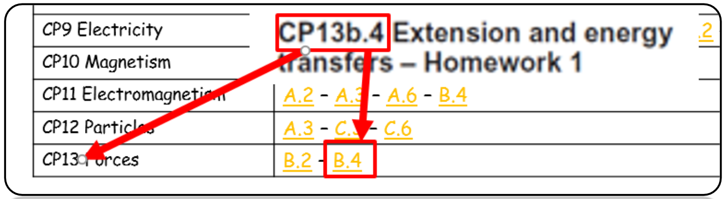


Equations and Math Skills Booklets

Answers

Unit Title	Code
CP1 Motion	B.6 - C.3 - D.6
CP2 Forces	A.5 - C.4 - C.7 - D.7 - F.3 - F.4 - G.5 - H.4
CP3 Conservation of Energy	A.2 - B.3 - B.6 - D.3 - F.2
CP4 Waves	B.2 - B.5
CP5 EM Spectrum	B.5 - C.2
CP6 Radioactivity	B.2 - B.4 - F.2 - F.5 - G.2
CP7 Energy	A.2 - A.3
CP8 Forces	B.3
CP9 Electricity	B.4 - B.5 - C.6 - D.5 - D.6 - E.5 - F.3 - F.6 - G.2 - G.5 - G.6
CP10 Magnetism	C.3
CP11 Electromagnetism	A.2 - A.3 - A.6 - B.4
CP12 Particles	A.3 - C.3 - C.6
CP13 Forces	B.2 - B.4

CP1 Motion and CP2 Forces

CP1b.6 Equation practice

1 speed = 100 m / 25 s = 4 m/s

2 distance = 3 m/s × 120 s = 360 m

3 a distance = 1.5 m/s × 300 s = 450 m

b distance = 5 m/s × 300 s = 1500 m

4 a speed = 100 m / 12 s = 8.33 m/s

b distance = 8 m/s × 25 s = 200 m

c time = 400 m / 8 m/s = 50 s

d speed = 800 m / 125 s = 6.4 m/s

e speed = 1000 m / 160 s = 6.25 m/s

f time = 2000 m / 6.25 m/s = 320 s

g distance = 6 m/s × 500 s = 3000 m

5 10 km = 10 000 m, $\frac{1}{2}$ hour = 30 minutes = 30 × 60 = 1800 seconds

speed = 10 000 m / 1800 s = 5.56 m/s

or 10 km / 1800 s = 0.00556 km/s = 55.6 m/s

6 20 km = 20 000 m

time = 20 000 m / 4 m/s = 5000 s

7 a A speed = 2000 m / 400 s = 5 m/s

B speed = (2400 m – 2000 m) / (600 s – 400 s) = 400 m / 200 s = 2 m/s

C speed = 0 m / 50 s = 0 m/s (or accept 0 m/s because line is horizontal)

D speed = (2700 m – 2400 m) / (800 s – 650 s) = 300 m / 150 s = 2 m/s

E speed = (3000 m – 2700 m) / (850 s – 800 s) = 300 m / 50 s = 6 m/s

b average speed = 3000 m / 850 s = 3.53 m/s

8 12 km = 12 000 m, 4 hours = 4 × 60 × 60 = 14 400 s

speed = 12 000 m / 14 400 s = 0.83 m/s

CP1c.3 Acceleration – Extend

1 a $t = (v - u) / a$

b 35 m/s

c 0 m/s

d −35 m/s

e The change in velocity is in the opposite direction to the velocity itself, which means the train has slowed down.

f t = −35 m/s / −0.5 m/s^2 = 70 s

2 a $v^2 = 0$, $u^2 = 1225$

b x = (1225 – 0) / (2 × −0.5) = 1225 m

3 a a = (28 m/s – 0 m/s) / 5 s = 5.6 m/s^2

b t = (0 m/s – 28 m/s) / −5 m/s^2 = 5.6 s

4 a Acceleration due to gravity is downwards, which is in the opposite direction to the movement of the ball.

b change in velocity = $a \times t$ = −9.8 m/s^2 × 2 s = −19.6 m/s

final velocity after 2 s = 20 m/s – 19.6 m/s = 0.4 m/s

c change in velocity after 4 s = −9.8 m/s^2 × 4 s = −39.2 m/s

final velocity after 4 s = 20 m/s – 39.2 m/s = −19.2 m/s

d The ball is moving in the opposite direction to its original motion (i.e. it is moving downwards).

5 a change in velocity = $a \times t$ = 200 000 m/s × 0.001 s = 200 m/s

This is also the muzzle velocity, as initial velocity was zero.

b time = change in velocity / acceleration = −200 m/s / −9.8 m/s^2 = 20.4 s

c change in velocity = -200 m/s – (–200 m/s) = –400 m/s

time = −400 m/s / −9.8 m/s^2 = 40.8 s

d distance = (200 m/s × 200 m/s – 0 m/s × 0 m/s) / (2 × 200 000 m/s^2) = 0.1 m or 10 cm

CP1d.6 Velocity/time graphs Homework 2

1 A, 4 m/s^2; B, 0 m/s^2; C, 1 m/s^2; D, −5 m/s^2

2 distance = 0.5 × 3 s × 12 m/s + 2 s × 12 m/s = 18 m + 24 m = 42 m

3 velocities for each section: A = 200 m / 50 s = 4 m/s; B = 150 m / 30 s = 5 m/s; C = 0 m/s; D = 80 m / 40 s = 2 m/s

Velocity–time graph for the following:

Time (s)	Velocity (m/s)
0–50	4
50–80	5
80–90	0
90–130	2

4 a velocity/time graph (straight line sloping down from maximum velocity 30 m/s)

b at 3 seconds

c −10 m/s^2

d This is the distance travelled from 0 to 3 s: distance = 0.5 × 3 s × 30 m/s = 45 m

e distance = 90 m

f Zero, as returned to its starting point.

3 a Sketch of boat showing up arrow labelled 'upthrust' and a slightly longer down arrow labelled 'weight'. Resultant is 50 N downwards, forces are unbalanced.

b Sketch of ball in hand, with up arrow labelled 'force from hand' and down arrow labelled 'weight' and approximately 0.2 times the length of the upwards arrow. Resultant force = 3 N upwards, forces are unbalanced.

c Sketch of ball with only 'weight' arrow. Resultant force = 2 N downwards, forces are unbalanced.

d Sketch of person with arrow pointing towards them labelled 'force from wind' and same sized arrow pointing from them labelled 'force from person leaning into the wind'. Resultant force = 0 (as forces are balanced).

e Sketch of boat with up arrow labelled 'upthrust', down arrow of same size labelled 'weight', resultant force in vertical direction = 0, vertical forces are balanced. Forwards arrow labelled 'force from sails', rearwards arrow labelled 'drag' and approximately 0.75 times the length of the forwards arrow. Resultant force = 50 N forwards, forces are unbalanced.

f Sketch of ball with downwards arrow labelled 'weight' and horizontal arrow approximately 4 times the length labelled 'air resistance'. Resultant force in the vertical direction = 40 N, vertical forces are unbalanced. Resultant force in the horizontal direction = 200 N, horizontal forces are unbalanced.

CP2c.4 Mass and weight – Extend

1 Mass is the amount of matter in an object, measured in kilograms. Weight is the pull of gravity on an object, measured in newtons. The weight of an object depends on its mass but also on the gravitational field strength. The gravitational field strength on Earth is 10 N/kg.

The mass of an object can only be changed by adding matter to it or taking some away. The weight of an object can be changed by changing its mass, or taking it to a place with a different gravitational field strength, such as a different planet.

2 a Mass = weight / gravitational field strength = 280 N / 1.4 N/kg = 200 kg

b Weight on Earth = mass × g = 200 kg × 10 N/kg = 2000 N

3 Weight on Titan = 319 kg × 1.4 N/kg = 447 N

Weight on Earth = 319 kg × 10 N/kg = 3190 N

4 a A falling object increases speed until its weight is balanced by its air resistance. The weight of the probe on Titan is less than on Earth because the gravitational field strength on Titan is less than on Earth, so the speed at which the air resistance balances the weight will be less. The probe will fall more slowly on Titan than it would on Earth.

b If the atmosphere is denser, the air resistance will be greater for a given speed. This means that the air resistance needed to balance the weight on Titan will be reached at an even lower speed. So the answer that the probe will fall more slowly on Titan is still valid.

5 A smaller parachute would be needed on Titan than on Earth because the gravity is weaker and the atmosphere is denser.

A smaller parachute would be needed on Mars than on Earth if the weaker gravity were the only difference. However the thinner atmosphere would mean a large parachute would be needed. We cannot compare the size of parachute needed on Mars and Earth without knowing which of these effects is the greatest.

