b) Friction from road/ground and air resistance

4 16·5 m

5 a) 58·8 J
  b) 58·8 J
  c) 9·8 m

Exercise 1.5.8

1 a) 3000 W
  b) 25 W
  c) 20 W
  d) 0·69 W

2 a) 34 000 J
  b) 1133·33 W

3 a) 900 N
  b) 36 000 J
  c) 720 W

4 1·11 W

5 291·67 W

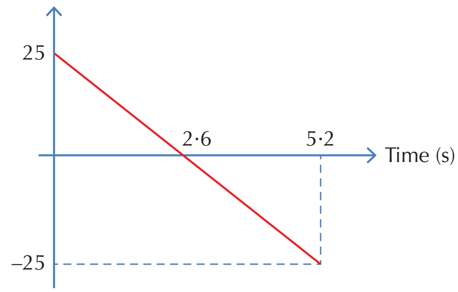
6 a) 2000 N
  b) 12 000 J
  c) 12 s

7 375 s

8 4500 m

9 133·33 kg

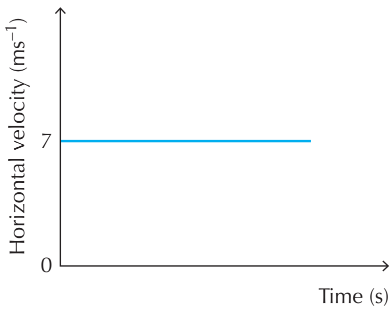
Exercise 1.6.1

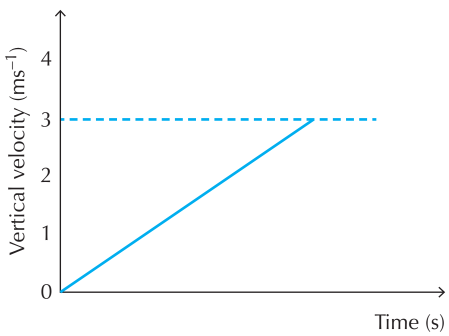
1 a) 2·6 s
  b) 5·2 s
  c) 

  d) 33·1 m

2 a) 13·7 ms^{-1}
  b) 9·6 m

Exercise 1.6.2

1. a) 0 ms^{-1}
  b) 2·1 m
  c) 2·94 ms^{-1}
  d) 

  e) 

  f) 0·44 m
  g) (i) No change
   (ii) R will be twice that found in part (a)

2 222·2 ms^{-1}

3 **a)** The arrow drops below the target because of gravity – the arrow has a vertical velocity.

b) 0·68 s

c) 2·3 m

4 **a)** 0 ms^{-1}

b) 2·04 s

c) 20·4 m

d) 30·08 m

5 No

6 **a)** 250 ms^{-1}

b) 0 ms^{-1}

c) 78·4 ms^{-1}

d) 313·6 m

e) 2000 m

f) Directly below the aeroplane

Exercise 1.6.3

1 **a)** $1{\cdot}67 \times 10^{-4}$ s

b) $1{\cdot}5 \times 10^{-3}$ s

c) 0·096 s

d) 0·017 s

2 0·24 s

3 0·008 s

4 $1{\cdot}2 \times 10^{7}$ m

5 $1{\cdot}35 \times 10^{8}$ m

Area 2: Exercise solutions

Exercise 2.8.1

1 **a)** $9{\cdot}5 \times 10^{15}$ m
b) $4{\cdot}3 \times 10^{16}$ m
c) $3{\cdot}2 \times 10^{17}$ m
d) $5{\cdot}3 \times 10^{14}$ m

2 **a)** 42 105 Ly
b) $8{\cdot}2 \times 10^{13}$ Ly
c) $3{\cdot}3 \times 10^{-5}$ Ly
d) 0·7 Ly

3 $1{\cdot}44 \times 10^{11}$ m

4 6·8 years

5 $6{\cdot}2 \times 10^{5}$ years

6 $6{\cdot}1 \times 10^{18}$ m

7 34 Ly

Area 3: Exercise solutions

Exercise 3.9.1

1 Proton – positive
Electron – negative

2 **a)** Same sign charges transfer to your body and hair. Same sign charges repel so hairs push against each other making your hair 'stand-up'.
b) Opposite charges attract. Charge can jump through the air with enough energy to produce light. Just like lightning.

3 Static charge builds up and repels. Hair brush pins are normally made of plastic.

Exercise 3.9.2

1 **a)** 60 C
b) 90 C
c) 0·06 C
d) 0·4 C
e) 320 s
f) 20 A
g) 0·00035 A
h) 200 s

2 4000 s

3 **a)** 1 800 000 C
b) 1·125E+25 particles

4 43 200 C

5 0·00025 A or 250 mA

Exercise 3.9.3

1 **a)** Straight horizontal line
b) Sine wave
c) Battery
d) Mains supply

2 AC (less current required for long distance supply)

3 Part (ii) is most appropriate

Exercise 3.10.1

1 **a)** 80 J
b) 8·5 J
c) 0·1 J
d) 210 000 J
e) 2·5 C
f) 0·000000015 C
g) 2 V
h) 6·25E+11 V

2 1200 J

3 Positive charge moves towards negative plate to low potential

4 240 V

5 **a)** 120 C
b) 1440 J

6 **a)** 20 J
b) (i) 20 J (ii) 31·62 ms^{-1}

7 Energy lost to heat

8 **a)** 8E-16 J
b) 42 163 702 ms^{-1} (0·14 c (c = speed of light))

