

Now test yourself answers

Chapter 1

- 1 $\text{kg m}^2 \text{s}^{-3}$
- 2 time
- 3 kilogram and kelvin
- 4 units of p : $\text{Pa} = \text{N m}^{-2} = (\text{kg}^1 \text{m}^1 \text{s}^{-2}) (\text{m}^{-2}) = \text{kg m}^{-1} \text{s}^{-2}$
units of hpg : $(\text{m}^1) (\text{kg}^1 \text{m}^{-3}) (\text{m}^1 \text{s}^{-2}) = \text{kg m}^{-1} \text{s}^{-2}$
- 5 units of F : $= \text{kg m s}^{-2}$
units of $6\pi\eta r v$: $(\text{kg}^1 \text{m}^{-1} \text{s}^{-1}) (\text{m}^1) (\text{m}^1 \text{s}^{-1}) = \text{kg m s}^{-2}$
- 6 $1.5 \times 10^{11} \text{ m}$
- 7 400 nm
- 8 1.0×10^9
- 9 $\pm 0.1 \text{ s}$
- 10 a C
b D
- 11 2100 N , 18°
- 12 vertically 470 N , horizontally 170 N

Chapter 2

- 1 displacement, velocity and acceleration
- 2 $a = 6.5 \text{ s}$
- 3 $a = 3.8 \text{ m s}^{-2}$
- 4 a $v = 33 \text{ m s}^{-1}$
b Graph x-axis labelled time, y-axis labelled speed.
Straight line from origin to point A (7.5, 33).
Horizontal line from A to point B (27.5, 33).
Straight line from B to point C (30.5, 0).
c $a = \text{gradient of the graph} = \Delta y / \Delta x = (0 - 33) / (30.5 - 27.5) = -11 \text{ m s}^{-2}$. This is the acceleration so the deceleration $= 11 \text{ m s}^{-2}$
d $s = 830 \text{ m}$
- 5 $a = \Delta v / \Delta t \rightarrow \Delta v = a \Delta t = 3.0 \times 4.2 = 12.6 \text{ m s}^{-1} \rightarrow 13 \text{ m s}^{-1}$
- 6 a $t = 29 \text{ s}$
b $a = 0.41 \text{ m s}^{-2}$
- 7 $a = 1.7 \text{ m s}^{-2}$
- 8 a Parabolic
b i Consider the vertical motion only: 0.49 s
ii Consider the horizontal movement only:
 $s = 140 \text{ m}$
c Assumption: air resistance is negligible
Effect on answer: there is air resistance, which means that the bullet slows down and the distance travelled before hitting the ground is less than that calculated.

Chapter 3

- 1 $p = 5.1 \times 10^{-19} \text{ N s}$
- 2 $v = 20 \text{ m s}^{-1}$
- 3 a $a = 2.9 \text{ m s}^{-2}$
b $F = ma = 1200 \times 2.86 = 3400 \text{ N}$
c $p = 22000 \text{ N s}$
- 4 Towards the centre of the Earth
- 5 Vertically downwards towards the Earth
- 6 Weight (downwards), frictional force (upwards) and buoyancy/upthrust force (upwards)
Resultant force $= 0$, the object is moving with a constant speed.
- 7 0.92 m s^{-1}
- 8 a 5.0 m s^{-1}
b kinetic energy before the collision $= \frac{1}{2} \times 0.25 \times 169 = 21.1 \text{ J}$
kinetic energy after the collision $= \frac{1}{2} \times (0.25 + 0.40) \times 25 = 8.1 \text{ J}$
The kinetic energy before the collision is more than the kinetic energy after the collision; therefore, the collision is inelastic.
- 9 a Momentum in a westerly direction $= 9.3 \text{ N s}$
b Momentum in a northerly direction $= 11 \text{ N s}$