CP2c.7 Equation practice

1 a weight = 5 kg (10 N/kg = 50 N

b 1200 kg × 10 N/kg = 12 000 N

c 15 kg × 10 N/kg = 150 N

d 200 g = 0.2 kg, weight = 0.2 kg × 10 N/kg = 2 N

e 100 g = 0.1 kg, weight = 0.1 kg × 10 N/kg = 1 N

f 50 mg = 0.05 g = 0.00005 kg, weight = 0.00005 kg × 10 N/kg = 0.0005 N

2 a mass = 400 N / 10 N/kg = 40 kg

b 850 N / 10 N/kg = 85 kg

c 0.2 N / 10 N/kg = 0.02 kg

d 125 000 N / 10 N/kg = 12 500 kg

e 8 000 000 N / 10 N/kg = 800 000 kg

f 1.5×10^4 N / 10 N/kg = 1.5×10^3 kg

3 a mass = 2 N / 1.6 N/kg = 1.25 kg

b weight = 1.25 kg × 9.8 N/kg = 12.25 N

c weight = 1.25 kg × 3.7 N/kg = 4.625 N

d 3 g = 0.003 kg, weight = 0.003 kg × 1.6 N/kg = 0.0048 N

4 a mass of tool = 8 N / 3.7 N/kg = 2.16 kg, weight on Earth = 2.16 kg × 9.8 N/kg = 21.17 N

b weight on Mercury = 2.16 kg × 3.7 N/kg = 7.99 N (or 8 N). Accept answer of 8 N because the gravitational field strength on Mercury is the same as that on Mars.

c weight on Moon = 2.16 kg × 1.6 N/kg = 3.46 N

5 weight of 5 kg mass in London = 5 kg × 9.816 N/kg = 49.08 N

weight in Mexico City = 5 kg × 9.766 N/kg = 48.83 N

difference = 0.25 N

CP2d.7 Equation practice

1 a force = 1500 kg × 2 m/s^2 = 3000 N
  b 1500 kg × 1.5 m/s^2 = 2250 N
  c 1500 kg × 3 m/s^2 = 4500 N
  d 1500 kg × 4 m/s^2 = 6000 N

2 a force = 1000 kg × 3.0 m/s^2 = 3000 N
  b mass = 3750 N / 2.5 m/s^2 = 1500 kg
  c acceleration = 1500 N / 1000 kg = 1.5 m/s^2
  d mass = 2400 N / 1.2 m/s^2 = 2000 kg
  e acceleration = 1500 N / 3000 kg = 0.5 m/s^2

3 total mass = 45 kg + 80 kg = 125 kg
  force = 125 kg × 120 m/s^2 = 15 000 N

4 50 g = 0.05 kg, acceleration = 30 N / 0.05 kg = 600 m/s^2

5 1 mg = 0.001 g = 0.000001 kg, force = 0.000001 kg × 1200 m/s^2 = 0.0012 N

6 a force = 1200 kg × 5 m/s^2 = 6000 N
  b total mass = 1200 kg + 500 kg = 1700 kg, force = 1700 kg × 5 m/s^2 = 8500 N

7 15 tonnes = 15 000 kg
  a total mass = 3000 N / 0.1 m/s^2 = 30 000 kg, mass of load = 30 000 kg – 15 000 kg = 15 000 kg
  b total mass = 1750 N / 0.05 m/s^2 = 35 000 kg, load = 35 000 kg – 15 000 kg = 20 000 kg
  c total mass = 4000 N / 0.2 m/s^2 = 20 000 kg, load = 20 000 kg – 15 000 kg = 5000 kg

8 a 4 g = 0.004 kg, force 0.004 kg × 2.5 × 10^5 m/s^2 = 1000 N
  b 1.6 g = 0.0016 kg, acceleration = 1000 N / 0.0016 kg = 625 000 m/s^2

9 total thrust (force) = 1015 kN + 13 300 kN = 14 315 kN = 14 315 000 N
  780 tonnes = 780 000 kg
  acceleration = 14 315 000 N / 780 000 kg = 18.4 m/s^2

CP1 Motion and CP2 Forces

CP2f.3 Momentum – Strengthen

1 momentum = mass × velocity = 5000 kg × 5 m/s = 25 000 kg m/s

2 a The minus sign shows that it is travelling in the opposite direction to truck A.

b momentum = 5000 kg × –5 m/s = –25 000 kg m/s

3 25 000 kg m/s + (–25 000 kg m/s) = 0

4 a They are stationary, so velocity and momentum are both zero.

b The total momentum is the same before and after the collision.

5 a 56 kg m/s

b –36 kg m/s

c they are opposite

d 56 kg m/s + (–36 kg m/s) = 20 kg m/s (to the right, i.e. in the positive direction)

e –28 kg m/s

f The total momentum after the collision must be the same. 48 kg m/s + (–28 kg m/s) = 20 kg m/s

g 48 kg m/s = 6 kg × ? m/s, velocity = 48 kg m/s / 6 kg = 8 m/s

6 change in momentum = ($mv - mu$) = (4 × 3) – (4 × 0) = 12

F = 12 / 2 = 6 N

7 change in momentum = ($mv - mu$) = (5 × 5) – (5 × 2) = 25 – 10 = 15

time = change in momentum / force = 15 / 20 = 0.75 s

CP2f.4 Momentum – Extend

1 a momentum = 0.001 kg × 300 m/s = 0.3 kg m/s

b mass = 1.001 kg

c 0.3 kg m/s – momentum is conserved: the momentum of the block of wood was zero as it was stationary, so the final momentum must be the same as the initial momentum of the bullet.

d velocity of bullet + wood = 0.3 kg m/s / 1.001 kg = 0.2997 m/s

2 momentum of first ball = 0.1 kg × 12 m/s = 1.2 kg m/s

momentum of larger ball after collision = 1.2 kg m/s (as first ball stops)

velocity of larger ball = 1.2 kg m/s / 0.2 kg = 6 m/s

(Accept answers that explain that the second ball must have half the velocity of the first ball as it has twice the mass.)

3 initial momentum = 80 kg × 4 m/s = 320 kg m/s

momentum of man and trolley after collision = 320 kg m/s

total mass after collision = 80 kg + 40 kg = 120 kg

velocity after collision = 120 kg / 320 kg m/s = 0.375 m/s

4 momentum of first car = 200 kg × +3 m/s = +600 kg m/s

momentum of second car = 130 kg × –2 m/s = –260 kg m/s

total momentum is 600 kg m/s + (–260 kg m/s) = +340 kg m/s

The momentum after the collision is the same as this, so the cars must end up moving in the positive direction.

5 momentum of cyclist and bike before picking up package = 100 kg × 10 m/s = 1000 kg m/s.

momentum of package = 0, so total momentum before = 1000 kg m/s

momentum after picking up package = 1000 kg m/s.

velocity after picking up package = 1000 kg m/s / 125 kg = 8 m/s

6 If the gun is not moving, the momentum before it is fired is zero, so the momentum after firing is also zero. The bullet and the gun move in opposite directions such that their momentums are equal in magnitude but in opposite directions and they cancel out. As the gun has a much larger mass than the bullet, it must have a much smaller velocity to give the same magnitude of momentum.

7 a force = ($mv - mu$) / t = (1000 × 3 – 1000 × 0) / 5 = 3000 / 5 = 600 N

b that the force from the two people is the same as the resultant force on the car (or that there is no friction to overcome)

c it will be larger, as the force calculated in part **a** is the resultant force and there are frictional forces to overcome

8 a force = ($mv - mu$) / t = (150 × 15 – 150 × 5) / 2 = (2250 – 750) / 2 = 1500 / 2 = 750 N

b 750 N as this is the same acceleration as in part **a**

c The engine force needed to accelerate from 5 m/s will be greater than that calculated in part **a**, as that number was the resultant force and there are frictional and drag forces to overcome. For the acceleration from 15 m/s the engine force will need to be even greater, as the drag forces increase with speed.

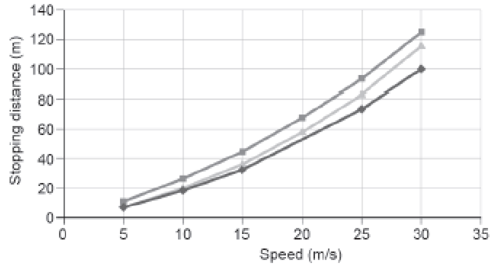
CP1 Motion and CP2 Forces

CP2g.5 Stopping distance graphs Homework 2

1 10, 15, 20, 25, 30

2 18, 32, ?, 73, 100

3 a graph as shown, with the lowest line plotted



b The actual values are 51 m stopping distance, 31 m thinking distance.

4 thinking times are all 1.8 m, thinking distances are 9, 18, 27, 36, 45, 54, stopping distances are 11, 26, 44, 67, 93, 124

5 the upper line plotted in the graph for question 3a

6 braking distances: 2.4, 9.6, 20.4, 37.2, 57.6, 84

stopping distances: 7.4, 19.6, 35.4, 57.2, 82.6, 114.0

7 the middle line plotted in the graph for question 3a

8 The worn brakes cause a greater increase to the overall stopping distance than the drunk driver in this example.

9 It is an easy method for making sure drivers have sufficient space to stop safely if the car in front stops suddenly.

10 These make the stopping distance longer.

11 If the car in front is moving faster, it will take longer to stop as well.

12 students' own suggestions

CP2h.4 Crash hazards – Extend

1 a force = (1000 kg × 0 m/s – 1000 kg × 15 m/s) / 0.05 s = –15 000 / 0.05 = –300 000 N

b force = (1000 kg × 0 m/s – 1000 kg × 30 m/s) / 0.05 s = –30 000 / 0.05 = –600 000 N

2 When the speed doubles the force doubles (if all other factors stay the same). A good answer may also point out that the force will be proportional to the speed if the mass and time stay the same.

3 For the 1000 kg car the answer is the same as question **1a**.

For the 2000 kg car: force = (2000 kg × 0 m/s – 2000 kg × 15 m/s) / 0.05 s = –30 000 / 0.05 = –600 000 N.

When the mass doubles the force doubles (if all other factors stay the same). A good answer may also point out that the force will be proportional to the mass if the speed and time stay the same.

4 force = (1000 kg × 0 m/s – 1000 kg × 15 m/s) / 0.1 s = –15 000 / 0.1 = –150 000 N

The time has doubled and the force has halved. The force is inversely proportional to the time it takes the car to come to a stop.

5 a Car B, because it has a longer bonnet and so is likely to have a longer crumple zone.

b Car B is also much bigger, and so will have a greater mass. The force depends on both mass and time to stop, so unless we have more details of mass/time to stop we cannot say which factor will make the most difference.

6 Car B has a greater mass, so if the cars are initially travelling at the same speed, a greater force from the brakes will be needed to provide the same deceleration.

