Answers to SAQs

Chapter 1

1 $\dfrac{1600}{174.29} = 9.18\,\text{m s}^{-1}$

2 **a** mm s^{-1}
b mph
c km s^{-1}
d m s^{-1}
e km h^{-1}

3 $2.0\,\text{mm s}^{-1}$

4 $0.125\,\text{m s}^{-1} \approx 0.13\,\text{m s}^{-1}$

5 **a** Constant speed.
b Increasing speed (accelerating).

6 For example, attach a card to a weight and drop it through a light gate. Alternatively, attach ticker-tape to the falling mass.

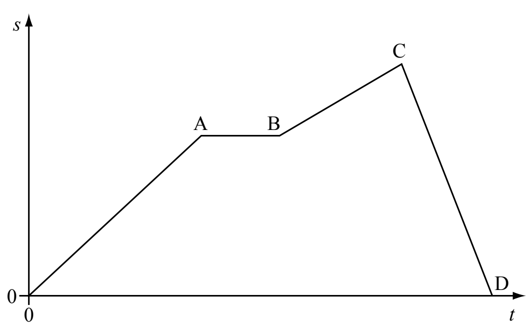
7 **a** Displacement.
b Speed.
c Velocity.
d Distance.

8 300 m

9 The Earth's speed is $29.9\,\text{km s}^{-1} \approx 30\,\text{km s}^{-1}$. As the Earth orbits the Sun, its direction of motion keeps changing. Hence its velocity keeps changing. In the course of one year, its displacement is zero so its average velocity is zero.

10 Sloping sections: bus moving; horizontal sections: bus stationary (e.g. at bus stops).

11



OA: constant speed; AB: stationary;
BC: reduced constant speed;
CD: running back to gate.

12 **a** $85\,\text{m s}^{-1}$
b Graph is a straight line through the origin, with gradient = $85\,\text{m s}^{-1}$.

13 **a** Graph is a straight line for the first 3 h; then less steep for the last hour.
b $23\,\text{km h}^{-1}$
c $21\,\text{km h}^{-1}$

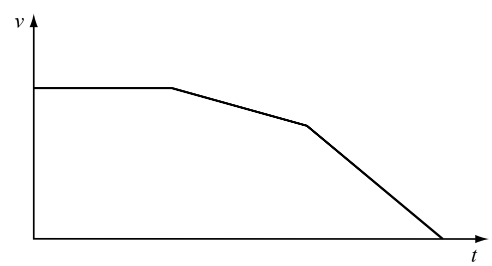
Chapter 2

1 $3.0\,\text{m s}^{-2}$

2 $a = -0.60\,\text{m s}^{-2}$
The magnitude of the deceleration is $0.60\,\text{m s}^{-2}$.

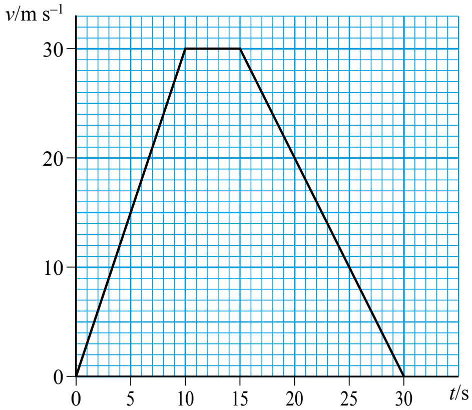
3 **a** $9.8\,\text{m s}^{-1}$
b $29.4\,\text{m s}^{-1} \approx 29\,\text{m s}^{-1}$

4



5 **a** Graph line at centre.
b Near centre.
c Constant distance from centre.
d Getting closer to centre.

6 **a** See figure.
b, c $3.0\,\text{m s}^{-2}$
d $-1.0\,\text{m s}^{-2}$
e From area under graph: 525 m



7 $u = 0.25$ m s^{-1}; $v = 1.0$ m s^{-1};
$\Delta t = 0.30$ s; $a = 2.5$ m s^{-2}

8 Dots evenly spaced, then getting steadily closer together.

9 $u = 1.0$ m s^{-1}; $v = 1.6$ m s^{-1};
$\Delta t = 0.10$ s; $a = 6.0$ m s^{-2}