Chapter 4

- 1 a 7.5 N m (750 N cm)
b 3.8 N m (380 N cm)
- 2 2.6 N m
- 3 $T = Fd = 4.2 \times 0.66 = 7.6 \text{ N cm}$
- 4 $T = Fd = 8 \times 2.4 = 19 \text{ N cm}$
- 5 Resultant torque on the ruler $= 0 = 2.0 \times (30 - 14) + (30 - 50) W$, where W is the weight of the ruler
 $W = (2.0 \times 16) / 20 = 1.6 \text{ N}$
mass $= 1.6 / 9.81 = 0.163 \text{ kg}$ which rounds to 0.16 kg
- 6 2.8 N
- 7 5.2 N
- 8 $2.7 \times 10^{-4} \text{ m}^3$ (270 cm³)
- 9 3.7 kg (3700 g)
- 10 $5.7 \times 10^3 \text{ Pa}$
- 11 $6.7 \times 10^3 \text{ Pa}$
- 12 $1.0 \times 10^5 \text{ Pa}$
- 13 a $A\rho g$
b $h\rho g$ and $(h + y)\rho g$
c $h\rho g A$

- d** $(h + y)\rho gA$
e $y\rho gA$
f The two formulae are identical in spite of the variables being in different orders.

Chapter 5

- 1 a** 27 J
b 23 J
c 0 J
2 a 100 J
b 25 J
3 a 7.55×10^5 J
b 0.30 or 30%
4 3.5×10^5 J
5 7.1×10^2 J
6 46 J
7 a 74 J
b 74 J
8 0.64 W
9 a 3.68×10^6 J
b 20 kW
10 $P = F/v$, so $F = P/v = 45\,000/24 = 1875$ N, which rounds to 1900 N
11 a 100 J
b 50 J
c 50 J
12 a 74 J
b 49 J
c 25 J

Chapter 6

- 1 a** 1.63×10^3 N m⁻¹
b 36 N
2 a

Mass of the load/g	Load/N	Length of the spring/cm	Extension/cm
0	0.000	26.2	0.0
100	0.981	28.3	2.1
200	1.96	30.4	4.2
300	2.94	32.8	6.4
500	4.91	36.6	10.4
600	5.89	38.8	12.6

- b** Two possible graphs, depending on which variable is plotted on which axis.
 1st graph: x-axis labelled 'Extension/cm'; y-axis labelled 'Load/N'
 2nd graph: x-axis labelled 'Load/N'; y-axis labelled 'Extension/cm'

These should give a straight-line graph through the origin. (Watch for the jump in masses added between 300 g and 500 g.)

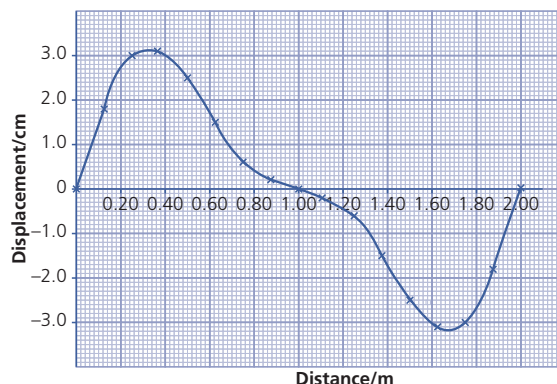
- c** 1st graph: gradient = $k = 0.47$ N cm⁻¹
 2nd graph: gradient = 2.13 cm N⁻¹,
 $k = 1/\text{gradient}$, therefore $k = 0.47$ N cm⁻¹

- 3** 1.6 J
4 8.7 kJ
5 3.8×10^9 Pa
6 2.7×10^{-3}

Chapter 7

- 1** $f = 1/T$
2 Axes labelled (time and displacement), sine wave drawn as in Figure 7.1(a), T labelled as in Figure 7.1(a) or other correct distance.
 Use $f = 1/T$
3 a i amplitude = 2 mm
ii frequency = 1.7 Hz
b The vibrations of the particles are parallel to the direction of travel of the wave.
4 Longitudinal, the trucks move back and forth in the direction of travel of the pulse.
5 The 'spot' will take less time to cross the screen therefore fewer waves will be displayed.
6 a The police officer will hear the highest frequency.
b However, the change is very small as the speed at which the police officer is running is much less than the speed of the sound.
7 a 5.91×10^{-7} m
b It is in the yellow region of the visible spectrum.
8 $0.59 I_0$