CP3a.2 Energy diagrams

1. From left to right: chemical, strain/elastic potential/kinetic
2. by forces
3. a. by electricity to the kettle, energy transferred by heating for all three arrows leading from the kettle, energy stored as thermal energy in the hot water, in the kettle, in the surroundings
   b. We use a kettle to heat water, so only the thermal energy stored in the hot water is useful.
4. a. 17 squares = 17 × 5 J = 85 J
   b. 2 squares = 10 J
   c. square = 5 J
5. a. by electricity
   b. 60 J – 33 J = 27 J
   c. Sankey diagram drawn correctly to scale and labelled

CP3 Conservation of Energy

CP3b.3 Energy efficiency – equation practice

1 a 80 J / 100 J = 0.8
  b 6.25 J / 25 J = 0.25
  c 12 J / 30 J = 0.4
  d 68 J / 80 J = 0.85
  e 0.9 × 1200 J = 1080 J
  f 0.95 × 5000 J = 4750 J
  g 0.3 × 750 J = 225 J
  h 350 J / 0.7 = 500 J
  i 260 J / 0.65 = 400 J
  j 10 J / 0.2 = 50 J

2 5 J / 100 J = 0.05

3 10 J / 300 J = 0.033

4 0.05 × 400 J = 20 J

5 a 9 J / 20 J = 0.45
  b 9 J / 0.05 = 180 J

6 a 300 000 J / 0.95 = 315 790 J (or 300 kJ / 0.95 = 315.8 kJ)
  b 300 000 kJ / 0.9 = 333 333 J (or 300 kJ / 0.9 = 333.3 kJ)

7 90 000 J / 0.8 = 112 500 J

8 useful energy transferred = 0.24 × 50 J = 12 J
energy transferred by sound = 12 J – 8 J = 4 J

9 energy transferred to light bulb = 1 J / 0.05 = 20 J
energy transferred to transmission lines = 20 J / 0.9 = 22.22 J
energy transferred to power station = 22.2 J / 0.5 = 44.4 J

4 a go up
  b Either: energy is being supplied to the room in the form of the electricity being used by the fridge, so the total energy in the room is increasing and this will be in the form of energy transferred from the fridge by heating. Or: all the energy extracted from the air inside the fridge will be given out at the back of the fridge, so this will not affect the temperature. However, the fridge has a motor which will be less than totally efficient, so the wasted energy from the motor will be transferred into the room by heating.

CP3d.3 Stored energies – Equations

1 a ΔGPE = 4 kg × 10 N/kg × 2 m = 80 J
  b ΔGPE = 2.5 kg × 10 N/kg × 3 m = 75 J
  c ΔGPE = 0.5 kg × 10 N/kg × 2.5 m = 12.5 J
  d mass = 800 J/(10 N/kg × 2 m) = 40 kg
  e Δh = 1125 J/(75 kg × 10 N/kg) = 1.5 m
  f Δh = 1500 J/(50 kg × 10 N/kg) = 3 m
  g mass = 50 J/(10 N/kg × 0.5 m) = 10 kg

2 a ΔGPE = 2 kg × 1.6 N/kg × 1.5 m = 4.8 J
  b g = 11.1 J/(2 kg × 1.5 m) = 3.7 N/kg
  c g = 280 000 J/(400 kg × 500 m) = 1.4 N/kg

3 a KE = 0.5 × 0.16 kg × $(44\ \text{m/s})^2$ = 154.9 J
  b KE = 0.5 × 0.4 kg × $(30\ \text{m/s})^2$ = 180 J
  c KE = 0.5 × 0.15 kg × $(30\ \text{m/s})^2$ = 67.5 J
  d mass = 185 J/(0.5 × $(48\ \text{m/s})^2$) = 0.16 kg
  e mass = 142 J/(0.5 × $(70\ \text{m/s})^2$) = 0.058 kg
  f KE = 0.5 × 0.0027 kg × $(40\ \text{m/s})^2$ = 2.16 J
  g mass = 186.3 J/(0.5 × $(90\ \text{m/s})^2$) = 0.046 kg

4 a KE = 0.5 × 1500 kg × $(10\ \text{m/s})^2$ = 75 000 J
  b KE = 0.5 × 1500 kg × $(20\ \text{m/s})^2$ = 300 000 J
  c KE = 0.5 × 1500 kg × $(30\ \text{m/s})^2$ = 675 000 J

5 bounce 1, GPE = 0.02 kg × 10 N/kg × 1.4 m = 0.28 J
  bounce 2, GPE = 0.02 kg × 10 N/kg × 1.0 m = 0.20 J
  bounce 3, height = 0.14 J/(0.02 kg × 10 N/kg) = 0.7 m
  bounce 4, height = 0.10 J/(0.02 kg × 10 N/kg) = 0.5 m
  bounce 5, height = 0.07 J/(0.02 kg × 10 N/kg) = 0.35 m

6 bounce 3: v^2 = 0.14 J/(0.5 × 0.02 kg) = 14 $(\text{m/s})^2$, v = 3.74 m/s
  bounce 4: v^2 = 0.10 J/(0.5 × 0.02 kg) = 10 $(\text{m/s})^2$, v = 3.16 m/s
  bounce 5: v^2 = 0.07 J/(0.5 × 0.02 kg) = 7 $(\text{m/s})^2$, v = 2.65 m/s

7 a ΔGPE = 30 kg × 10 N/kg × 0.5 m = 150 J
  b v^2 = 150 J/(0.5 × 30 kg) = 10 $(\text{m/s})^2$, v = 3.16 m/s

8 a ΔGPE = 5000 kg × 10 N/kg × 6 m = 300 000 J
  v^2 = 300 000 J/(0.5 × 5000 kg) = 120 $(\text{m/s})^2$, v = 10.95 m/s
  b ΔGPE = 5000 kg × 10 N/kg × 3 m = 150 000 J
  v^2 = 150 000 J/(0.5 × 5000 kg) = 60 $(\text{m/s})^2$, v = 7.75 m/s

CP3f.2 Fair Isle

1 October – the hours from wind more than doubled in this month

2 a 16 hours, or 17 hours (500 ÷ 30 = 16.67) – accept answers near this if students have estimated from the graph

b There are fewer days in February.

3 a Most wind energy is available in the winter months.

b The number of hours of wind-generated electricity each day is also greatest in the winter months (fewer hours of electricity were generated using diesel).

4 a Information for a whole year with both turbines operating (or for more than one year) because data for just one year might not be representative.

b No – most onshore sites would be sheltered from the wind from some directions.

5 about 70% over a whole year

Approximate figures from graph A are (hours diesel/wind):

Jun – 420/80; Jul – 410/120; Aug – 410/100; Sept – 360/200; Oct – 70/650; Nov – 120/570; Dec – 380/350; Jan – 100/620; Feb – 120/510; Mar – 230/420; Apr – 220/400; May – 190/480

totals: diesel – 3030, wind – 4500 so approx 67% was supplied by wind

6 any two from: We would need a lot of wind turbines to provide a significant proportion of our electricity. Most of the windy sites for these will be in scenic locations where there are likely to be objections to building them. These are also places where we would need new connections to send the electricity to users. Putting wind turbines out at sea costs more in building and maintenance.

CP4b.2 Equation practice

1 a v = 2000 m/6 s = 333.3 m/s
b v = 50 m/0.5 s = 100 m/s
c x = 5000 m/s × 4 s = 20 000 m
d t = 600 000 m/3000 m/s = 200 s
e x = 200 m/s × 25 s = 5000 m
f t = 3000 m/1500 m/s = 2 s

2 a t = 100 000 m/1500 m/s = 66.7 s
b x = 1500 m/s × 600 s = 900 000 m (or 900 km)

3 v = 100 m/0.3 s = 333 m/s

4 a v = 12 200 Hz × 0.5 m = 6100 m/s
b v = 50 Hz × 80 m = 4000 m/s
c f = 330 m/s/1.65 m = 200 Hz
d λ = 1500 m/s/15 000 Hz = 0.1 m
e λ = 3500 m/s/500 Hz = 7 m
f f = 150 m/s/0.015 m = 10 000 Hz

5 λ = 4 m/s/8 Hz = 0.5 m

6 f = 0.021 m/s/0.015 m = 1.4 Hz

7 a t = (2 × 322 000 m) / (3 × 10^8 m/s) = 0.002 s
b t = (2 × 2.25 × 10^{11} m) / (3 × 10^8 m/s) = 1500 s (or 25 minutes)
c t = (2 × 4.9 × 10^{12} m) / (3 × 10^8 m/s) = 32 667 s (or 544 minutes or 9.1 hours)

8 x = 3 × 10^8 m/s × (4 × 60 × 60) = 4.32 × 10^{12} m
This is the total distance travelled by the signal, so the distance of the probe from Earth = 4.32 × 10^{12} m/2 = 2.16 × 10^{12} m.