Exercise 3.11.1

1 **a)** 2 Ω
b) 575 Ω
c) 275 V
d) 200 V
e) 0·002 A

2 153 Ω

3 9·2 A

4 12 V

5 **a)** V = parallel, A = series
d) 4 Ω

6 **a)** Straight line
b) R = gradient

Exercise 3.12.1

1 **a)** V = 6 V, I = 4 A
b) V = 4 V, I = 2·5 A
c) V = 1 V, I = 0·5 A
d) V = 5 V, I = 0·3 A

2 **a)** All go out (series circuit)
b) Current same at all points in a series circuit

3 **a)** Ammeter connected in series
b) Voltmeter connected across bulb
c) Voltmeter connected across R2

Exercise 3.12.2

1 **a)** 35 Ω
b) 5 kΩ
c) 502 kΩ
d) 5 kΩ

2 **a)** 50 Ω
b) 0·4 A

3 If one bulb fails then all bulbs go out. Every bulb would need to be checked.

4 **a)** 24 Ω
b) Series circuit
c) 96 Ω
d) 48 V

5 **a)** 22·5 Ω
b) 5 V
c) 0·5 Ω
d) If bulb burns out then motor switches off.

6 Add them

Exercise 3.12.3

1 **a)** V = 7 V, I = 1.5 A
b) V = 12 V, I = 7·5 A
c) V = 20 V, I = 0·5 A
d) V = 9 V, I = 2 A

2 **a)** Voltage the same in parallel
b) 4·8 A
c) Other bulb remains lit as parallel bulbs independent

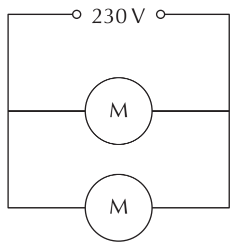
3 **a)** Ammeter
b) Ammeter in series with R2
c) Voltmeter across R3

Exercise 3.12.4

1 **a)** 5 Ω
b) 3·75 Ω
c) 6·38 Ω
d) 1·48 Ω

2 **a)** 2·18 Ω
b) 4·6 A

3 **a)** Each bulb receives 12 V
b) Parallel circuit branches are independent

4 **a)**


b) 28·75 Ω
c) 14·375 Ω

5 **a)** Series; 10 Ω + 50 Ω
b) Parallel; 100 and 25
c) Parallel; 50 Ω, 100 Ω and 1000 Ω
d) Parallel 50 Ω, 500 Ω with series 10 Ω

6 Current adds in parallel

Exercise 3.12.5

1 **a)** 9·7 Ω
b) 2·4 Ω
c) 8·2 Ω
d) 12·1 Ω

Exercise 3.12.6

1 **a)** V1 = 3·38 V, V2 = 5·62 V
b) V1 = 7 V, V2 = 9 V
c) V1 = 3·95 V, V2 = 7·05 V
d) V1 = 4·88 V, V2 = 8·12 V
e) V1 = 0·91 V, V2 = 9·09 V

Exercise 3.12.7

1 LED uses little power/energy. Converts electrical energy to light. Bulb uses much more energy and is not as efficient. Converts electrical energy to heat and light.

2 LED only allows current flow in one direction. Must point to negative with protective resistor.

3 237·5 Ω

Exercise 3.12.8

1 **a)** 0·24 V
b) 2·5 V
c) Light level decreases, resistance increases, voltage increases above 0·7 V, transistor switches on so LED lights.
d) Variable resistor

2 **a)** 90°C
b) Transistor switches on at around 0·7 V
c) Alter size of resistor
d) Swap transistor and resistor

Exercise 3.13.1

1 **a)** 200 W
b) 950 W
c) 5400 J
d) 21 600 J
e) 18·8 s

2 14 400 J

3 1·96 s

4 375 W

Exercise 3.13.2

1 **a)** 60 W
b) 270 W
c) 0·00006 W
d) 0·08 W
e) 106·67 Ω
f) 4·47 A
g) 920 Ω
h) 40 Ω
i) 3 μW (0·0000003 W)
j) 0·06 A

2 **a)** 0·017 W
b) 0·3 W
c) 0·000000017 W
d) 0·02 W
e) 0·94 Ω
f) 268·33 V
g) 0·11 Ω
h) 0·025 Ω
i) 360 W
j) 0·03 V
k) 1516·58 V

3 150 W

4 146·94 W

5 2822·4 W

6 44·5 V

7 1·83 A

Area 4: Exercise solutions

Exercise 4.14.1

1 138 J/kg°C
2 58·5 J
3 a) 69·44°C
b) 41·67°C
4 257 600 J
5 0·09 kg
6 158 000 J

Exercise 4.14.2

1 a) 55·56 W
b) 5000 J/kg°C
c) Errors; heat is lost to the surroundings.
2 a) 204 000 J
b) 204 000 J
c) 32·54°C
3 2229·33 W
4 a) 919 600 J
b) 1702·96 W

Exercise 4.15.1

1 $5{\cdot}2 \times 10^6$ J
2 a) 36 kJ
b) 216 kJ
3 $1{\cdot}7 \times 10^5$ J/kg
4 1·67 kg

Exercise 4.15.2

1 a) 4 752 000 J
b) 10·8 °C
2 a) 550 ms^{-1}
b) $1{\cdot}41 \times 10^8$ J
c) 481·25 J/kg°C
3 a) $2{\cdot}2 \times 10^7$ J
b) 2095°C
c) No
d) Changes state; glows white hot
4 Material C

Exercise 4.16.1

1 a) 40 Pa
b) 24 Pa
c) 10 Pa
d) 6000 N
e) 575 N
f) 0·10 m^2
g) 0·08 m^2
h) 66·67 m^2
i) 1038·46 Pa
2 61·25 Pa
3 1 500 000 N
4 0·40 m^2

Exercise 4.16.2

1 Sharp end has smaller area so creates greater pressure. The larger the area the less the pressure.
2 Lying down is better as it increases the area. As area of contact increases the pressure decreases.
3 Ballet dancer stands over smaller area so pressure is greater. Tank has its force spread over greater area by its tracks.
4 P = F/A
As A increases the pressure decreases.