Chapter 8

- 1**
- 
- 2** $640/128 = 5$, so this is the fifth harmonic of the fundamental note of the string, thus the 640 Hz vibrations will drive this oscillation in the string.
3 a 0.80 m
b 320 m s⁻¹
4 304 m s⁻¹ ≈ 300 m s⁻¹

- 5 2.5 cm
- 6 The gap in the harbour wall, although quite wide, has a width of the order of the wavelength of the incoming waves. The waves will spread significantly after passing through the gap, causing waves in the area you might expect to be calm.

7

Type of wave	Wave-length/m	D/m	x/m	a/m
Visible light	6×10^{-7}	1	2×10^{-3}	3×10^{-4}
Sound waves	1	5	4	1.3
Micro-waves	3×10^{-2}	0.7	0.2	0.1
Ripples on a ripple tank	1×10^{-2}	0.5	0.1	5×10^{-2}

* Wavelength of visible light ranges from 3.8×10^{-7} to 7.4×10^{-7} m

- 8 2.8×10^{-4} m
- 9 4.0×10^{-7} m

Chapter 9

- 1 180 C
- 2 0.17 A
- 3 $9.1 \times 10^{24} \text{ m}^{-3}$
- 4 a 1.5 A
b 9.0 W
c 1350 C
d 8100 J
- 5 a 2.5 Ω
b 3.3 Ω
c The temperature of the filament increases as more thermal energy is transferred to it. The increased lattice vibrations reduce the mean free paths of the charge carriers.
- 6 a 960 Ω
b 17 m

Chapter 10

- 1 a 0.374 A
b 1.3 V
- 2 -0.60 A ; the minus sign shows that the current is away from the junction.
- 3 There is a single loop leading to $6.0 = 4.8I + 1.6I \rightarrow 6.0 = 6.4I$; therefore $I = 6.0/6.4 = 0.94 \text{ A}$.
- 4 12 Ω : all four resistors in series; 0.75 Ω : all four resistors in parallel; 4.0 Ω : one in series with three in parallel, 3.0 Ω : two in series, in parallel with another two in series 1.2 Ω ; two in parallel across two in series.

- 5 6.45 V
- 6 1.22 V
- 7 16.1 Ω

Chapter 11

- 1 There are two common isotopes of chlorine, Cl-35 (approximately 75%) and Cl-37 (approximately 25%). The figure given as the atomic mass, 35.5, is the weighted average of these isotopes and all the other isotopes of chlorine.
- 2 a 0, 1, 22, 21, 21
b ${}^1_1\text{H}$ and ${}^2_1\text{D}$
- 3 Each ionisation that a radioactive emission produces means a little of the kinetic energy of the emission is lost. Many collisions per unit length means much kinetic energy is lost and the emission does not travel far.
- 4 ${}^{142}_{58}\text{Ce} \rightarrow {}^{138}_{56}\text{Ba} + {}^4_2\alpha$
- 5 ${}^{90}_{39}\text{Y} \rightarrow {}^{90}_{40}\text{Zr} + {}^0_{-1}\beta$
- 6 $2e$
- 7 a $+e$
b $\bar{u}d$ and the charge is $-e$
- 8 In β^+ decay, a proton turns into a neutron with the emission of a fast moving positron and an antineutrino. A proton consists of 2 up quarks and 1 down quark, a neutron consists of 2 down quarks and 1 up quark – hence an up quark has changed to a down quark.
- 9 Two antiup quarks and one antidown quark

Chapter 12

- 1 a 30°
b 540°
c 300°
- 2 a $\pi/18 \text{ rad} = 0.17 \text{ rad}$
b $4\pi/15 \text{ rad} = 0.84 \text{ rad}$
c $3.5\pi \text{ rad} = 11 \text{ rad}$
- 3 7.9 rad s^{-1}
- 4 0.79 rad s^{-1}
- 5 3.4 ms^{-1}
- 6 a 0.37 ms^{-2}
b 0.17 N
- 7 a 0.60 rad s^{-1}
b 7200 N