9 a x = 1533 m/s × 2 s = 3066 m, depth = 3066 m/2 = 1533 m
b x = 1493 m/s × 2 s = 2986 m, depth = 2986 m/2 = 1493 m
c x = 1533 m/s × 0.05 s = 76.65 m, distance to fish = 38.3 m
x = 1533 m/s × 0.7 s = 1073.1 m, distance to fish = 536.6 m

10 a 120 kHz = 120 000 Hz, λ = 1533 m/s/120 000 Hz = 0.0128 m
200 kHz = 200 000 Hz, λ = 1533 m/s/200 000 Hz = 0.0077 m
b 120 kHz = 120 000 Hz, λ = 1493 m/s/120 000 Hz = 0.0124 m
200 kHz = 200 000 Hz, λ = 1493 m/s/200 000 Hz = 0.0075 m
c t = 2 × 3000 m/1533 m/s = 3.91 s

11 v = 300 m/0.2 s = 1500 m/s
λ = 1500 m/s/50 000 Hz = 0.03 m

CP4b.5 Wave velocity – Homework 2

1 $v = 2000\ \text{m}/2.5\ \text{s} = 800\ \text{m/s}$

2 $t = 10\,000\ \text{m}/3000\ \text{m/s} = 3.33\ \text{s}$

3 a $\lambda = 1500\ \text{m/s} / 30\ \text{Hz} = 50\ \text{m}$

b $x = 1500\ \text{m/s} \times 300\ \text{s} = 450\,000\ \text{m}$ (or 450 km)

4 total distance = 1700 m,
$v = 1700\ \text{m}/5\ \text{s} = 340\ \text{m/s}$

5 a 17 hours = 17 × 60 × 60 = 61 200 s
$v = 8\,600\,000\ \text{m}/61\,200\ \text{s} = 140.5\ \text{m/s}$

b $x = 1\,500\,000\ \text{m}/140.5\ \text{m/s} = 10\,676\ \text{s}$ (or 177.9 minutes or 3 hours)

6 a Arrival time for seismic wave = 8 600 000 m/800 m/s = 10 750 s

So this will be 61 200 s – 10 750 s = 50 450 s ahead of the tsunami (or 840 minutes or 14 hours)

b Arrival time for seismic wave = 1 500 000 m/800 m/s = 1875 s

So this will be 10 676 s – 1875 s = 8801 s ahead of the tsunami (or 147 minutes or 2.4 hours)

7 a $f = 3 \times 10^8\ \text{m/s} / 100\ \text{m} = 3 \times 10^6\ \text{Hz}$

b $\lambda = 3 \times 10^8\ \text{m/s} / 3 \times 10^{10}\ \text{Hz} = 0.01\ \text{m}$

c $f = 3 \times 10^8\ \text{m/s} / 1 \times 10^{-6}\ \text{m} = 3 \times 10^{14}\ \text{Hz}$

d $\lambda = 3 \times 10^8\ \text{m/s} / 3 \times 10^{12}\ \text{Hz} = 1 \times 10^{-4}\ \text{m}$

e $f = 3 \times 10^8\ \text{m/s} / 1 \times 10^{-7}\ \text{m} = 3 \times 10^{15}\ \text{Hz}$

f $\lambda = 3 \times 10^8\ \text{m/s} / 3 \times 10^{19}\ \text{Hz} = 1 \times 10^{-11}\ \text{m}$

8 a $= 385\,000\,000\ \text{m}/3 \times 10^8\ \text{m/s} = 1.28\ \text{s}$

b Assuming that the laser beam travels the shortest possible distance, the distance travelled

= 2 × (distance between centres – radius of Earth – radius of Moon)

= 2 × (385 000 km – 6371 km – 1740 km) = 753 778 km

time = $753\,778\,000\ \text{m}/3 \times 10^8\ \text{m/s} = 2.5\ \text{s}$

CP5b.5 The electromagnetic spectrum – Homework 2

1 a The atmosphere absorbs almost all of the gamma rays passing through it. On a mountain there is less atmosphere above the telescope to absorb the gamma rays, so some of them will get through.

b Advantage: gamma rays can be detected without any atmospheric absorption.

Disadvantage: any from – it costs more, cannot be easily repaired, has to be smaller/lighter, or any other sensible disadvantage.

c telescopes to detect ultraviolet or infrared radiation

2 nanometres, micrometres, millimetres, centimetres, metres, kilometres

3 a 100 nm = 1×10^{-7} m

b 1 µm = 1×10^{-6} m

c 10 µm = 1×10^{-5} m

d 1 km = 1×10^{3} m

4 (Answers may vary if students choose different typical wavelengths.)

gamma and X-rays: $f = 3 \times 10^8$ m/1×10^{-9} m = 3×10^{17} Hz

ultraviolet: $f = 3 \times 10^8$ m/1×10^{-7} m = 3×10^{15} Hz

infrared: $f = 3 \times 10^8$ m/1×10^{-4} m = 3×10^{12} Hz

microwaves: $f = 3 \times 10^8$ m/1×10^{-2} m = 3×10^{10} Hz

radio waves: $f = 3 \times 10^8$ m/10 m = 3×10^7 Hz

5 a A typical wavelength of ultraviolet rays is 100 nm, and a typical wavelength of gamma rays is 1 nm, so for these values ultraviolet waves have a wavelength 100 times longer. However this is not always correct, it depends on where within the range of wavelengths for ultraviolet waves and for gamma rays you take your examples.

b Taking a typical radio wave wavelength as 100 m and a typical microwave wavelength as 1 cm (0.01 m), then radio waves have wavelengths 10 000 times longer than those of microwaves.

6 wavelength = 2×10^8 m/s / 3×10^{14} Hz
= 6.7×10^{-7} m

7 speed = 2.4×10^{16} Hz × 5×10^{-9} m
= 1.2×10^8 m/s.

CP5c.2 Masts and aerials

1 Mobile phones use microwaves, which travel in straight lines, as light waves do.

2 The building allows the transmitter to be in a high position, to get a long range, without a similarly high tower having to be built.

3 a distance = $3570 \times \sqrt{15}$ m = 13 827 m

b distance = $3570 \times \sqrt{25}$ m = 17 850 m

c Advantage: fewer masts are needed, because each one covers a bigger area.

Disadvantage: one from – taller towers are more expensive to build/more likely to spoil the view.

d The power of the transmitter may not be sufficient, and the signal may be reflected or absorbed by buildings/trees etc.

e There are likely to be a lot more calls made in a city because there are a lot more people, so more masts are needed to handle the number of calls.

4 Height above sea level of top of mast = 456 m + 309 m = 765 m

Distance from top of mast = $3570 \times \sqrt{765}$ m = 98 741 m

5 H The radio waves may be refracted/undergo refraction in the ionosphere.

6 mobile phones: wavelength = 3×10^8 m/s / 800 000 000 Hz = 0.375 m

FM radio: wavelength = 3×10^8 m/s / 100 000 000 Hz = 3 m

longwave: wavelength = 3×10^8 m/s / 270 000 Hz = 1111 m

7 mobile phones 0.1875 m, FM radio 1.5 m, longwave radio 555 m

CP6 Radioactivity

CP6b.2 Atomic notation practice

1 a mass number 11, atomic number 5
b mass number 14, atomic number 7
c mass number 4, atomic number 2
d mass number 59, atomic number 28
e mass number 55, atomic number 25
f mass number 48, atomic number 22
g mass number 108, atomic number 47
h mass number 195, atomic number 78

2 a 5 protons, 6 neutrons
b 7 protons, 7 neutrons
c 2 protons, 2 neutrons
d 27 protons, 32 neutrons
e 25 protons, 30 neutrons
f 22 protons, 26 neutrons
g 47 protons, 61 neutrons
h 78 protons, 117 neutrons

3 a $^{7}_{3}Li$
b $^{19}_{9}F$
c $^{32}_{16}S$
d $^{84}_{36}Kr$
e $^{40}_{20}Ca$
f $^{59}_{27}Fe$
g $^{23}_{11}Na$
h $^{127}_{53}I$

4 $^{16}_{8}O$, $^{17}_{8}O$, $^{18}_{8}O$

5 $^{238}_{92}U$, $^{235}_{92}U$

6 a $^{54}_{26}Fe$, 26 protons, 28 neutrons
b $^{56}_{26}Fe$, 26 protons, 30 neutrons
c $^{57}_{26}Fe$, 26 protons, 31 neutrons
d $^{58}_{26}Fe$, 26 protons, 32 neutrons

7 a 63
b 120
c 136, 54
d 226, 88
e 37
f 65

CP6 Radioactivity

CP6b.4 Inside atoms – Homework 1

1

Atom	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons
$^{1}_{1}H$	1	1	1	0	1
$^{2}_{1}H$	1	2	1	1	1
$^{3}_{1}H$	1	3	1	2	1
$^{6}_{3}Li$	3	6	3	3	3
$^{7}_{3}L$	3	7	3	4	3
$^{12}_{6}C$	6	12	6	6	6
$^{14}_{6}C$	6	14	6	8	6
$^{24}_{12}Mg$	12	24	12	12	12
$^{25}_{12}Mg$	12	25	12	13	12
$^{26}_{12}Mg$	12	26	12	14	12

2 a atoms with the same number of protons but different numbers of neutrons

b three

c atomic number, number of protons and number of electrons

d mass number and number of neutrons

3

Particle	Location	Relative charge	Relative mass
proton	in nucleus	+1	1
electron	around nucleus	–1	1/1835
neutron	in nucleus	0	1

4 a number of protons/atomic number, number of electrons

b number of neutrons

c $^{10}_{5}B$, $^{11}_{5}B$

CP6f.2 Nuclear equation practice

1 a $^{251}_{87}Fr$

b $^{20}_{10}Ne$

c $^{4}_{2}He$

d $^{53}_{25}Mn$

e $^{4}_{2}He + ^{148}_{62}Sm$

2 a $^{240}_{92}U$

b $^{233}_{91}Pa$

c $^{8}_{4}Be$

d $^{187}_{77}Ir$

e $^{222}_{86}Rn$

f $^{16}_{7}N$

g $^{200}_{83}Bi$

3 a $^{0}_{-1}e$

b $^{0}_{+1}e$

c $^{4}_{2}He$

d $^{4}_{2}He + ^{142}_{60}Nd$

e $^{0}_{-1}e + ^{247}_{96}Cm$

4 a $^{223}_{87}Fr$

b $^{38}_{19}K$

c $^{144}_{60}Nd$

d $^{24}_{11}Na$

e $^{20}_{11}Na$

CP6f.5 Radioactive decay Homework 2

1 a Both consist of charged particles.

b Alpha radiation consists of helium nuclei with a 2+ charge and relative mass of 4. Beta radiation consists of particles with negligible mass and a 1– charge.