Exercise 4.16.3

1 a) 473 K
b) 3 K
c) 373 K
d) 261 K
e) 23 K
2 a) 0°C
b) –273°C
c) –73°C
d) –152°C
e) –223°C
3 a) 303 K and 348 K
b) 36 450 J
4 a) 50 K
b) 248·94 J/kgK

Exercise 4.16.4

1 a) 3 m^3
b) 193·33 Pa
c) 315 Pa
d) 3920 m^3
e) 280 Pa
2 30·06 m^3
3 2 400 000 Pa
4 a) 202 000 Pa
b) 505 000 Pa
c) 2 525 000 Pa
5 6·34 m^3

Exercise 4.16.5

1 a) 22 m^3
b) 213·33 K
c) 31·11 m^3
d) 725 K
e) 301 K
2 242°C
3 0·46 m^3

Exercise 4.16.6

1 a) 1458·33 Pa
b) 91 910 Pa
c) 153·125 K
d) 630 K
e) 278·4 K
2 1451·1 K (1177·95°C)
3 a) 232 503·36 Pa
b) When car moves, friction with the road increases the temperature and the kinetic energy of particles. This resulting increase in pressure could give a false high pressure reading.
c) The temperature increases, the kinetic energy increases. Particles move faster and hit the sides more often and with increased force. This could lead to a higher pressure than that recommended by the manufacturer.
4 44 279·35 Pa
5 822·86 K
6 a) 66·88 K
b) $P \propto T$
As air leaves the can the pressure decreases and therefore the temperature decreases.

Exercise 4.16.7

1 a) 3663 Pa
b) $1·7 \times 10^5$ Pa
c) 7·8 litres
d) 88·1 litres
e) 5·3 K
f) 0·13 K
2 29·6 litres
3 28·25 litres
4 263 000 Pa
5 160·76 litres
6 41·27 cm^3

Area 5: Exercise solutions

Exercise 5.17.1

1 Any 3 from sound, light, heat, radio, X-rays.

2 **a)** Longitudinal

b) The coils are moving back and forth in the same direction as the wave/energy.

c) Sound waves

3 **a)** Transverse

b) The water molecules are moving perpendicular to the direction of the waves/energy.

c) Light, heat, X-rays etc.

Exercise 5.17.2

1 **a)** 1·5 m

b) 2 m

2 **a)** 2·8 m

b) 0·75 m

3 The amplitude would increase but the wavelength would stay the same.

4 0·09 m

Exercise 5.17.3

1 0·32 Hz

2 66 waves

3 20 s

4 2 Hz

5 0·06 s

Exercise 5.17.4

1 1·9 ms^{-1}

2 48 m

3 11·8 s

4 12 s

5 **a)** 12 500 m

b) The storm is getting closer.

6 0·05 s

7 **a)** 900 m

b) There is something between the boat and the sea bed, for example, a shoal of fish.

Exercise 5.17.4

1 42·9 Hz

2 340 ms^{-1}

3 **a)** 0·4 Hz

b) 15 m

4 3·1 m

5 **a)** 67 ms^{-1}

b) 267 Hz

c) 0·0037 s

6 **a)** 1000 ms^{-1}

b) 8 s

7 240 000 m

8 0·0005 s

9 3×10^8 ms^{-1}

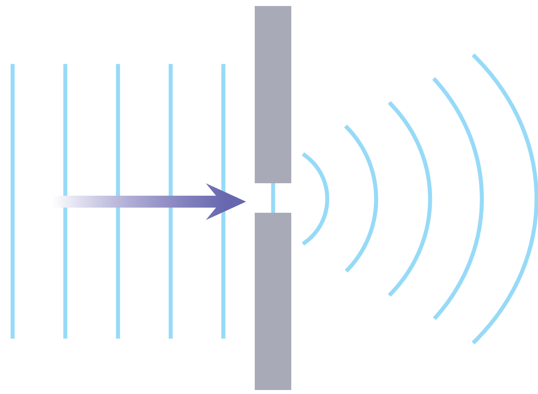
10 **a)** 333 ms^{-1}

b) 1·2 m

Exercise 5.17.6

1 Diffraction

2



3 Long waves diffract more than short waves, so they are more likely to change direction enough to reach the car.

Exercise 5.18.1

1 They all travel at the speed of light, 3×10^8 ms^{-1}.

2 Radio, **Microwaves**, Infrared, Visible, **Ultra-violet**, X-Rays, **Gamma rays**.

3 Looking inside a body without having to cut it open, checking the quality of important welds, scanning luggage for security etc.

4 **a)** Gamma rays
 b) Radio

5 $6{\cdot}0 \times 10^{14}$ Hz

6 3×10^{8} ms^{-1}

7 1×10^{-9} m

8 They have a higher energy.

9 Infrared radiation.

10 $4{\cdot}3 \times 10^{14}$ Hz

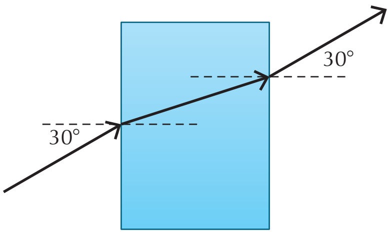
11 Heating food, mobile phones

12 Detecting forged bank notes, killing bacteria, causing a sun tan

Exercise 5.19.1

1 Changing speed, wavelength and often direction when light passes from one medium into another with a different density.