Chapter 13

- 1 $7.4 \times 10^{-8} \text{ N}$
- 2 $2.0 \times 10^{20} \text{ N}$
- 3 a 7280 s, 2.0 h
b $1.6 \times 10^3 \text{ ms}^{-1}$

- 4 There is nothing special about the surface of the Earth as a reference point in space, whereas at infinity from other gravitational objects, all objects have the same potential energy per unit mass at that point.
- 5 $-2.8 \times 10^6 \text{ J kg}^{-1}$
- 6 $2.4 \times 10^3 \text{ m s}^{-1}$
- 7 **a** Taking the mass of the human body as 80 kg:
 $-5.0 \times 10^9 \text{ J}$
b $-5.0 \times 10^9 \text{ J}$

Chapter 14

- 1 B
- 2 58°C ; 331 K
- 3 $930 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$
- 4 $410 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$
- 5 $3.3 \times 10^5 \text{ J kg}^{-1}$
- 6 0.60 kg (don't forget the energy needed to raise the temperature of the water to 100°C)

Chapter 15

- 1 $1.7 \times 10^{-27} \text{ kg}$
- 2 Na: 12.0×10^{23} , C: 6.02×10^{23} , O: 18.1×10^{23}
- 3 820 cm^3
- 4 **a** 2.93 mol
b 11.7 g
- 5 $1.38 \times 10^{-23} \text{ J K}^{-1}$
- 6 **a** $18.0 \times 10^4 \text{ m}^2 \text{ s}^{-2}$
b 424 m s^{-1}
- 7 500 m s^{-1}
- 8 $6.1 \times 10^{-23} \text{ J}$

Chapter 16

- 1 The gas will either expand or be compressed, so the potential energy of the system will either be reduced or increased accordingly.

Chapter 17

- 1 **a** $f = 0.56 \text{ Hz}$
b 3.5 rad s^{-1}
c 54 cm s^{-2}
- 2 **a** 1.0 s
b 120 cm s^{-2}
- 3 $v_{\text{max}} = 24 \text{ cm s}^{-1}$
 $v_{2.5} = 20 \text{ cm s}^{-1}$
- 4 **a** 0.17 m s^{-1}
b 0.12 N
c $7.1 \times 10^{-3} \text{ J}$
d $7.1 \times 10^{-3} \text{ J}$

- 5 Critical damping is when the minimum damping is such that the potential oscillation falls to zero in the minimum time without an oscillation. Heavy damping is greater than critical damping and it takes longer for the disturbance to return to zero, without oscillation.
- 6 Resonance is when the natural frequency of vibration is equal to the driving frequency, giving a maximum amplitude of vibration.

Chapter 18

- 1 $2.2 \times 10^{-15} \text{ N}$
- 2 $2.5 \times 10^5 \text{ V m}^{-1}$
- 3 **a** No change
b Field is doubled
- 4 **a** $1.6 \times 10^4 \text{ V m}^{-1}$
b $2.8 \times 10^{15} \text{ m s}^{-2}$
- 5 230 N
- 6 $5.8 \times 10^{-13} \text{ N}$
- 7 $8.0 \times 10^4 \text{ V m}^{-1}$
- 8 $2.4 \times 10^4 \text{ V}$
- 9 $1.1 \times 10^{-10} \text{ m}$

Chapter 19

- 1 $2.6 \times 10^{-3} \text{ C}$
- 2 33 000 pF
- 3 $1.7 \times 10^{-11} \text{ F}$ (17 pF)
- 4 60 μF
- 5 One in parallel across three in series
- 6 **a** 750 μF
b 8400 μF
- 7 **a** 13.5 mC
b $6.1 \times 10^{-2} \text{ J}$
- 8 Units of $C = F = \text{C V}^{-1} = \text{A s V}^{-1}$
Units of $R = \text{V A}^{-1}$
Therefore, $RC = \text{V A}^{-1} \text{A s V}^{-1}$
Cancelling the As and the Vs leaves s (seconds)
- 9 **a** $C = 3.0 \times 10^{-2} \text{ F}$
Time for half the charge to flow off the plates
 $\tau = CR = 3.0 \times 10^{-2} \times 200 = 6.0 \text{ s}$
 $t_{1/2} = 6.0 \times \ln 2 = 4.16 \text{ s}$
b Time for half the remaining charge to flow off the plates = 4.16 s