2 Gamma radiation is electromagnetic radiation and does not consist of particles.

3 a less ionising

b more penetrating

c no mass

d no charge

4 a decreases by 2

b decreases by 4

5 a no effect

b no effect

6 a no effect

b decreases by 1

7 a increases by 1

b no effect

8 thorium-234

9 neptunium-244

10 a alpha decay

b beta decay

11 a $^{211}_{87}Fr \rightarrow \, ^{4}_{2}He + \, ^{207}_{85}At$

b $^{13}_{9}Be \rightarrow \, ^{1}_{0}n + \, ^{27}_{13}Al$

c $^{59}_{26}Fe \rightarrow \, ^{0}_{-1}e + \, ^{59}_{27}Co$

12 neptunium-244

13 phosphorus-31

14 a $^{14}_{7}N + \, ^{4}_{2}He \rightarrow \, ^{17}_{8}O + \, ^{1}_{1}H$

b $^{14}_{7}N + \, ^{1}_{0}n \rightarrow \, ^{14}_{6}C + \, ^{1}_{1}H$

CP6g.2 Radiocarbon dating

1	a	One nuclear decay per second.
	b	It decreases by half.
	c	about 5700 years
2	a	They have decayed.
	b	a quarter, or 25%
	c	a quarter, or 25%
	d	2
	e	11 400 years
3	a	one-eighth, or 12.5%
	b	one-eighth, or 12.5%
	c	about 17 000 years (17 100 years)

CP7a.2 Work done and power

1 (Rows can be in any order – here they are in the order the quantity symbol appears in the word box.)

Symbol	Description	Unit symbol	Work done or power equation?
d	distance moved in direction of force	m	work done
E	work done	J	work done
E	work done	J	power
F	force	N	work done
P	power	W	power
t	time taken	s	power

2 a work done = 30 N × 3 m = 90 J

b power = $\frac{90 \text{ J}}{10 \text{ s}}$ = 9 W

3 a Δ*GPE*

b mass × gravitational field strength

c change in vertical height

4 a work done = 50 N × 1 m = 50 J

b Δ*GPE* = 5 kg × 10 N/kg × 1 m = 50 J

5 a Δ*GPE* = 500 kg × 10 N/kg × 20 m
= 100 000 J

b 10 000 J is wasted energy. Energy cannot be created or destroyed, so the difference between the 100 000 J stored in the raised mass and the total energy transferred by the crane is the wasted energy.

c It is stored as heat in the crane or its surroundings. It is not useful, because it is dissipated/spread out.

d efficiency = $\frac{100\,000 \text{ J}}{110\,000 \text{ J}}$ = 0.91

CP7a.3 Equation practice

1 a work done = 50 N × 4.8 m = 240 J
b work done = 80 N × 4.0 m = 320 J
c work done = 180 N × 4.5 m = 810 J
d work done = 250 N × 4.5 m = 1125 J
e work done = 55 N × 2.0 m = 110 J
f work done = 100 N × 2.0 m = 200 J
g work done = 140 N × 2.5 m = 350 J
h work done = 153 N × 2.5 m = 382.5 J
I work done = 40 N × 1.5 m = 60 J

2 a force = $\frac{10\,000 \text{ J}}{20 \text{ m}}$ = 500 N

b force = $\frac{10 \text{ J}}{0.5 \text{ m}}$ = 20 N

c distance = $\frac{80 \text{ J}}{40 \text{ N}}$ = 2 m

d distance = $\frac{350 \text{ J}}{70 \text{ N}}$ = 5 m

e force = $\frac{5\,000\,000 \text{ J}}{500 \text{ m}}$ = 10 000 N

f distance = $\frac{0.16 \text{ J}}{0.2 \text{ N}}$ = 0.8 m

3 work done = 100 N × 7 m = 700 J

4 a power = $\frac{90\,000 \text{ J}}{30 \text{ s}}$ = 3000 W

b work done = 20 W × 5 s = 100 J

c power = $\frac{100 \text{ J}}{2 \text{ s}}$ = 50 W

d time taken = $\frac{245 \text{ J}}{700 \text{ W}}$ = 0.35 s

e work done = 25 W × 75 s = 1875 J

f time taken = $\frac{500\,000 \text{ J}}{50\,000 \text{ W}}$ = 10 s

g power = $\frac{450 \text{ J}}{3 \text{ s}}$ = 150 W

h time taken = $\frac{5 \text{ J}}{0.5 \text{ W}}$ = 10 s

5 a work done = 500 N × 0.8 m = 400 J

b power = $\frac{400 \text{ J}}{5 \text{ s}}$ = 80 W

c work done = 160 N × 2.5 m = 400 N

d power = $\frac{400 \text{ N}}{8 \text{ s}}$ = 50 W

6 a work done = 750 N × 200 m = 150 000 J

b 20 min = 1200 s

power = $\frac{150\,000 \text{ J}}{1200 \text{ s}}$ = 125 W

c time = $\frac{150\,000 \text{ J}}{5000 \text{ W}}$ = 30 s

CP8b.3 Vector diagram practice

1 Answers will depend on the accuracy of students' drawings, but should be close to the following values.

a 56 N at an angle of 27° to A

b 126 N at an angle of 16° to A

c 68 N at an angle of 29° to A

2 a The resultant will act between the two forces shown, closer to the direction of the 20 kN force than the 5 kN force.

The resultant is 21 kN at an angle of 14° from the direction the aeroplane is pointing.

b The resultant will act between the two forces shown, closer to the 40 kN force than the 10 kN force.

The resultant is 48 kN at an angle of 6° from the direction the aeroplane is pointing.

3 a Along the direction the sled is moving – if it is the only force on the sled, the force and the direction of movement must be the same (or the forces are symmetrical about the line of movement, so the resultant must be along that line).

b If the two forces were in line, the resultant would be 100 N; as they are at an angle it must be a bit less than this. Accept answers between 80 N and 95 N.

c resultant = 90 N

4 a The resultant will be at an angle to the right of vertical on the diagram. Its size will be less than the sum of the two forces – accept estimates between 2000 N and 2400 N.

b resultant = 2317 N at an angle of 18° to the right of the line of the 1000 N force

5 a normal component = 1182 N, component along slope = 208 N

b normal component = 1992 N, component along slope = 104 N

c normal component = 1409 N, component along slope = 513 N

CP9b.4 Circuits – Homework 1

1 **a** current

b potential difference (voltage)

c ammeter in series, voltmeter in parallel

2 A = 1 A, B = 4.0 A

3 A = 2 V, B = 4.5 V

4 the same as, half, half, half

CP9b.5 More about circuits
Homework 2

1 **a** circuit with battery, lamp and switch; ammeter in series and voltmeter in parallel

b ammeter

c voltmeter

2 a potential difference (provided by a cell/ battery) across the circuit and a complete unbroken circuit

3 The potential difference between two points is the difference in potential energy that a charge would have after moving from one point to the other. (The potential difference between two points is 1 V if 1 J of energy is transferred to or from a charge of 1 C when it moves from one point to the other.)

4 **a** single lamp (F) = 4.8 A, two lamps in parallel = 2.4 A (i.e. half through each), three lamps in parallel = 1.6 A (i.e. one-third through each)

b potential difference = sum of series potential differences = (6.6 + 3.3 + 2.2) V
= 12.1 V

5 Cells in series have a higher total potential difference than one cell, but will last for the same time as one cell. Cells in parallel will have the same potential difference as one cell but will last for a longer time than one cell.

6 **a** a = b = c = 0.1 A, d = 3 × a (or b or c) = 0.3 A, e = d + a (or b or c) = 0.4 A

b V across a = V across b = V across c = 0.6 V

c V across d = V across a + V across b + V across c = 1.8 V

V across E = 2.4 V

Battery potential difference = 1.8 V + 2.4 V = 4.2 V

CP9c.6 Equation practice

1 **a** 180 C

b 12.5 A

c 720 s

d 0.5 A

e 3600 s (or 1 hour)

2 **a** 180 C

b 3000 s or 50 minutes

3 **a** 220 C

b 15 840 C

4 **a** 11 400

b 3

c 300

d 2000

e 12

5 **a** **i** $Q = I \times t = 0.001 \times 1 \times 60 \times 60 = 3.6$ C

ii 6000 mA = 6A
$Q = I \times t = 6 \times 1 \times 60 \times 60 = 21\,600$ C

iii $t = Q \div I = 21\,600 \div 2 = 10\,800$ s or 3 hours

b **i** $E = Q \times V = 21\,600 \times 5 = 108\,000$ J

ii $E = Q \times V = 1000 \times 5 = 5000$ J

CP9d.5 Resistance and resistors Homework 2

1 a ohm Ω

b $V = I \times R$

2 a Current decreases.

b Increased resistance means it is more difficult for current to flow, so for the same potential difference current is less.

3 $\frac{9}{36} = 0.25$ A

4 $\frac{230}{12} = 19$ Ω (or 19.2 Ω to 3 sf)

5 a The total resistance is increased because the current has to pass through both resistors so it is more difficult. (or Because the potential difference is shared between the resistors.)

b The total resistance is less because there are two paths for current to pass so it is easier.

6 a $\frac{24}{3 \times 1000} = 0.008$ A (or 8 mA)

b 3 kΩ + 5 kΩ = 8 kΩ

c $I = \frac{V}{R} = \frac{24}{8}$ kΩ = 0.003 A or 3 mA

d I 3 kΩ × 3 mA = 9 V

II 5 kΩ × 3 mA = 15 V

7 a Series circuit: cell or battery, variable resistor, fixed resistor, ammeter (switch optional). A voltmeter connected in parallel with the resistor – not with the variable resistor or the cell.

b I Measure current and potential difference.

II Use $V = I \times R$ to calculate resistance.

III Adjust the variable resistor so that the resistance is lower to give a higher current.