10 a 20 m s^{-1}
b 100 m
c 12 s

11 a 0.16 m s^{-2}
b 12 m s^{-1}
c 1200 m

12 10 m s^{-1}

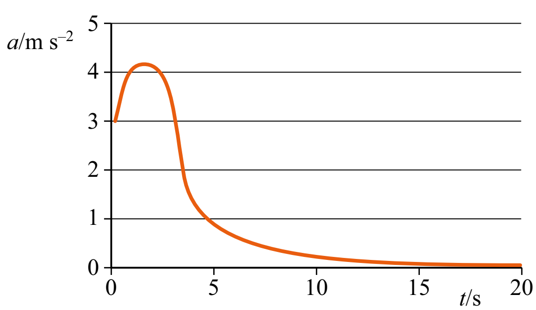
13 64.3 m ≈ 64 m

14 Speed 25.5 m s^{-1}; only just over the speed limit.

15 a $t = 7.5$ s; $v = 220$ m s^{-1}
b Approximately 20 m s^{-2}

16 a The car is slowing down with constant (uniform) deceleration.
b 20 m s^{-1}; 8 m s^{-1}
c –0.40 m s^{-2}
d 420 m
e 420 m

17 a Change in displacement in each second.
b 10.2 m s^{-1}
c 4.1 m s^{-2}; 0.1 m s^{-2}
d Sketch graph – there is no need for a detailed graph.



e The area under the velocity against time graph is distance.
distance = area under graph = 200 m
(the length of the race)

18 100 m

19 The train comes to a halt at the end of the 100 s; distance travelled = 2500 m.

20 a 800 m
b 1.25 m s^{-2} ≈ 1.3 m s^{-2}; 750 m
c 5.0 s
d 1000 m

Chapter 3

1 1600 N

2 40 m s^{-2}

3 10 m s^{-1}

4 Apples vary in mass; gravity varies from place to place.

5 Estimated masses are shown in brackets:
a (1.0 kg) 10 N
b (1.0 kg) 10 N
c (60 kg) 600 N
d (0.025 kg) 0.25 N
e 400 000 N

6 a See table.
b Graph is a parabola through the origin.
c 30.6 m ≈ 31 m
d 2.86 s ≈ 2.9 s (Check using $s = ut + \frac{1}{2}at^2$.)

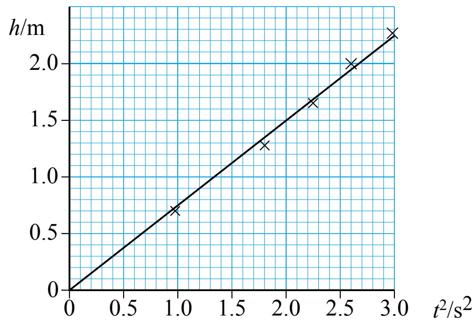
Time t/s	0	1.0	2.0	3.0	4.0
Displacement s/m	0	4.9	19.6	44.1	78.4

7 a 0.40 s
b 3.9 m s^{-1}

8 a 9.36 m s^{-2} ≈ 9.4 m s^{-2}
b Air resistance; delay in release of ball.

9 a See table and figure.
b 1.6 m s^{-2} (approx.)
c This object is not falling on the Earth; perhaps on the Moon.

Height h/m	0.70	1.03	1.25	1.60	1.99
Time t/s	0.99	1.13	1.28	1.42	1.60
Time^2 t^2/s^2	0.98	1.28	1.64	2.02	2.56



10 Drop an object towards the sensor, but take care not to break it. A better method is to use a sloping ramp with a trolley; gradually increase the angle of slope. Deduce value of acceleration when ramp is vertical.

11 The greater the mass of the car, the greater the force needed to slow it down with a given deceleration. For large cars, it is less demanding on the driver if the engine supplies some of the force.

12 Inertia: the driver continues forward although the car stops. A seat belt provides the force needed to overcome this inertia.

13 The large one; its weight is greater, so it reaches a greater speed before air resistance is sufficient to equal its weight.

14 a Lubricate skis.

b Wear tight-fitting, smooth clothing to reduce air resistance.

c Develop powerful muscles to provide a large forward force.

d The steeper the slope, the better.

15 a The lighter one; lower terminal velocity.

b Turn head-first, and pull in arms and legs to produce streamlined shape.

Chapter 4

1 a 7.0 km

b, c 5.0 km; 53° E of N (or 37° N of E)

2 $2.154\,\mathrm{m\,s^{-1}} \approx 2.2\,\mathrm{m\,s^{-1}}$ at 68° to the river bank

3 a See figure.

b 1000 N upwards

c She will accelerate upwards (i.e. decelerate).

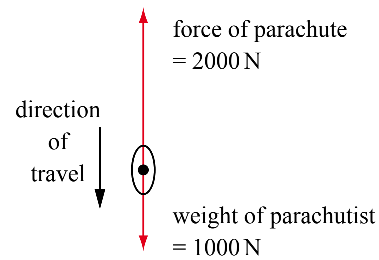
4 a Yes, constant velocity (not accelerating).

b 1000 kN

c 50 kN

5 a 2.5 N at 37° to vertical

b No.