Chapter 20

- 1 **a** Diagram similar to Figure 20.1(c)
b Same shape but the arrows in opposite directions
- 2 **a** Diagram similar to Figure 20.3(a)
b Same shape but the arrows in opposite directions

- 3 Downwards towards the bottom of the page
 4 $6.5 \times 10^{-3} \text{ N}$
 5 3.2 A
 6 0.24 T
 7 3.0 MV
 8 $1.1 \times 10^{-15} \text{ N}$
 9 140 m
 10 $1.0 \times 10^{-3} \text{ T}$
 11 E has the unit $\text{V} = \text{J C}^{-1} = \text{J}(\text{A s})^{-1} = \text{J A}^{-1} \text{ s}^{-1}$
 $N\Delta\phi/\Delta t$ has the unit: $\text{N A}^{-1} \text{ m}^{-1} \times \text{m}^2 \text{ s}^{-1} = \text{N A}^{-1} \text{ m s}^{-1}$
 $= \text{J A}^{-1} \text{ s}^{-1}$
 12 a i $9.6 \times 10^{-7} \text{ T m}^2$
 ii $1.9 \times 10^{-3} \text{ T m}^2$
 b $1.4 \times 10^{-3} \text{ T m}^2$
 13 4700 V

Chapter 21

- 1 1.7 A
 2 68 V
 3 30 W
 4 0.30 s

Chapter 22

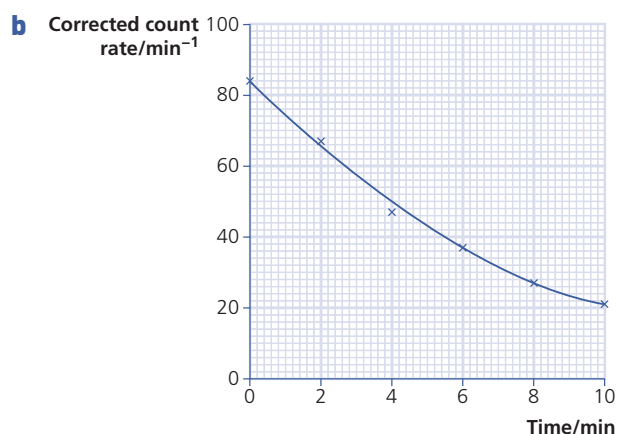
- 1 $3.4 \times 10^{-19} \text{ J}$, 2.1 eV
 2 $5.0 \times 10^{-16} \text{ J}$, 3.1 keV
 3 a $6.4 \times 10^{-13} \text{ J}$
 b 2.0 MV
 4 $2.7 \times 10^{-27} \text{ N s}$
 5 $8.9 \times 10^{14} \text{ Hz}$
 6 $1.2 \times 10^{-20} \text{ J}$
 7 a $2.3 \times 10^{-10} \text{ m}$
 b The wavelength of the neutron would be much smaller (by a factor of 1800) than the wavelength of the electron because it is much (1800 times) more massive.
 8 $1.3 \times 10^{-13} \text{ m}$
 9 a $1.2 \times 10^{-7} \text{ m}$
 b This is in the ultraviolet region of the spectrum.
 c A transition from the third to the second energy level would produce a photon in the visible spectrum.
 10 The wavelength of the photon determines the energy of the photon (the shorter the wavelength, the greater the photon energy). If the electron is right at the surface of the metal, then minimum work is done in removing the electron from the surface (the work function of the metal). Any energy left over from the removal of the electron from the surface is transferred to the kinetic energy of the released electron.