8 a Connect each wire in turn in series with a battery and an ammeter. There will be no current through the broken wire.

b Series circuit: battery, ammeter, yellow wire, 47 Ω resistor, blue wire, 10 Ω resistor, red wire, 3 Ω resistor, green wire, battery.

c resistors in series:
total resistance = 47 Ω + 3 Ω + 10 Ω
= 60 Ω

d $\frac{12\text{ V}}{60\ \Omega} = 0.2$ A (or 200 mA)

e $\frac{12\text{ V}}{0.16\text{ A}} = 75$ Ω

f all 4 wires: 75 Ω − 60 Ω = 15 Ω
1 wire = 15 ÷ 4 = 3.75 Ω (3.8 Ω to 2 sf)

CP9d.6 Equation practice

1 230, 4, 1800, 12, 0.1, 18 (17.7 to 3 sf)

2 $\frac{5}{1000} \times (1 \times 1000) = 5\ \text{V}$

3 a $\frac{9}{3} = 3\ \Omega$

b $\frac{3}{12} = 4\ \text{A}$

4 a $A = \frac{12}{0.030} = 400\ \Omega$

$B = \frac{6}{0.012} = 500\ \Omega$

$C = \frac{12}{0.015} = 800\ \Omega$

b C

CP9e.5 Components with changing resistance – Homework 2

1 It increases.

2 It doubles because the resistance is constant and $V = I \times R$.

3 a A graph of *I* against *V* showing *I* is zero for negative values of *V* and for very small positive values. It then increases with very steep gradient (see graph A in *CP9e More about resistance* in the Student Book).

b The current is zero because the diode can only conduct in one direction.

c At a small value of positive potential difference the resistance of the diode falls so the diode starts to conduct and the current increases. It now has a very small resistance so a small increase in potential difference causes the current to rise by a large amount.

d To stop current passing in the wrong direction in a circuit and causing damage, for example.

e A light-emitting diode.

4 a $\frac{5\ \text{V}}{100\ \Omega} = 0.05\ \text{A}$

b It will decrease.

c It will increase.

d e.g. to switch on a light when it gets dark

5 a $\frac{12\ \text{V}}{3\ \text{A}} = 4\ \Omega$

b It will increase.

c It will decrease.

d e.g. switching on a heater, switching on a cooling fan

Extra challenge

6 a I It will be very large.

II It may damage the LED.

b to keep the potential difference across the LED to 2 V or less (Accept 'to keep the current low', but do not accept 'so it doesn't damage the LED'.)

c If p.d. across LED is 2 V then p.d. across resistor is 5 − 2 = 3 V.
The current in the circuit is 10 mA = 0.01 A or 1×10^{-2} A.
The resistance of the resistor is
$\frac{3\ \text{V}}{0.01\ \text{A}} = 300\ \Omega$

d Higher, so that the potential difference across the resistor is higher and the current through it is lower. This will mean the potential difference across the LED is lower than 2 V.

P9f.3 Equation practice

1 a 496 800 J
  b 86 400 J
  c 4 A
  d 6 V
  e 900 s
  f 3000 s

2 230 V × 2 A × 1 × 60 s = 27 600 J

3 2880 J ÷ (12 V × 0.5 A) = 480 s = 8 minutes

4 230 V × 13 A × 1 × 60 × 60 s
= 10 764 000 J
= 11 MJ to the nearest MJ

5 82 800 J ÷ (230 V × 0.3 A)
= 1200 s
= 20 minutes

6 energy used by kettle A
= 230 V × 13 A × 5 × 60 s
= 897 000 J

time taken by kettle B
= 897 000 J ÷ (230 V × 10 A)
= 390 s = 6.5 minutes

or Allow directly from $E = I \times V \times t$
say $I \times t$ is the same in both cases
(because E and V are the same)
so:

time = (13 A ÷ 10 A) × 5 minutes = 6.5 minutes.

CP9f.6 Resistance and thermal energy – Homework 2

1 e.g. kettle. Electric current passes through the element which heats up and then heats the water.

2 e.g. a cable carries a high current, it gets very hot and sets fire to something in the surroundings, e.g. walls of a house.

3 There are a lot of currents close together and the chip gets very hot. If it did not have a fan the chip would overheat, which damages it – or even causes it to catch fire.

4 a current = 0.16 + 0.3 + 0.4 = 0.86 A

b These items all carry a much higher current – when these are added the total current in the cable may make the cable too hot and start a fire.

5 a Diagram similar to Figure b, page 392 Student Book

b When free electrons pass through the material they collide with the positive ions. Energy is transferred to the ions so these collisions cause resistance.

c more ions closer together

d Increasing temperature causes ions to vibrate more so that it is more difficult for the electrons to pass through without colliding. More collisions cause more resistance.

e More electrons passing through leads to more collisions, and more collisions leads to more energy transfer to the ions.

6

1 Choose a material with a lower resistance, e.g. copper rather than iron.

2 Use thicker wires.

3 Cool the wires.

7 $E = 13\text{ A} \times 230\text{ V} \times 3 \times 60 \times 60\text{ s}$

$= 32\,292\,000\text{ J} = 32\text{ MJ}$ (to nearest MJ)

8 $t = 2\,400\,000\text{ J} \div (0.4\text{ A} \times 230\text{ V})$

$= 26\,086.9\text{ s} = 7$ hours 15 minutes (to nearest minute)

Extra challenge

9 a Energy required
$= 5.1 \times 10^5\text{ J} \times (49 - 15)\text{ °C}$
$= 1.734 \times 10^7\text{ J}$

Time required
$= 1.734 \times 10^7\text{ J} \div (13\text{ A} \times 230\text{ V})$
$= 5799\text{ s}$
= 1 hour 37 min (to nearest minute)

b Some of the energy is needed to heat the tank, the wires and the heater, and some thermal energy will be transferred to the surroundings, so the current will need to pass for a little longer for this additional energy to be transferred.

c If there is no water the thermal energy will not be conducted and convected away from the heating element of the immersion heater as efficiently. The heating element will overheat and will be damaged.

CP9 Electricity

CP9g.2 Energy and power

1 Predictions: (Students are not required to give their reasoning, but you might wish to discuss this with them so it is included here.)

Students should choose a heating device for the highest power rating, but not the iron (energy transferred less than three times that for the hair dryer, although on for three times as long), the hair dryer (less than twice the kettle, though on for twice as long), or the toaster (much less than the kettle although time not much less) – so fan heater or kettle. The kettle has the highest power; as they all have the same voltage this means it has the highest current and lowest resistance.

For lowest, LED light is sensible choice – on for longest yet only two appliances use less energy, both of which are only on for very short time. The LED lamp has the lowest power, as they all have the same voltage this means it has the lowest current and highest resistance.

Answers to **2a**, **4a** and **7a** are in the table.

Answers to **2a, 4a** and **7a** are in the table.

Appliance	Power (W)	Current (A)	Resistance (Ω)
Fan heater	2000	8.70	26
Filament bulb	100	0.43	529
iron	1000	4.35	53
Hair dryer	2200	9.57	24
television	150	0.65	353
kettle	2800	12.17	19
toaster	1200	5.22	44
LED light	3	0.01	17 633
Electric drill	600	2.61	88
Blender	300	1.30	176

2 **b** highest kettle, lowest LED light

3 highest kettle, lowest LED light (because voltage is the same, $P = I \times V$, and these have the highest and lowest power)

4 **b** highest kettle, lowest LED light

5 The appliance with the highest current will be the one with the highest power rating.

6 highest LED light, lowest kettle (because voltage is the same, $V = I \times R$ and current is lowest for LED light and highest for kettle)

7 **b** highest LED light, lowest kettle

8 The appliance with the highest resistance will be the one with the lowest power rating.

CP9g.5 Electric power and energy transfer – Homework 2

1 a watts, W

b Power is the rate of transfer of energy OR power is the energy transferred per second.

2 $P = \frac{E}{t}$

3 $P = I \times V \quad P = I^2 \times R$

4 a 400 W × 2 × 60 s = 48 kW

b 230 V × 2.2 A = 506 W

c $\frac{1400\ \text{W}}{230\ \text{V}} = 6.1\ \text{A}$

5 energy transfer in 3 kW kettle = 3000 × 5 × 60 s
= 900 000 J

1.8 kW kettle: $\frac{900\,000\ \text{J}}{1800\ \text{W}} = 500\ \text{s}$
= 8 minutes 20 seconds

6 a $\frac{78\,000\ \text{J}}{5 \times 60\ \text{s}} = 260\ \text{W}$

b $\frac{260\ \text{W}}{36\ \text{V}} = 7.2\ \text{A}$

c $\frac{260}{(7.2)^2} = 5.0\ \Omega$ (or $\frac{36\ \text{V}}{7.2\text{A}} = 5.0$ A)

7 $\frac{200\ \text{W}}{(0.87\ \text{A})^2} = 264\ \Omega$ (260 Ω, to 2sf)

8 a $\frac{3 \times 10^3}{400 \times 10^3} = 7.5$ mA OR 7.5×10^{-3} A

$\frac{3 \times 10^3}{230\ \text{V}} = 13\ \text{A}$

b $(7.5 \times 10^{-3})^2 \times 10 = 5.6 \times 10^{-5}$ W OR 0.056 mW which is very small but $(13)^2 \times 240 = 1690$ W which is much larger.

c At 230 V over half of the 3 kW transmitted was transferred in heating the cable, because of its resistance, whereas at 400 kV only a very small amount was transferred in heating the cable. As the overhead cables are long they will have some resistance and the power wasted is much less at the higher voltage.

CP9g.6 equation practice

1 a 2700 W
  b 780 J
  c 1800 s

2 a 14 000 W
  b 0.43 A
  c 18 V (Accept answers with extra figures which round to these values.)

3 a 100 W
  b 8 A
  c 115 Ω

4 (Allow use of $P = \frac{V^2}{R}$ where appropriate.)

a I $P = I \times V$ = 2300 W

II $P = \frac{E}{t}$ (or $E = P \times t$) = 69 000 J

III $P = I^2 \times R$ or $R = \frac{P}{I^2}$ = 23 Ω

b I $P = I \times V$ or $I = \frac{P}{V}$ = 0.039 A or 39 mA

II $P = I^2 \times R$ or $R = \frac{P}{I^2}$ = 5900 Ω

III $E = P \times t$ = 5400 J

c $P = I \times V$ or $I = \frac{P}{V}$ = 4.17 A

$P = I^2 \times R$ or $R = \frac{P}{I^2}$ = 2.9 Ω

CP10c.3 Magnetic forces – equation practice

1 F represents force, measured in newtons (N), B represents magnetic flux density, measured in tesla (T) or N/A m, I represents current, measured in amps/amperes (A), and l represents length, measured in metres.