6 a $F_x = 17.3\,\mathrm{N} \approx 17\,\mathrm{N}$; $F_y = 10\,\mathrm{N}$

b $v_x = 1.7\,\mathrm{m\,s^{-1}}$; $v_y = -4.7\,\mathrm{m\,s^{-1}}$

c $a_x = -5.2\,\mathrm{m\,s^{-2}}$; $a_y = -3.0\,\mathrm{m\,s^{-2}}$

d $F_x = 77.3\,\mathrm{N} \approx 77\,\mathrm{N}$; $F_y = 20.7\,\mathrm{N} \approx 21\,\mathrm{N}$

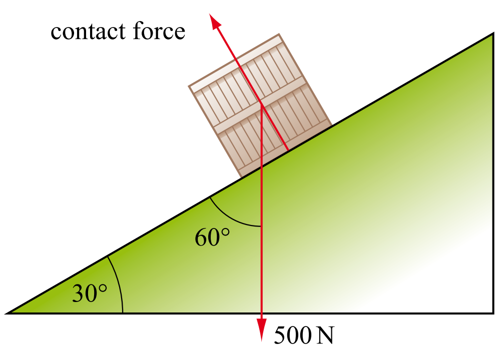
7 With rope horizontal, the force pulling the box is F. With the rope at an angle θ to the horizontal, the horizontal component (= $F\cos\theta$) is less, since $\cos\theta$ is less than 1.

8 a See figure.

b 250 N

c It's at 90°.

d Friction; up the slope.



9 a $4.1\,\mathrm{m\,s^{-2}}$

b $2.1\,\mathrm{m\,s^{-2}}$

10 5 s (i.e. 1 s more)

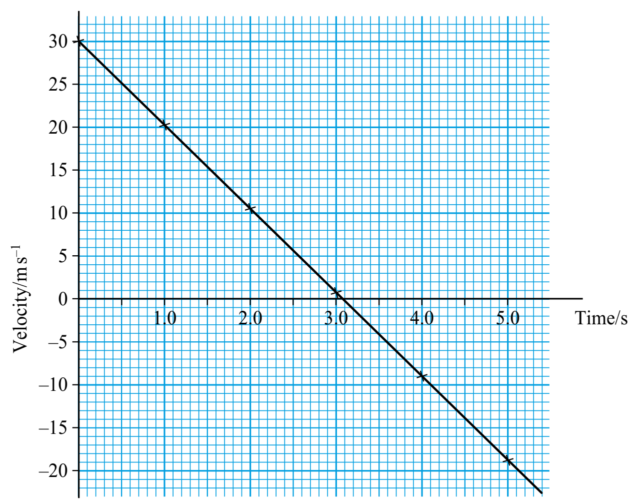
In solving the quadratic equation, you will have found a second solution, $t = -1$ s. Obviously, the stone could not take a negative time to reach the foot of the cliff. However, this solution does have a meaning: it tells us that, if the stone had been thrown upwards from the foot of the cliff at the correct speed, it would have been travelling upwards at 20 m s^{-1} as it passed the top of the cliff at $t = 0$ s.

11 **a** See table.

b See figure.

c, d 3.1 s

Velocity/m s^{-1}	30	20.19	10.38	0.57	–9.24	–19.05
Time/s	0	1.0	2.0	3.0	4.0	5.0



12 163 m ≈ 160 m

Chapter 5

1 **a** Upthrust.

b Friction.

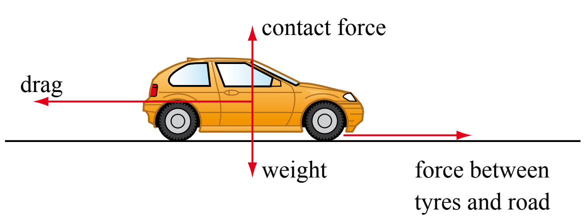
c Weight.

d Contact force (normal reaction).

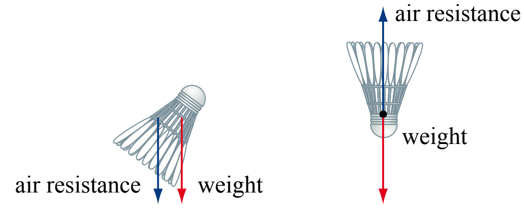
e Tension.

f Drag.

2



3 **a** Going up **b** Going down



4 **a** 67 N

b 160 N

5 **a** 173 g.

b By this method, weighing could be carried out with a limited selection of relatively small masses.

6 **a, b** F_1, 0 N m; F_2, 2.5 N m clockwise; F_3, 2.5 N m clockwise; F_4, 5 N m anticlockwise.

c Yes, the moments are balanced.