Chapter 23

- 1 $2.13 \times 10^{-30} \text{ kg}$; $2.3 \times$ rest mass of an electron
 2 7.69 MeV; $1.23 \times 10^{-12} \text{ J}$ per nucleon
 3 ${}_{94}^{239}\text{Pu} + {}_0^1\text{n} \rightarrow {}_{94}^{240}\text{Pu} \rightarrow {}_{60}^{150}\text{Nd} + {}_{34}^{88}\text{Se} + 2{}_0^1\text{n}$
 4 a ${}_1^1\text{H} + {}_1^1\text{H} \rightarrow {}_1^2\text{H} + {}_1^0\beta + {}_0^0\bar{\nu}$
 b $2.9 \times 10^{-30} \text{ kg}$; $1.7 \times 10^{-3} \text{ u}$
 5 a It means that radioactive decay is independent of external factors such as temperature and pressure.
 b The practical evidence is the inconsistency with which emissions occur. With low counts, you might detect two or three in quick succession, followed by a lag, then a single count, then a further couple of counts, etc. For higher counts, the reading (of counts per unit time) on the detector continually varies around an average number.

6 a

Time/ minutes	0	2.0	4.0	6.0	8.0	10.0
Received count rate/ minutes ⁻¹	96	78	59	47	40	33
Corrected count rate/ minutes ⁻¹	84	66	47	35	28	21



- c The scatter of the points shows the random nature of radioactive decay.
 d $5.0 \pm 0.2 \text{ min}$
 e 0.14 min^{-1}
 7 a $2.5 \times 10^{-4} \text{ h}^{-1}$
 b 2800 hours (120 days)

Chapter 24

- 1 The resolution of the image is determined by the wavelength of the ultrasound waves. The higher the frequency, the shorter the wavelength and the better the resolution.
- 2 $3.0 \times 10^6 \text{ Hz}$
- 3 **a** $1.4 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}$
b 9.4×10^{-3} or 0.94%
- 4 $396 \text{ kg m}^{-2} \text{ s}^{-1}$
- 5 6900 m s^{-1}
- 6 0.068 cm^{-1}
- 7 830 kV
- 8 36%
- 9 Absorption of X-rays by fatty tissue is small; longer wavelength means lower photon energy, so less damage to tissues.
- 10 CT scan gives a three-dimensional image whereas X-ray image is two-dimensional.
The precise position of an organ can be seen on a CT scan, whereas the depth of an organ in the body cannot be ascertained by simple X-rays.
Organs shielded by denser organs cannot be examined by a simple X-ray image.
Softer X-rays can be used to investigate tissues that are less absorbing than materials like bone.
- 11 ${}^{18}_{9}\text{F} \rightarrow {}^{18}_{8}\text{O} + {}^0_1\beta + {}^0_0\nu$
- 12 Before the annihilation there is zero momentum.
The momentum in any direction must therefore be zero after the annihilation event; thus, the two photons must travel in opposite directions.
They must have equal magnitude momenta for the two momenta to add up to zero (remember momentum is a vector). If they have the equal magnitude momenta, they must have equal photon energies.
- 13 $1.3 \times 10^{-15} \text{ m}$
- 14 The atoms, making up the patient, surrounding the point at which the positron is formed are rich in electrons. Consequently, the positron will travel only a very few atomic diameters before encountering an electron, resulting in annihilation of both electron and positron.

Chapter 25

- 1 $F_{\text{Earth}} : F_{\text{Mars}}$ is 1 : 0.56
- 2 $3.8 \times 10^{31} \text{ W}$
- 3 **a** $8.0 \times 10^{-7} \text{ m}$
b Although the peak wavelength is invisible to the human eye, there is a range of wavelengths produced, some of which are in the red end of the visible spectrum.
- 4 **a** $2.9 \times 10^{-7} \text{ m}$
b 26 : 1
- 5 $3.0 \times 10^7 \text{ m s}^{-1}$
- 6 420 nm
- 7 There is no correct answer to this question.
You might suggest that the evidence for Hubble's law itself seems quite flimsy and if this central premise is flawed, then the whole theory might come crashing down!
At a more philosophic level, if the Big Bang theory is correct, what was there before the Big Bang? Some say there was nothing, not matter, not time, not space. It is almost impossible to comprehend what such nothingness is.