2 $B = \dfrac{F}{I \times l}$

3 a F = 0.2 N/A m × 1.2 A × 0.5 m = 0.12 N

b $B = \dfrac{0.06\text{ N}}{0.01\text{ A} \times 1.2\text{ m}} = 5\text{ N/A m}$

c $B = \dfrac{0.02\text{ N}}{10\text{ A} \times 20\text{ m}} = 0.0001\text{ N/A m}$

d $I = \dfrac{0.1\text{ N}}{0.01\text{ N/A m} \times 2\text{ m}} = 5\text{ A}$

e $l = \dfrac{0.016\text{ N}}{0.02\text{ N/A m} \times 2\text{ A}} = 0.4\text{ m}$

f F = 4 N/A m × 0.001 A × 0.2 m = 0.0008 N

g $I = \dfrac{0.6\text{ N}}{2\text{ N/A m} \times 0.1\text{ m}} = 3\text{ A}$

h $l = \dfrac{0.003\text{ N}}{0.005\text{ N/A m} \times 2\text{ A}} = 0.3\text{ m}$

4 50 cm = 0.5 m

$B = \dfrac{0.02\text{ N}}{5\text{ A} \times 0.5\text{ m}} = 0.008\text{ N/A m}$

5 4 mA = 0.004 A, 10 cm = 0.1 m, 2 mT = 0.002 T

F = 0.002 T × 0.004 A × 0.1 m = 0.000 000 8 N (8×10^{-7} N)

6 $I = \dfrac{3 \times 10^{-4}\text{ N}}{0.002\text{ T} \times 0.1\text{ m}} = 1.5\text{ A}$

7 $F = 2 \times 10^{-3}\text{ T} \times 0.5\text{ A} \times 0.05\text{ m} = 5 \times 10^{-5}\text{ N}$

CP11a.2 Inductive charging

1 Toothbrushes are usually used in bathrooms, often with wet hands. Using induction charging means that all the conducting components that might give the user an electric shock can be completely sealed inside an insulating case.

2 a efficiency = (useful energy transferred by the device)/(total energy supplied to the device)

So if we consider the energy each second (the power):

total energy supplied to the device each second = useful energy transferred by the device each second/efficiency

$$\text{energy supplied per second} = \frac{500\text{ J}}{0.7} = 714.3\text{ J}$$

extra energy per second = 714.3 J – 500 J = 214.3 J

b $$\text{energy supplied per second} = \frac{500\text{ J}}{0.4} = 1250\text{ J}$$

extra energy per second = 1250 J – 500 J = 750 J

3 a $\frac{0.5\text{ J}}{0.7} = 0.71\text{ J}$

b 0.71 W × 24 × 60 × 60 seconds = 61 344 J

c 0.5 W × 24 × 60 × 60 seconds = 43 200 W

4 A yes or a no answer is acceptable, as long as it is justified – although a no answer is preferable. A yes answer could be justified by convenience. A no answer is justified by referring to the energy wasted, and the need to reduce carbon dioxide emissions by trying to use more efficient appliances (which induction chargers are not).

5 power supplied when the phone is being charged $= \frac{2\text{ W}}{0.7} = 2.86\text{ W}$

so 365 × 1 × 60 × 60 s × 0.86 W = 1.314 MJ is wasted per year while the phone is being charged

energy wasted while the phone is on standby = 365 × 23 × 60 × 60 × 0.71 W = 21.45 MJ

total energy wasted in a year = 22.76 MJ

CP11a.3 Transformers equation practice sheet

1 a $\frac{12\ V \times 3\ A}{0.75\ A} = 48\ V$

b $\frac{12\ V \times 4\ A}{6\ V} = 8\ A$

c $\frac{60\ V \times 4\ A}{120\ V} = 2\ A$

d $\frac{20\ V \times 30\ A}{5\ A} = 120\ V$

e $\frac{200\ V \times 0.75\ A}{50\ V} = 3\ A$

f $\frac{60\ V \times 8\ A}{32\ A} = 15\ V$

g $\frac{80\ V \times 20\ A}{5\ A} = 320\ V$

h $\frac{4000\ V \times 5\ A}{200\ V} = 100\ A$

2 Students can calculate from either the primary values or the secondary values.

a 12 V × 3 A = 36 W

b 12 V × 4 A = 48 W

c 120 V × 2 A = 240 W

d 120 V × 5 A = 600 W

e 50 V × 3 A = 150 W

f 60 V × 8 A = 480 W

g 80 V × 20 A = 1600 W

h 4000 V × 5 A = 20 000 W

3 $\frac{230\ V \times 20\ A}{33\ 000\ V} = 0.14\ A$

CP11a.6 Transformers – Homework 2

1 a Change the voltage/potential difference of an electricity supply.

b A transformer consists of an iron core with two coils of wire wrapped around it, not electrically connected to each other. The primary coil is connected to the electricity supply, the secondary coil produces the output voltage/potential difference.

c electromagnetic induction

2 a Power is the rate at which energy is transferred OR energy transferred per second.

b current through the appliance and potential difference/voltage across it

c power (W) = current (A) × potential difference (V)

3 a power = 0.04 A × 230 V = 9.2 W

b current = $\frac{9.2\text{ W}}{100\text{ V}}$ = 0.092 A

4 a V_P is the potential difference across the primary coil, I_P is the current in the primary coil.

V_S is the potential difference across the secondary coil, I_S is the current in the secondary coil.

b 100% efficiency

5 a 200 V × I_P = 10 V × 80 A, 200 V × I_P = 800,

$I_P = \frac{800}{200} = 4\text{ A}$

b 100 V × 2 A = V_S × 20 A, 200 = V_S × 20 A,

$V_S = \frac{200}{20} = 10\text{ V}$

c 10 V × 3 A = 200 V × I_S, 30 = 200 V × I_S,

$I_S = \frac{30}{200} = 0.15\text{ A}$

6 a current = $\frac{9.2\text{ W}}{4\text{ V}}$ = 2.3 A

b It is not 100% efficient, as some energy is being transferred to the surroundings by heating.

c Less: not all the energy/power transferred to the transformer is being output as electricity.

CP11b.4 Transformers and energy Homework 1

1 It wastes less energy.

2 heating

3 step-up, step-down, step-down

4 230 V – voltage used in homes, shops and schools

11 kV – voltage used by small factories

25 kV – voltage generated in power stations

33 kV – voltage used by large factories

400 kV – voltage in transmission lines

5 a step-up (SU) on left-hand transformer, step-down (SD) on all the others

b voltages from left to right: 25 kV, 400 kV, 33 kV, 11 kV, 230 V

CP12a.3 Density Equation practice sheet

1 a density = $\frac{50\ kg}{5\ m^3}$ = 10 kg/m^3

b density = $\frac{125\ kg}{2.5\ m^3}$ = 50 kg/m^3

c density = $\frac{0.8\ kg}{4\ m^3}$ = 0.2 kg/m^3

d mass = 0.8 kg/m^3 × 3 m^3 = 2.4 kg

e mass = 70 kg/m^3 × 1.5 m^3 = 105 kg

f volume = $\frac{20\ kg}{25\ kg/m^3}$ = 0.8 m^3

g volume = $\frac{0.6\ kg}{0.02\ kg/m^3}$ = 30 m^3

h mass = 15 kg/m^3 × 0.4 m^3 = 6 kg

I mass = 6 kg/m^3 × 7.5 m^3 = 45 kg

j volume = $\frac{0.8\ kg}{0.04\ kg/m^3}$ = 20 m^3

2 density = $\frac{200}{0.074}$ kg/m^3 = 2703 kg/m^3 (reference value is 2712 kg/m^3; this answer is a result of giving the volume to only 2 s.f.)

3 density = $\frac{50}{0.0044}$ kg/m^3 = 11 364 kg/m^3 (reference value is 11 340 kg/m^3, this answer is a result of giving the volume to only 2 s.f.)

4 volume = $\frac{12.4\ kg}{19\ 320\ kg/m^3}$ = 0.000 62 m^3

5 density = $\frac{1030\ g}{1000\ cm^3}$ = 1.03 g/cm^3

6 a 30 g = 0.03 kg,

density = $\frac{0.03\ kg}{0.05\ m^3}$ = 0.6 kg/m^3

b 60 g = 0.06 kg,

volume = $\frac{0.06\ kg}{0.8\ kg/m^3}$ = 0.075 m^3

7 mass of oil = 0.85 g/cm^3 × 30 cm^3 = 25.5 g

mass of vinegar = 1.05 g/cm^3 × 10 cm^3
= 10.5 g

total mass = 25.5 g + 10.5 g = 36 g

8 volume of hydrogen = $\frac{0.2\ kg}{0.08\ kg/m^3}$ = 2.5 m^3

volume of air = $\frac{0.2\ kg}{1.205\ kg/m^3}$ = 0.166 m^3

difference = 2.5 m^3 – 0.166 m^3 = 2.334 m^3

CP12 Particles and CP13 Forces

CP12c.3 Energy Equation practice sheet

1 a energy = 2 kg × 1005 J/kg °C × 10 °C
= 20 100 J

b energy = 5 kg × 840 J/kg °C × 20 °C
= 84 000 J

c temperature change

$$= \frac{5000\text{ J}}{3\text{ kg} \times 880\text{ J/kg °C}} = 1.9\text{ °C}$$

d $\text{specific heat capacity} = \frac{62\,790\text{ J}}{20\text{ kg} \times 15\text{ °C}}$
= 209.3 J/kg °C

e $\text{mass} = \frac{10\,000\text{ J}}{800\text{ J/kg °C} \times 5\text{ °C}} = 2.5\text{ kg}$

f temperature change

$$= \frac{3000\text{ J}}{10\text{ kg} \times 1480\text{ J/kg °C}} = 0.2\text{ °C}$$

g $\text{mass} = \frac{2500\text{ J}}{4182\text{ J/kg °C} \times 20\text{ °C}} = 0.03\text{ kg}$

h $\text{specific heat capacity} = \frac{673\,500\text{ J}}{50\text{ kg} \times 30\text{ °C}}$
= 449 J/kg °C