7 28.3 N ≈ 28 N

8 9.83 N ≈ 9.8 N

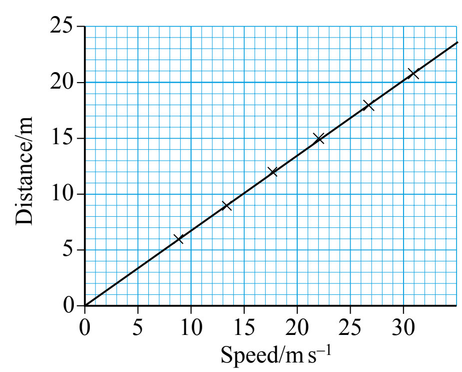
9 381 N ≈ 380 N

10 20 kPa

11 Taking weight = 600 N, area of feet = 500 cm^2 = 0.05 m^2, pressure = 12 kPa.

Chapter 6

1 Thinking time = 0.67 s.

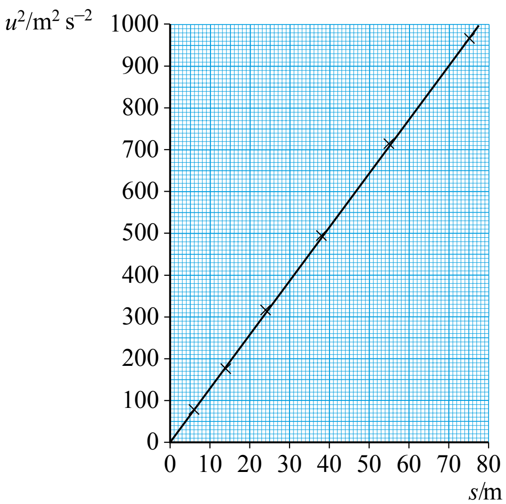


2 **a** See table.

b See figure.

c $-6.4\,\text{m}\,\text{s}^{-2}$

Speed/m s^{-1}	Speed^2/m^2 s^{-2}	Braking distance/m
8.9	79	6
13.3	177	14
17.8	317	24
22.2	493	38
26.7	713	55
31.1	967	75



3 Thinking distance = 18 m

Braking distance = 150 m

Therefore stopping distance = 18 + 150 = 168 m; the car will not stop before the incident.

4 The driver in front may have faster reactions (so that their thinking distance is less); they may also have better brakes, allowing them to stop in a shorter distance. If the driver behind cannot stop in the same distance or less, there will be a collision.

5 A wide belt gives reduced pressure (for a given force) and so is less likely to damage the wearer.

6 4.47×10^{-8}%

Chapter 7

1 **a** Yes, work done against friction.

b Yes, gravity does work in making you go faster.

c No, because the conker remains at constant distance from the centre of the circle.

d No, because the force does not move.

2 1700 J

3 **a** 2500 J

b 2500 J (ignoring work done against air resistance)

4 20 kJ

5 Work done by force up slope = 50 J; work done by contact force = 0 J; work done by force down slope = –15 J; work done by gravity = 35 J.

6 1274 J ≈ 1300 J

7 5400 kJ or 5.4 MJ

8 The motorcycle has more KE.

9 10 J

10 The result is unchanged for any value of mass.

11 7.1×10^9 J. This energy becomes increased energy of the air – its temperature rises.

12 $14\,\text{m}\,\text{s}^{-1}$

13 **a** 0.92 (92%)

b Heat (because work is done against air resistance).

14 3.0×10^6 J (or 3.0 MJ)

15 70 kW

16 **a** 28 000 J (28 kJ) **b** 28 kW

17 560 W

Chapter 8

1 **a** D

b A

c C

2 Metals from most stiff to least stiff:

	Metal	*Young modulus*/GPa
Most stiff	steel	210
	iron (wrought)	200
	copper	130
	brass	90–110
	aluminium	70
	tin	50
Least stiff	lead	18

3 Stiffest non-metal is glass (Young modulus = 70–80 GPa).

4 A, 15 GPa; B, 5.0 GPa

5 1.0×10^8 Pa, 5.0×10^{-4} (0.05%), 2.0×10^{11} Pa

6 9.79×10^{-5} m $\approx 9.8 \times 10^{-5}$ m

7 Stress = 8.0×10^6 Pa; strain = 1.25×10^{-3} (at most); Young modulus = 6.4×10^9 Pa (but could be more, because extension may be less than 1 mm).

8 **a** Small loads, iron bath is elastic. Large loads, the cast iron is brittle and breaks.
b At high pressure (load) the aluminium undergoes plastic deformation: it is ductile.
c Small loads and slowly, plastic deformation. Large loads and rapidly, brittle.