2 **a)** 30°
 b)



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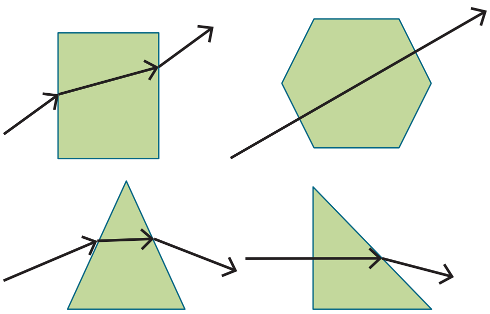


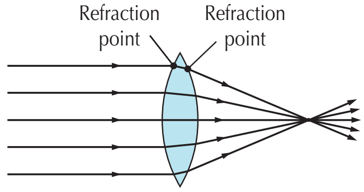
4 **a)** It is deeper than it appears.
 b) The fish will appear closer to the surface than it is.

5 Because the frequency does not change.

6 Yes. Although its direction does not change, its speed and wavelength change.

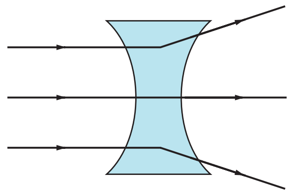
Exercise 5.19.2

1 **a)** Convex
 b)



 c) Long sight (Hypermetropia)

2 **a)** Concave
 b)

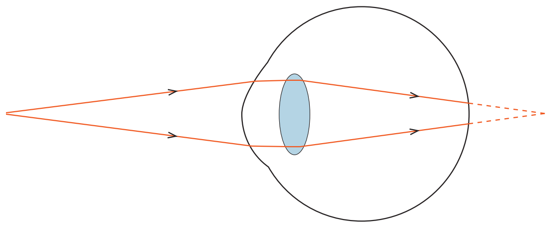


 c) Short sight (Myopia)

3 **a)** C **b)** A
 c) Focus a distant object on a screen and measure the lens–image distance.

4 **a)** Short sight
 b) Concave lens

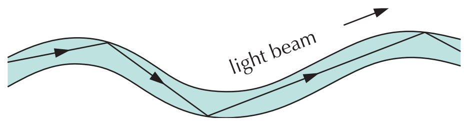
5 **a)** Short sight
 b) Concave lens
 c)



Exercise 5.19.3

1 It is totally internally reflected.

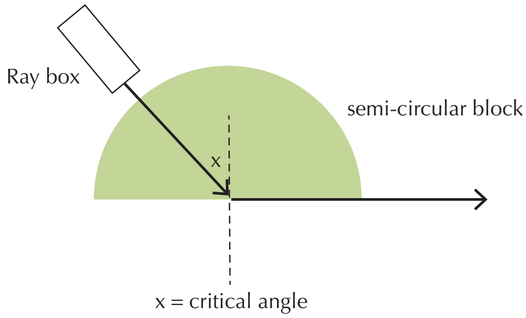
2



3 0·025 s

4 Shine light from a ray box into the curved side of a semi-circular block. Change the

angle of incidence until the ray of light follows the flat edge of the semi-circular block. This is the critical angle. Measure this angle with a protractor.



Exercise 5.19.4

1 Blue light
2 Different colours (wavelengths) refract by different amounts.

Area 6: Exercise solutions

Exercise 6.20.1

1 The process by which an atom gains or loses an electron.

2 Protons and neutrons are found in the nucleus. The nucleus is orbited by electrons. The nucleus is far more massive than the electrons.

3 Alpha particles, beta particles and gamma rays.

4 **a)** Beta radiation. Beta particles are high energy electrons which have a negative charge. The negative charge is attracted to the positive plate.

b) To protect the technician from the radiation during the experiment.

5 **a)** Geiger-Muller tube

b) Beta and Gamma. Paper has little/no effect so no alpha particles. Some radiation is stopped by the 2 cm of aluminium so there must be beta particles, but some get through so there must also be gamma rays.

6 Gamma, beta, alpha.

Exercise 6.20.2

1 The number of decays per second, with the unit becquerels.

2 **a)** 6·25 Bq

b) 16·7 Bq

c) 4 Bq

d) 0·14 Bq

e) 3818 Bq

f) 0·13 Bq

3 10 000 Bq

4 480×10^{6} isotopes

Exercise 6.20.3

1 0·003 J

2 2×10^{-4} Gy

3 5·7 mGy

4 64·7 kg

Exercise 6.20.4

1 The absorbed dose (so the energy absorbed and the mass absorbing the radiation), the type of radiation, and the part of the body that absorbs the radiation.

2 **a)** Becquerels, Bq

b) Grays, Gy

c) Sieverts, Sv

3 2×10^{-4} Sv

4 $4{\cdot}1 \times 10^{-5}$ Sv

5 1·5 mGy

6 **a)** 20

b) 1

c) More ionising

Exercise 6.20.5

1 2.7 μGy

2 2000 times

3 2.5 μSv h^{-1}

Exercise 6.20.6

1 Any two from radon gas from granite, cosmic rays, medicine, some food, nuclear testing, buildings/ground.

2 It will make the activity seem slightly higher than it actually is. Measure the background radiation before measuring the activity of the source, then deduct this from the value measured from the source.

3 2 hours

4 8 hours

Exercise 6.20.7

1 Medical equipment can be exposed to radiation to kill any living organisms (such as bacteria or viruses). This can even be done after they have been sealed in their packages ensuring that they are sterile when they are opened.

2 **a)** A few hours or so. Long enough to give an accurate reading but short enough to prevent harm to the patient.

b) It is very harmful due to it being very ionising. It cannot penetrate skin so it can't be detected outside the body.