2 a energy = 10 kg × 1480 J/kg °C × 80 °C
= 1 184 000 J

b energy = 10 kg × 800 J/kg °C × 80 °C
= 640 000 J

c $\text{mass} = \frac{20\,000\text{ J}}{800\text{ J/kg °C} \times 80\text{ °C}} = 0.3125\text{ kg}$

3 a energy = 0.5 kg × 846 000 J/kg
= 423 000 J

b $\text{mass} = \frac{5\,000\text{ J}}{846\,000\text{ J/kg}} = 0.006\text{ kg}$

c $\text{latent heat} = \frac{5960\text{ J}}{0.02\text{ kg}} = 298\,000\text{ J/kg}$

d $\text{latent heat} = \frac{20\,860\,000\text{ J}}{70\text{ kg}} = 298\,000\text{ J/kg}$

e energy = 25 kg × 2 257 000 J/kg
= 56 425 000 J

f $\text{mass} = \frac{950\,000\text{ J}}{2\,257\,000\text{ J/kg}} = 0.42\text{ kg}$

g $\text{mass} = \frac{321\,600\text{ J}}{402\,000\text{ J/kg}} = 0.8\text{ kg}$

h energy = 0.2 kg × 402 000 J/kg = 80 400 J

4 a energy = 3 kg × 298 000 J/kg = 894 000 J

b energy = 0.5 kg × 846 000 J/kg
= 423 000 J

c energy = 0.02 kg × 402 000 J/kg = 8040 J

5 $\text{mass} = \frac{80\,000\text{ J}}{846\,000\text{ J/kg}} = 0.095\text{ kg}$

6 $\text{latent heat} = \frac{6\,420\,000\text{ J}}{20\text{ kg}} = 321\,000\text{ J/kg}$

7 a copper: $\Delta\theta$ = 1495 °C – 20 °C = 1475 '

energy = 0.5 kg × 390 J/kg °C × 1475
= 287 625 J

silver: $\Delta\theta$ = 961 °C – 20 °C = 941 °C

energy = 0.5 kg × 230 J/kg °C × 941 °
= 108 215 J

gold: $\Delta\theta$ = 1063 °C – 20 °C = 1043 °C

energy = 0.5 kg × 130 J/kg °C × 1043
= 67 795 J

b energy needed to reach melting point
= 287 625 J

energy available to melt copper
= 300 000 J – 287 625 J = 12 375 J

$\text{mass of copper melted} = \frac{12\,375\text{ J}}{207\,000\text{ J/kg}}$
= 0.06 kg

a energy needed to reach melting point
= 108 215 J

energy available to melt silver
= 200 000 J – 108 215 J = 91 785 J

energy needed to melt all the silver
= 0.5 kg × 88 000 J/kg = 44 000 J

energy to heat liquid silver
= 91 785 J – 44 000 J = 47 785 J

temperature rise in liquid silver

$$= \frac{47\,785\text{ J}}{0.5\text{ kg} \times 280\text{ J/kg °C}} = 415.5\text{ °C}$$

final temperature = 961 °C + 415.5 °C
= 1376.5 °C = 1380 °C (3 s.f.)

b energy needed to reach melting point =
0.05 kg × 130 J/kg °C × (1063 °C – 20 °C)
= 6779.5 J

energy needed to melt gold =
0.05 kg × 67 000 J/kg = 3350 J

energy needed to heat liquid gold to 1200 °C
= 0.05 kg × 150 J/kg °C ×
(1200 °C – 1063 °C) = 1027.5 J

total energy = 6779.5 J + 3350 J + 1027.5 J
= 11 157 J = 1.12×10^4 J

CP12c.6 Energy calculations Homework 2

1 a energy = 0.5 kg × 10 N/kg × 1.2 m = 6 J

b 6 J × 20 = 120 J

c $c = \dfrac{120\ \text{J}}{(0.5\ \text{kg} \times 1.5\ °\text{C})} = 160\ \text{J/kg °C}$

d Some of the thermal energy transferred to the lead would then have been transferred to the surroundings and the bung and tube. If all the energy had stayed in the lead, the temperature rise would have been greater and the calculated value of specific heat capacity would have been lower.

2 a energy transferred = 1400 W/m^2 × 3600 s
= 5 040 000 J

sand: temperature change

$= \dfrac{5\,040\,000\ \text{J}}{(100\ \text{kg} \times 835\ \text{J/kg °C})} = 60.4\ °\text{C}$

water: temperature change

$= \dfrac{5\,040\,000\ \text{J}}{(100\ \text{kg} \times 4200\ \text{J/kg °C})} = 12\ °\text{C}$

b No energy is transferred from the material being heated to its surroundings.

3 a energy = 1.5 kg × 4182 J/kg °C × 90 °C
= 564 570 J

b mass $= \dfrac{564\,570\ \text{J}}{2\,257\,000\ \text{J/kg}} = 0.25\ \text{kg}$

4 a energy = 0.150 kg × 4182 J/kg °C × 20 °C
= 12 546 J

b energy = 0.015 kg × 334 000 J/kg
= 5010 J

c energy stored = 12 546 J – 5010 J
= 7536 J

temperature $= \dfrac{7536\ \text{J}}{0.165\ \text{kg} \times 4182\ \text{J/kg °C}}$
= 10.9 °C

5 The energy transferred to the lead shot as it falls is calculated from the gravitational potential energy and is proportional to the mass of lead shot. The specific heat capacity is calculated by dividing the energy transferred by the change in temperature and the mass. The mass cancels out.

CP13b.2 Extension and energy transfers – Equation practice

1 a $f = 2\text{ N/m} \times 0.2\text{ m} = 0.4\text{ N}$

b $f = 15\text{ N/m} \times 0.6\text{ m} = 9\text{ N}$

c $k = \frac{6\text{ N}}{2\text{ m}} = 3\text{ N/m}$

d $x = \frac{5\text{ N}}{50\text{ N/m}} = 0.1\text{ m}$

e $x = \frac{16\text{ N}}{800\text{ N/m}} = 0.02\text{ m}$

f $k = \frac{37.5\text{ N}}{0.5\text{ m}} = 75\text{ N/m}$

g $f = 28\text{ N/m} \times 0.03\text{ m} = 0.84\text{ N}$

h $x = \frac{0.005\text{ N}}{0.01\text{ N/m}} = 0.5\text{ m}$

2 $k = \frac{20\text{ N}}{0.02\text{ m}} = 1000\text{ N/m}$

3 $k = \frac{30\text{ N}}{0.13\text{ m} - 0.1\text{ m}} = 1000\text{ N/m}$

4 $k = \frac{10\,000\text{ N}}{0.05\text{ m}} = 200\,000\text{ N/m}$

5 $k = \frac{1000\text{ N}}{0.05\text{ m}} = 20\,000\text{ N/m}$

6 $k = \frac{120\text{ N}}{0.003\text{ m}} = 40\,000\text{ N/m}$

7 a $E = 0.5 \times 4\text{ N/m} \times (0.3\text{ m})^2 = 0.18\text{ J}$

b $E = 0.5 \times 16\text{ N/m} \times (0.5\text{ m})^2 = 2.0\text{ J}$

c $E = 0.5 \times 6\text{ N/m} \times (3\text{ m})^2 = 27\text{ J}$

d $k = \frac{0.8\text{ J}}{(0.5 \times (0.2\text{ m})^2)} = 40\text{ N/m}$

e $k = \frac{0.48\text{ J}}{(0.5 \times (0.04\text{ m})^2)} = 600\text{ N/m}$

f $k = \frac{9\text{ J}}{(0.5 \times (0.6\text{ m})^2)} = 50\text{ N/m}$

g $E = 0.5 \times 14\text{ N/m} \times (0.04\text{ m})^2 = 0.0112\text{ J}$

h $k = \frac{0.0064\text{ J}}{(0.5 \times (0.8\text{ m})^2)} = 0.02\text{ N/m}$

8 $E = 0.5 \times 50\text{ N/m} \times (0.2\text{ m})^2) = 1\text{ J}$

9 a $x^2 = \frac{200\text{ J}}{(0.5 \times 20\text{ N/m})} = 20,$

$x = 4.47\text{ m}$ (or 4.5 m)

b $x^2 = \frac{15\text{ J}}{(0.5 \times 20\text{ N/m})} = 1.5,$

$x = 1.22\text{ m}$ (or 1.2 m)

c $x^2 = \frac{50\text{ J}}{(0.5 \times 20\text{ N/m})} = 5,$

$x = 2.24\text{ m}$ (or 2.2 m)

10 $E = 0.5 \times 30\,000\text{ N/m} \times (0.1\text{ m})^2 = 150\text{ J}$

11 $k = \frac{20\text{ N}}{0.5\text{ m}} = 40\text{ N/m}$

$E = 0.5 \times 40\text{ N/m} \times (0.5\text{ m})^2 = 5\text{ J}$

12 $k = \frac{50\text{ J}}{0.5 \times (0.01\text{ m})^2} = 1\,000\,000\text{ N/m}$

$F = 1\,000\,000\text{ N/m} \times 0.01\text{ m} = 10\,000\text{ N}$

CP13b.4 Extension and energy transfers – Homework 1

1 the force needed to stretch it by a metre

2 force = spring constant × extension

3 a force = 80 N/m × 0.1 m = 8 N

b extension = $\frac{2 \text{ N}}{80 \text{ N/m}}$ = 0.025 m

4 energy = 0.5 × 80 N/m × $(0.4 \text{ m})^2$ = 6.4 J

5 spring constant = $\frac{300 \text{ J}}{(0.5 \times (0.2 \text{ m})^2)}$

= 15 000 N/m