9 **a** 50 GPa, 150 MPa
b 100 GPa, 125 MPa
c 25 GPa, 100 MPa

10 1.08 J ≈ 1.1 J
The rubber band is assumed to obey Hooke's law; hence the answer is an estimate.

11 9.6×10^3 J

12 **a** A has greater stiffness (less extension per unit force).
b A requires greater force to break (line continues to higher force value).
c B requires greater amount of work done to break (larger area under graph).

Chapter 9

1 Towards the right – look at the movement of the positive ions.

2 **a** Current to left.
b Current towards A, away from B (clockwise).
c Positive terminal of cell at B.

3 6.0 C

4 5.0 A

5 2.5 A

6 **a** 0.25 h (or 15 minutes)
b 1.8×10^5 C

7 6.25×10^{18} protons

8 4.5 A

9 1.5 A, towards P

10 1.89 A ≈ 1.9 A

11 4.68×10^{-4} m s^{-1} $\approx 4.7 \times 10^{-4}$ m s^{-1}

12 The electrons will speed up because there are fewer of them in the silver wire than in the copper. (Their mean drift velocity will increase in the inverse ratio of the number densities, i.e. by a factor of 8.5/5.9.)

Chapter 10

1 0.33 A

2 60 watt

3 **a** 50 V
b 100 V

4 575 Ω

5 **a** See figure.
b All except point at 7.9 V – ignore this one.
c 48 Ω
d Yes.

6 At 2.0 V, R = 200 Ω; at 8.0 V, R = 133 Ω ≈ 130 Ω; it does not obey Ohm's law.

7 **a** θ_1: 12.5 Ω, θ_2: 10 Ω
b θ_1

8 **a** A = lamp, B = steel wire
b 8.0 V
c 2.35 Ω ≈ 2.4 Ω

9 **a** **i** 3.1 kΩ
ii 1.5 kΩ
b **i** 5 °C
ii 36 °C
c **i** about −0.09 kΩ °C^{-1}
ii about −0.04 kΩ °C^{-1}
iii about −0.01 kΩ °C^{-1} (almost zero)

10 Total resistance in circuit decreases; current increases; lamp becomes brighter.

11 Advantage of a thermistor: its resistance changes by a large amount over a small temperature range, and this is easy to detect. Advantage of a metal: its resistance changes over a wide temperature range; a thermistor is only useful within a narrow range of temperatures.

12 **a** 0.45 m
b 2.2 m
c 4.5 m

13 $0.106\,\Omega \approx 0.11\,\Omega$

14 **a** $2.5\,\Omega$
b $2.0\,\Omega$

15 $40\,\Omega$

Chapter 11

1 **a** 6.0 J
b 5.0×10^3 J (5.0 kJ)

2 **a** 120 C
b 1440 J
c 1440 J

3 In 1 s, 3.0 C flows round circuit. 18 J of energy is transferred to charge in 1 s; 18 J of energy is transferred by charge to resistor.

4 0.26 A

5 1.0×10^9 W (1000 MW or 1 GW)

6 **a** $43.48\,\text{A} \approx 43\,\text{A}$
b 50 A (for example)

7 4.5×10^{-4} W

8 **a** 0.65 A
b $353\,\Omega \approx 350\,\Omega$

9 $541\,\Omega \approx 540\,\Omega$

10 2.16 MJ

11 **a** 200 C
b $2.0\,\text{J}\,\text{C}^{-1}$
c 2.0 V

12 100 kW h

Chapter 12

1 $20\,\Omega$

2 0.80 V

3 **a** All five cells connected in series.
b Three facing one way, two the other.
c Four facing one way, one the other.

4 $2.5\,\Omega$

5 **a** $300\,\Omega$
b $66.7\,\Omega \approx 67\,\Omega$
c $120\,\Omega$

6 **a** 0.024 A (= 24 mA)
b 0.008 A (= 8.0 mA)
c 0.036 A (= 36 mA)

7 Total resistances possible are (in Ω): 40, 50, 67, 75, 100 (two ways), 167, 200, 250, 300 and 400.

8 $10\,\Omega$

9 0.50 A

10 0.95 A

11 $20\,\Omega$

12 Two in series, connected in series with two in parallel.

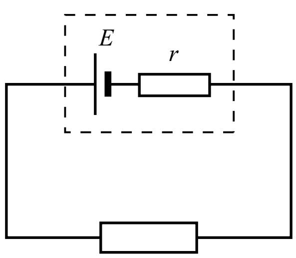
13 **A**, **B** and **E**: 6.0 A; **C**: 1.0 A; **D**: 5.0 A

14 **a** 0.10 A
b 0.095 A

Chapter 13

1 Current = 0.5 A

$E = 5.0$ V, $r = 2.0\,\Omega$



2 **a** 0.125 A, 0.5 V, 2.5 V
b 0.33 A, 1.33 V, 1.67 V

3 2.5 A

4 0.71 Ω

5 1.5 V, 0.5 Ω (approx.)