3 Inject a radioactive substance into the patient's blood. An unusual amount of blood is used by the tumour leading to the radiation collecting there. This area can then be detected using a gamma camera.

4 Photographic film. Place the part of the body with the suspected broken bone in between the film and the source of X-rays. The X-rays will be stopped by the bone but will pass through the break and the soft tissue and darken the photographic film.

5 **a)** It will be absorbed by a few cm of air, making it safe to have near living areas. Its penetration will also be affected by smoke.

b) A long half-life so that the alarm functions for a long time.

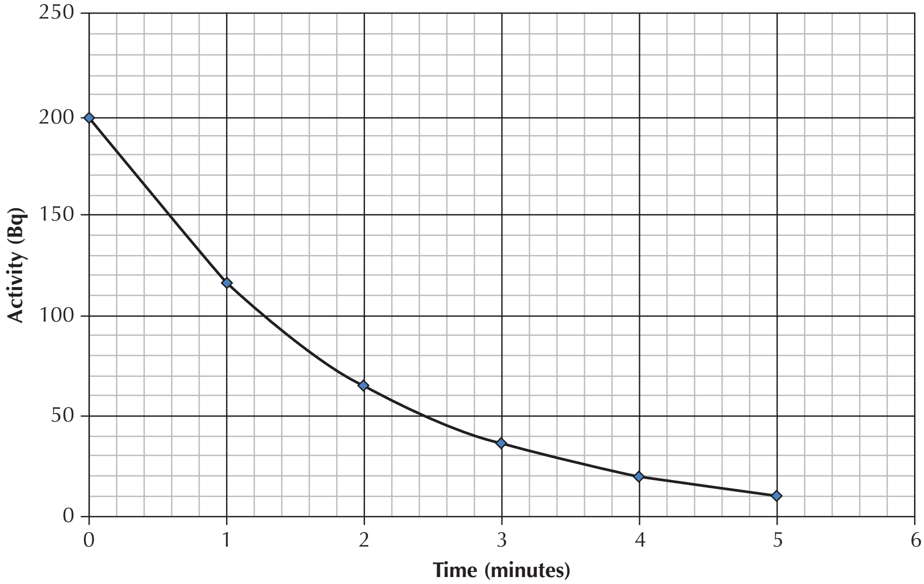
c) It is very penetrating so may affect living things nearby. It may also pass through the smoke particles meaning the smoke goes undetected.

Exercise 6.20.8

1 The length of time it takes for the activity of a radioactive substance to drop to half its original value.

2 6 days

3



From the graph, $t_{½}$ = 1·2 mins = 72 s.

4 15 Bq

5 7 days

6 80 years

7 57 600 Bq

8 34 200 years

Exercise 6.20.9

1 Unstable isotopes decay, releasing radiation and energy.

2 Neutrons released by one decaying isotope go on to cause others to decay. They in turn release more neutrons causing even more isotopes to decay.

3 To maintain a safe core temperature, preventing the core from exploding.

4 **a)** Contain the radioactive source.

b) Control the rate of the reaction.

c) Slow the neutrons, making them more likely to stimulate further nuclear decays.

5 All of the students' opinions are sensible. What do you think?

AREA 1: Dynamics

ANSWERS TO EXAM-STYLE QUESTIONS

1 Scalar has magnitude only; vector has both magnitude and direction.

Scalars: speed, distance, time

Vectors: velocity, displacement, force

2 a) 2 ms^{-2}

b) Travelling at a constant speed.
c) The forces are balanced.

d) The distance travelled. (n.b. not displacement as the graph is a speed-time graph.)

3 0·67 ms^{-2}

4 Mass – amount of matter making up an object, scalar. Weight – force per unit mass acting on an object due to gravity, vector.

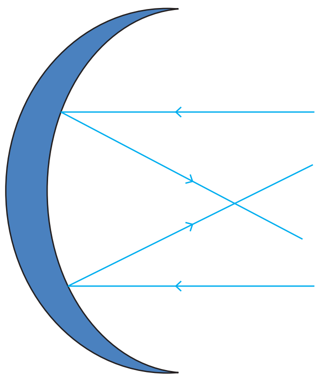
5 a) 784 N b) 80 kg c) 128 N

6 a) Constant velocity

b) Constant acceleration due to gravity

c) 0·125 s

7



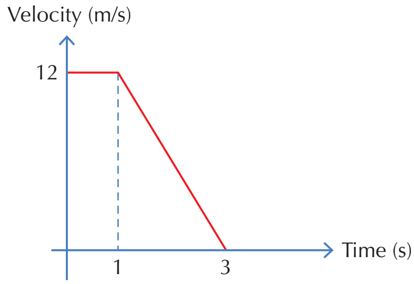
Weak signals can all be focused to one point to increase the strength of the signal.

8 a) 3×10^8 ms^{-1} b) 0·083 s

9 Some energy is converted into non-useful forms, such as heat and sound energy. The motor therefore has to produce more energy than is strictly required because some will be wasted.

10 a) Measure distance with trundle wheel, record time with stop clock then use = d/t

b) i) –6 m/s^2

ii) 

iii) 24 m

11 a) 0–20 s constant acceleration, 20–80 s constant speed, 80–120 s constant deceleration

b) 0·8 m/s^2

c) 1440 m

12 a) 11·2 ms^{-1} on bearing 117 °

b) 20 160 m on bearing 117 °

c) The swimmer should swim between SW and WSW so that the resultant vector is north to south.