6 a 8.0 V
b 4.0 Ω
c 16 W

7 0 V to 8.0 V

8 20 °C: 9.5 V; 60 °C: 0.91 V

9 Resistance of LDR decreases so V_{out} decreases.

10 Full sunlight: 6 V; darkness: 11.996 V ≈ 12 V

11 Show the usual potential divider circuit with resistor and thermistor connected in series to a battery. The voltmeter must be placed across the resistor to give the desired output.

Chapter 14

1 $\Sigma I_{in} = \Sigma I_{out} = 6.5$ A;
Kirchhoff's first law is satisfied.

2 $I_x = -2.0$ A (i.e. 2.0 A towards P)

3 8.0 V; 80 Ω

4 a The loop containing the 5.0 V cell at the top, the 10 Ω resistor with current I, and the central 5.0 V cell (because the only current involved is I).
b 1.0 A

5 18 Ω

6 In series, the 1 C charge passes through both batteries and gains or loses 6 J in each. If they are connected back-to-front, it gains energy in one cell but loses it in the next. In parallel, half the charge flows through each cell, so total energy gained is 6 J.

7 A_1: 0.50 A, A_2: 0.25 A, A_3: 0.25 A

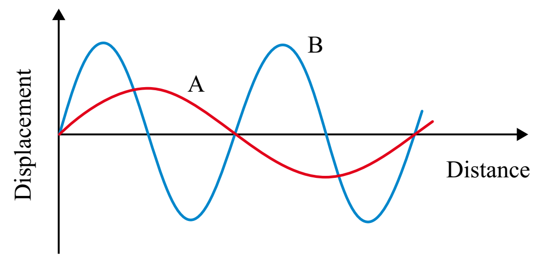
8 a 0.25 A
b 20 Ω, 0.25 A

9 0.033 A to the right

Chapter 15

1 a 15 cm, 4.0 cm
b 20 cm, 2.0 cm

2



3 a 7.96 W m^{-2} ≈ 8.0 W m^{-2}
b 1.99 W m^{-2} ≈ 2.0 W m^{-2}

4 a 1600 W m^{-2}
b 2.5 cm

5 20 240 Hz ≈ 20 kHz

6 89.6 m s^{-1} ≈ 90 m s^{-1}

7 a 5.0 cm
b 30 Hz
c 1.5 m s^{-1}

8

Station	Wavelength λ/m	Frequency f/MHz
Radio A (FM)	3.07	
Radio B (FM)	3.17	
Radio B (LW)		0.198
Radio C (MW)		0.433

9 a 1.7 : 1
b 2.3 : 1

Chapter 16

1 a 4.3 × 10^{14} Hz
b 4.3 × 10^{14} Hz; 470 nm

2

Radiation	Wavelength range/m	Frequency/Hz
radio waves	>10^{6} to 10^{-1}	300 to 3 × 10^{9}
microwaves	10^{-1} to 10^{-3}	3 × 10^{9} to 3 × 10^{11}
infrared	10^{-3} to 7 × 10^{-7}	3 × 10^{11} to 4.3 × 10^{14}
visible	7 × 10^{-7} (red) to 4 × 10^{-7} (ultraviolet)	4.3 × 10^{14} to 7.5 × 10^{14}
ultraviolet	4 × 10^{-7} to 10^{-8}	7.5 × 10^{14} to 3 × 10^{16}
X-rays	10^{-8} to 10^{-13}	3 × 10^{16} to 3 × 10^{21}
γ-rays	10^{-10} to 10^{-16}	3 × 10^{18} to 3 × 10^{24}

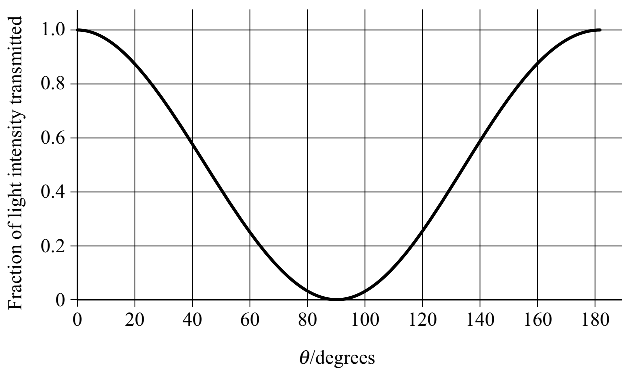
3 **a** Visible.
b Ultraviolet.
c 1–100 mm
d 400–700 nm
e 4.3×10^{14} Hz to 7.5×10^{14} Hz

4 **a** Radio waves, **b** microwaves, **c** infrared, **d** visible light, **e** ultraviolet, **f** X-rays or γ-rays.

5 **a** Radio waves, **b** radio waves, **c** visible light, **d** X-rays or γ-rays.

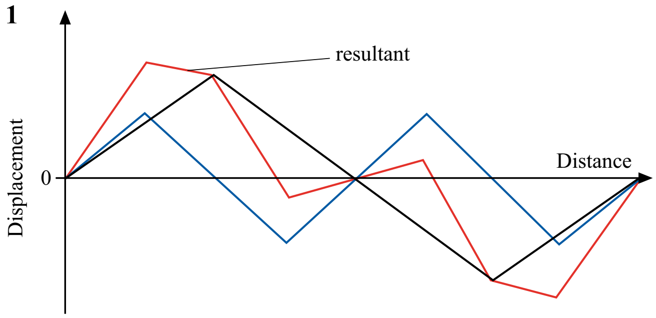
6 100 W m^{-2}; polarised at 45° to the vertical.

7



Chapter 17

1

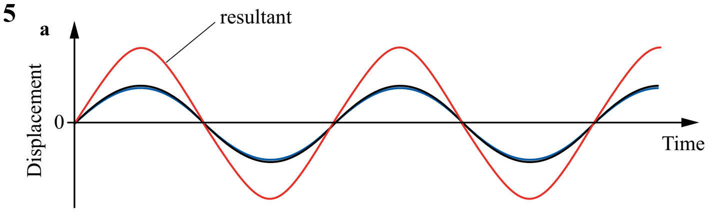


2 The grid spacing is much smaller than the wavelength of the microwaves, so the waves do not pass through. However, the wavelength of light is much smaller, so it can pass through unaffected.

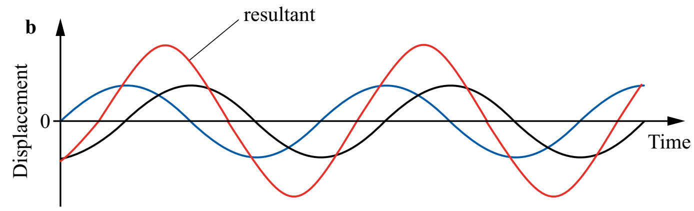
3 Two loudspeakers with slightly different frequencies might start off in step, but they would soon go out of step. The interference at a particular point might be constructive at first, but would become destructive.

4 The intensity would increase.

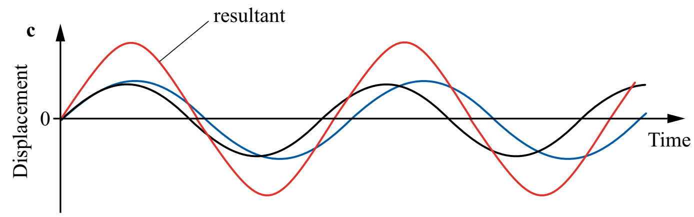
5 **a**



b



c



6 D: dark fringe, because rays from slits 1 and 2 differ in path length by one-and-a-half wavelengths ($1\frac{1}{2}\lambda$).
E: bright fringe, because the path difference is 2λ.

7 3.0 mm

8 **a** $x = \frac{\lambda D}{a}$. Therefore $x \propto \frac{1}{a}$, so decreasing a gives increased x.
b Blue light has shorter wavelength, so x is less ($x \propto \lambda$).
c For larger D, x is greater, so there is greater precision in x ($x \propto D$).

9 3.5 mm

10 D and a are fixed. So:

$$\frac{\lambda 1}{x_1} = \frac{\lambda 2}{x_2}$$

and so:

$$x_2 = \frac{4.5 \times 10^{-7} \times 2.4 \times 10^{-3}}{6.0 \times 10^{-7}}$$
$$= 1.8 \times 10^{-3}\ \text{m} = 1.8\ \text{mm}$$

(Or, wavelength is $\frac{3}{4}$ of previous value, so spacing of fringes is $\frac{3}{4}$ of previous value.)

11 For the second-order maximum, rays from adjacent slits have a path difference of 2λ, so they are in phase.

12 a 20.4°

b Maxima at 31.5°, 44.2°, 60.6°. You cannot have $\sin\theta > 1$. There are 11 maxima.