13 a) A seatbelt provides the unbalanced force required to keep you in your seat – without it you would keep moving at a constant speed when the vehicle stopped, resulting in injury.

b) –62·5 ms^{-2}

c) 4375 N

14 a) 784 000 N

b) 2 384 000 N

c) The mass reduces because of fuel burn, reducing the weight and increasing the unbalanced force upwards. Gravity reduces as height increases, reducing weight and increasing the unbalanced force upwards.

15 Decreased deceleration results in decreased force.

16 a) 377·1 ms^{-1}

b) Because his weight was equal to the air resistance, and balanced forces result in constant velocity (Newton's first law).

c) Air pressure is lower at a greater height so air resistance is also lower. This will allow the skydiver to reach a greater terminal velocity before the force of air resistance balances out the skydiver's weight downwards.

d) The parachute opening increased the air resistance, resulting in an unbalanced force upwards to cause the deceleration.

17 a) Air and gases ejected backwards cause an equal and opposite force forwards.

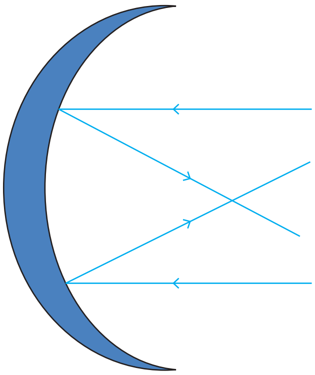
b) 2·45 ms^{-2}

c) (i) 44·9 s

(ii) 2469·5 m

d) Air forced downwards results in an equal and opposite force upwards called lift.

18 a)



b) Many weak signals are focused to the same point, giving a strong signal.

c) 0·13 s

d) It remains at the same position above the earth and therefore has an orbit of 24 hours.

e) The bulb is positioned at the focus and a curved reflector reflects the rays of light outwards in a beam of light.

19 a) 11·76 J b) 3·43 ms^{-1} c) H: 3·43 ms^{-1}, V: 0 ms^{-1}
d) 1·37 m e) 3·92 ms^{-1}

AREA 2: Space exploration and cosmology

ANSWERS TO EXAM-STYLE QUESTIONS

1 a) The distances are too large; the metre is too small a unit.

b) $2{\cdot}28 \times 10^{18}$ m

AREA 3: Electricity

ANSWERS TO EXAM-STYLE QUESTIONS

1 Metals generally make good conductors. In a metal there are many carriers that can move freely. This permits current to flow more readily.

OR

Semiconductor materials, like silicon, can be good conductors as the material has enough energy to free more charge carriers. This can be done by passing a current through the device or ionisation by radiation.

2 As the rubber belt rotates and rubs against the engineer's arm, it builds up a static charge. The static charges all have the same sign of charge (e.g. negative, positive) and as such will repel each other. The hairs build up static charge over a period of time and hence will have the same charge and repel each other, giving the appearance of the hairs standing on end.

3 a) $I_{total} = 250 \times 10^{-3} + 250 \times 10^{-3} = 500 \times 10^{-3}$ A = $\underline{0{\cdot}5\ \text{A}}$

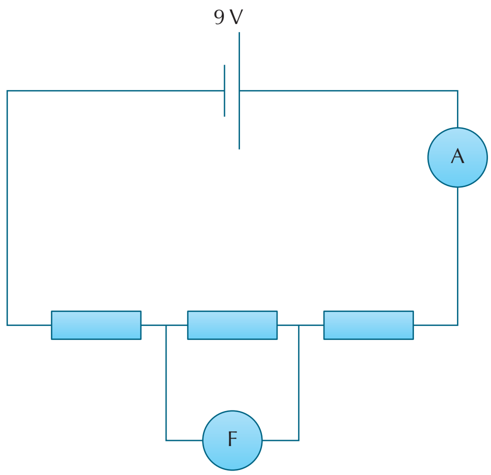
b) $R_{Motor} = V/I = 6/250 \times 10^{-3} = \underline{24\ \Omega}$

c) $R_{total} = V_{total}/I = 10/0{\cdot}5 = \underline{20\ \Omega}$

d) $R_{variable} = 20 - R_{parallel} = 20 - 12 = \underline{8\ \Omega}$

e) $Q = It = 250 \times 10^{-3} \times (2 \times 60) = \underline{30\ \text{C}}$

4 a)



Voltmeter can be across any resistor.

b) Voltage shared in a series circuit. Voltage will be $\underline{3\ \text{V}}$

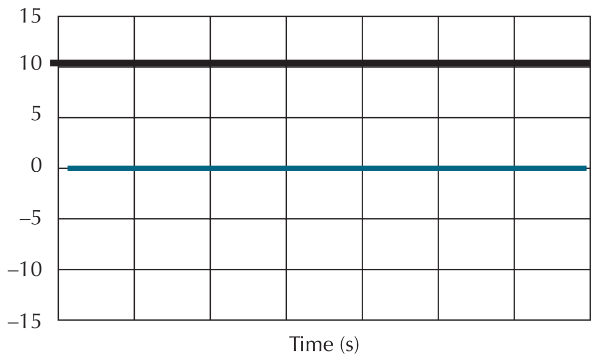
c) $I_{total} = V/R_{total} = 9/300 = \underline{0{\cdot}03\text{A}}$

5 a) The energy at the top of the hill is 100% potential energy. The bike has an initial speed of 0 ms^{-1}. The bike will accelerate down the hill at 9·8 ms^{-2}. As the bike gains speed the potential energy transfers to kinetic energy. Half way down the slope the bike has 50% kinetic energy and 50% potential energy. At the bottom of the slope, at maximum speed, the bike will have 100% kinetic energy and 0% potential energy.

b) Energy is lost due to friction with the ground and air resistance.

c) It is transferred into heat and sound energy.