13 a θ increases, so the maxima are more spread out and there may be fewer of them. (Note: $\sin\theta \propto \lambda$)

b d decreases, so again θ increases. (Note: $\sin\theta \propto \frac{1}{d}$)

14 a *Calculation* gives a total width of 8.7 mm, but with a ruler the student will *measure* 9 mm.

b *Calculation* gives an angle of 19.12°, but the student will *measure* 19.1°.

c For the double-slit experiment, a measured width of 9 mm for 10 fringes will give an answer for the wavelength of 562 nm. For the diffraction grating experiment, the measured second-order angle of 19.1° will give an answer of 545 nm. Hence the diffraction grating method is more accurate. In practice, it is also much more precise because the fringes are bright and sharp (well-defined).

15 a $\theta_{red} = 20.5°$; $\theta_{violet} = 11.5°$; angular separation = 9.0°.

b The third-order maximum for violet light is deflected through a smaller angle than the second-order maximum for red light.

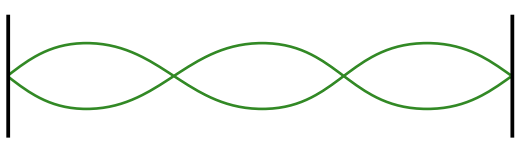
Chapter 18

1 a 50 cm

b 12.5 cm

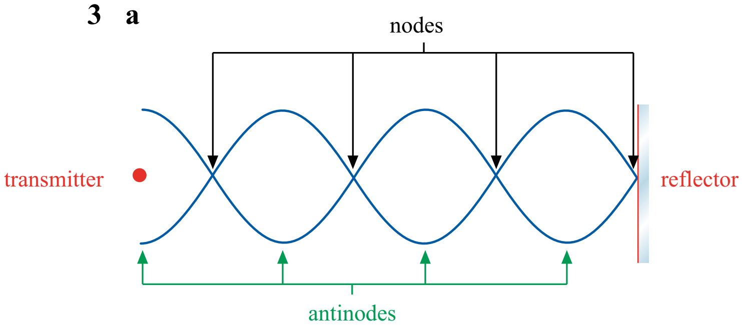
2 a 60 cm; 30 cm

b



c 40 cm

3 a



b 28 mm, 1.07×10^{10} Hz ≈ 11 GHz

4 In both cases, waves are reflected (by the metal sheet or by the water). The outgoing and reflected waves combine to produce a stationary wave pattern.

5 a Much easier to detect where sound falls to zero than where sound is a maximum.

b Increased accuracy – if the wavelength is short it is difficult to measure just one wavelength.

6 a 13.3 cm ≈ 13 cm

b 330 m s^{-1}

7 a 52.4 cm ≈ 52 cm

b 0.50 cm

c 330 m s^{-1}

Chapter 19

1 6.63×10^{-8} J ≈ 6.6×10^{-8} J

2 2.8×10^{-19} J, 5.0×10^{-19} J

3 a γ-ray.

b X-ray.

c Ultraviolet.

d Infrared.

e Radio wave.

4 3.26×10^{15} s^{-1} ≈ 3.3×10^{15} s^{-1}

5 1.2 eV, 1.92×10^{-19} J ≈ 1.9×10^{-19} J

6 12 400 eV ≈ 12 keV

7 Ultraviolet (wavelength ≈ 1.24×10^{-7} m).

8 a 2.4×10^{-16} J

b 5.31×10^5 m s^{-1} ≈ 5.3×10^5 m s^{-1}

9 ~ 6.5×10^{-34} J s

10 a 2.0 eV, 3.0 eV

b 0.2 eV and 1.2 eV; 3.2×10^{-20} J and 1.9×10^{-19} J

11 a Gold.

b Caesium.

c 1.04×10^{15} Hz

d 620 nm

12 a 8.3×10^{-19} J

b 5.5×10^{-19} J

c 1.1×10^6 m s^{-1}

13 5.9×10^{-20} J

14 a Electrons can behave as waves so they can be diffracted by spaces between atoms.

b Each metal has a different lattice structure, so each will produce a different diffraction pattern.

15 a 1.0 keV

b 1.9×10^{7} m s^{-1}; 1.7×10^{-23} kg m s^{-1}

c 3.9×10^{-11} m

d The wavelength is much smaller than the spacing, so there will only be a small amount of diffraction.

Chapter 20

1 a 5.6×10^{-18} J, 8.4×10^{15} Hz, 3.6×10^{-8} m (emission)

b 5.0×10^{-19} J, 7.5×10^{14} Hz, 4.0×10^{-7} m (emission)

c 2.2×10^{-18} J, 3.3×10^{15} Hz, 9.0×10^{-8} m (absorption)

2 9.0 eV, 11 eV, 25 eV, 34 eV and 45 eV correspond to differences between energy levels, so they can all be absorbed. 6.0 eV and 20 eV do not correspond to differences between energy levels and so cannot be absorbed.

3 a 15.0 eV, 24.9 eV, 49.7 eV

b See figure for one possible solution.