6 a) Electrical current is the rate of flow of electric charge and is the amount of charge passing a fixed point per unit of time.

b) 

c) The charge carriers in an alternating current circuit change direction. This is shown by the positive and negative voltage on the trace. The frequency of the switch in direction is given by how many waves pass per second.

d) (i) 0·5 C

(ii) $3{\cdot}1 \times 10^{18}$ electrons

7 a) 6 J of energy per Coulomb of electrical charge. The potential difference (voltage) of the supply is a measure of the energy given to the charge carriers in a circuit. The electric potential difference is the difference in voltage between two points.

b) Charge particles have non-zero charge. Protons have a positive charge and electrons have a negative charge. The charged particles can be manipulated by an electric (and magnetic) field. The field orientation can control the path of the particles.

8 As the temperature of a filament inside the bulb increases, the resistance of the bulb increases. When the bulb is switched on it will be cold and have a relatively low resistance. This small resistance will allow a large current to flow through the filament in the bulb causing it to melt thus breaking the bulb.

9 a) Two 10 Ω resistors in parallel and one in series = 15 Ω

b) Light Emitting Diode (LED)

c) The resistor is used to limit the voltage through the LED.

d) The LED must point towards the negative terminal and so its direction must be changed.

e) 6 – 1·2 = 4·8 V. R = V/I = 4·8/1·0 mA = 4·8 KΩ

10 a) Appliances have a fuse to protect them from surges of electricity. The fuse serves as a safety device. It will burn out, protecting consumers from being socketed.

b) Devices that draw a large current with a large power usage will cost more to operate. Devices such as cookers, heaters, kettles and irons use a lot of energy.

c) P = 2 kW = 2000 W   E = P/t = <u>5·6 J</u>
V = 0·1 litres
t = 5 minutes = 6 × 60 = 360 s

AREA 4: Properties of matter

ANSWERS TO EXAM-STYLE QUESTIONS

1 Heat energy causes the temperature of the space craft to rise. The choice of material for its construction is important to ensure that the high temperature does not result in a change of state, damaging the space craft.

2 The lead has a higher specific heat capacity than the aluminium. $E_h = Cm\Delta T$

3 $E_h = ?$ $\underline{E_h = 56\ 848\ J}$

$C = 4180$ J/Kg°C

$m = 0{\cdot}2$ l

$\Delta T = 88 - 20 = 68$°C

4 a) Temperature in Kelvin = $^0C + 273$

$T = 20 + 273 = 293$ K

b)

$P_1 = 18$ Pa $P_2 = P_1 \times T_2 / T_1 = \underline{17{\cdot}69\ Pa}$

V_1 = constant

$T_1 = 293$ K

$P_2 = ?$

V_2 = constant

$T_2 = 15+273 = 288$ K

5 a) As the temperature increases the average kinetic energy of the particles increases and hence the speed of the particles increases. The number of collisions between the particles and the walls increases. The average force of the collisions also increases. All the changes in behaviour of the gas particles result in an increase in gas pressure.

b)

(i) $P = F/A = 3800/(\pi\ r^2) = \underline{503\ 780\ Pa}$

(ii) $P_1 = 126\ 667$ Pa $\quad P_2 = P_1 \times V_1 / V_2 = \underline{1\ 266\ 670 \text{ Pa}}$

$V_1 = 0{\cdot}1$ ml

$T_1 = 88 + 273 = 361$ K

$P_2 = ?$

$V_2 = 0{\cdot}01$ ml

$T_2 = 88 + 273 = 361$ K

This relationship, where pressure and volume are connected at constant temperature and mass, is named after the scientist Boyle.

6 a) Infra-Red radiation is used to determine the heat emitted from an object.

b) The school canteen contains devices that transfer electrical energy to heat energy to produce food. These devices, such as the oven, will allow some heat to escape, therefore increasing the temperature of the canteen. For example, the oven may not be perfectly insulated, the walls of the oven will become hot and radiate energy into the kitchen etc.

c) The tomato sauce is made up mostly of water. The sauce has a higher specific heat capacity than the crust. It retains more heat energy than the crust. Heat energy is found by: $E_h = Cm\Delta T$.

d)

$E_h = ?$ $\quad \underline{E_h = 4180 \times 2 \times 75 = 627\ 000 \text{ J}}$

$C = 4180$ J/Kg°C

$m = 2$ Kg

$\Delta T = 90 - 15 = 75$°C

7 $P_1 = 1 \times 10^5$ Pa $\quad P_2 = P_1 \times T_2 / T_1 = \underline{79\ 983 \text{ Pa}}$

$V_1 = 20$ l

$T_1 = 22°C + 273 = 295$ K

$P_2 = ?$

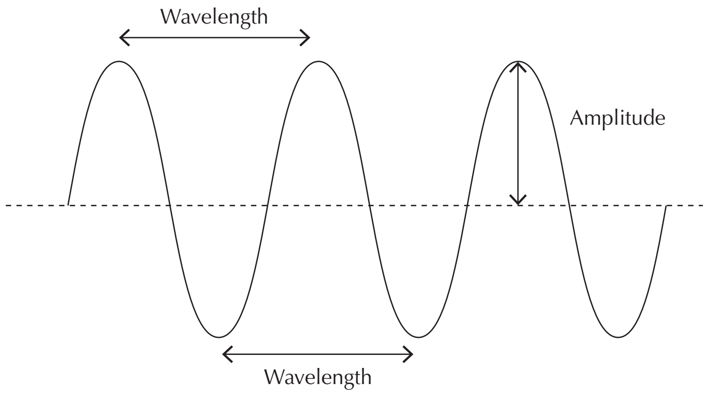
$V_2 =$ constant

$T_2 = -40°C + 273 = 233$ K

AREA 5: Waves

ANSWERS TO EXAM-STYLE QUESTIONS

1



2 a) 3×10^8 ms^{-1}

b) Radio, microwaves, infrared, visible, ultra-violet, Gamma rays

c) Radio

3 A – Angle of incidence

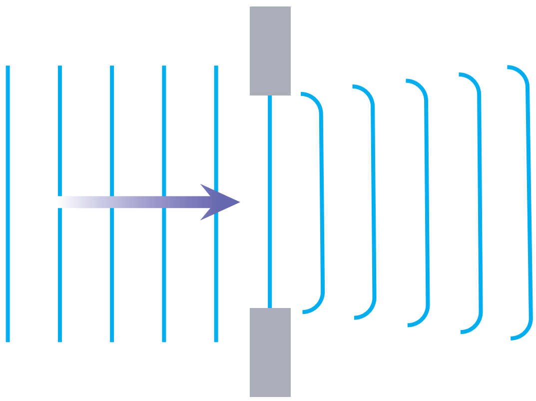
B – Normal

C – Angle of refraction

4 a) 0·03 m

b) 0·075 m

5



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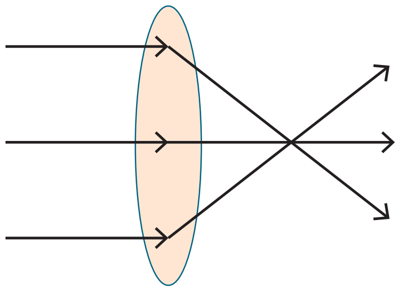


7 a) Number of oscillations (or waves) passing a given point per second.

b) (i) 1·7 Hz

(ii) 5 m

(iii) 0·59 s

(iv) 8·5 ms^{-1}

c) Transverse – the water molecules move perpendicular to the direction of the wave.

8 As long a wavelength as possible should be used. Longer waves diffract around objects by a larger amount making it more likely to be able to receive a signal.

9 a) They all travel at the speed of light, 3×10^8 ms^{-1}.

b)

Radio	Microwaves	***Infrared***	Visible	UV	***X-rays***	Gamma

c) $8 \cdot 5 \times 10^{-12}$ m

10 a) 0·02 s

b) The sprint is won by just 0·01 s. However, the athlete in lane 8 actually ran faster than the winner, but started running 0·02 s after the winner, and was not first to cross the finish line. This problem could be solved by attaching a loudspeaker to each athlete's starting block and starting the race with an electronic signal.

11 a) Gamma rays

b) 2×10^{-15} J

c) X-rays can be used in medicine to see if someone has a broken bone without cutting them open. Too much exposure to X-rays can kill/damage cells therefore it is necessary to limit the exposure of patients and technicians.

or

Can be used to check luggage at airport security. Care must be taken to minimise exposure to workers and passengers.

12 a) When a wave travels into an object with a different density:

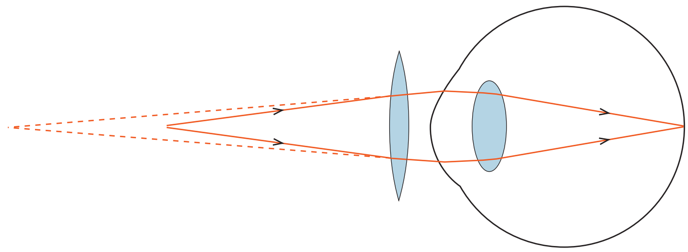
Its wavelength will change

Its speed will change

Its direction will usually change.

b) The speed and wavelength will decrease. If the angle of incidence is not 90° (measured to the normal) the wave will change its direction *towards the normal*.

c)



AREA 6: Nuclear radiation

ANSWERS TO EXAM-STYLE QUESTIONS

1 a) Medicine – sterilisation, tracing, treating cancers etc.

Generating electricity through nuclear fission.

b) Radiation that is naturally always around us.

c) Radon gas from granite, food, medicine, nuclear testing, cosmic rays etc.

2 a) 1280 kBq

b) 40 Bq

3 a) Gamma radiation, because this is easily detected outside the body since its penetrating power is greater than alpha or beta particles.

b) A suitable half-life would be about 6 hours since this would provide enough time to carry out any measurements and the isotope would be virtually untraceable after a couple of days, i.e. the recipient would not be subject to high doses of radiation for too long a period of time.

4 Measure the activity of the source with:

no shielding

sheet of paper

2cm of aluminium

If no change when paper is introduced you have alpha particles and perhaps beta and gamma.

If activity drops when paper is introduced but not to 0 you have beta and gamma.

If no change when aluminium is introduced you have gamma.

5 a) They would need to measure background radiation, and activity of plant, then deduct the background reading from the measured activity.

b) They must protect themselves from exposure by: limiting time of exposure, wearing protective clothing such as lead aprons and keeping as much distance as possible.

6 a) 15 decays per second

b) 0·1 Sv

7 a) The length of time it takes for the activity of a radioactive source to drop to half its initial value.

b) Measure the background radiation. Measure the activity of the source and correct for the background radiation. Measure the activity some time later and again correct for background radiation. Repeat until there are enough results to plot a graph. The half-life can be calculated from this graph.

c) 12 hours

8 Nuclear fusion releases large amounts of energy which is used to boil water and generate electricity through the use of turbines.

Advantages: no carbon emissions, relatively low cost, one power station can generate huge amounts of electricity.

Disadvantages: Risk of harm to environment if radioactive material is not carefully contained, radioactive sources have a very long half-life so will need to be contained for many generations, nuclear power stations have a limited lifetime and are extremely expensive to decommission.