

Data

speed of light in free space,	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
	$(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
elementary charge,	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant,	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant,	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant,	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall,	$g = 9.81 \text{ m s}^{-2}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
gravitational potential,	$\phi = -\frac{Gm}{r}$
hydrostatic pressure,	$p = \rho gh$
pressure of an ideal gas,	$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$
simple harmonic motion,	$a = -\omega^2 x$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$ $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
electric potential,	$V = \frac{Q}{4\pi\epsilon_0 r}$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + \dots$
capacitors in parallel,	$C = C_1 + C_2 + \dots$
energy of charged capacitor,	$W = \frac{1}{2} QV$
resistors in series,	$R = R_1 + R_2 + \dots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \dots$
alternating current/voltage,	$x = x_0 \sin \omega t$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

Answer **all** the questions in the spaces provided.

- 1 (a) The frequency of an X-ray wave is 4.6×10^{20} Hz.

Calculate the wavelength in pm.

wavelength = pm [3]

- (b) The distance from Earth to a star is 8.5×10^{16} m. Calculate the time for light to travel from the star to Earth in Gs.

time = Gs [2]

- (c) The following list contains scalar and vector quantities.

Underline **all** the scalar quantities.

acceleration force mass power temperature weight [1]

- (d) A boat is travelling in a flowing river. Fig. 1.1 shows the velocity vectors for the boat and the river water.



Fig. 1.1

The velocity of the boat in still water is 14.0 m s^{-1} to the east. The velocity of the water is 8.0 m s^{-1} from 60° north of east.

- (i) On Fig. 1.1, draw an arrow to show the direction of the resultant velocity of the boat. [1]
- (ii) Determine the magnitude of the resultant velocity of the boat.

magnitude of velocity = ms^{-1} [2]

- 2 Fig. 2.1 shows an object M on a slope.

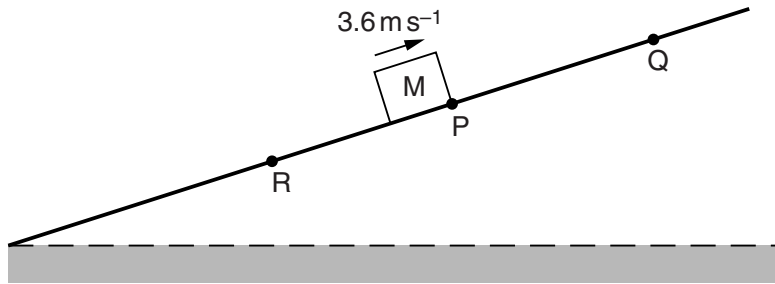


Fig. 2.1

M moves up the slope, comes to rest at point Q and then moves back down the slope to point R. M has a constant acceleration of 3.0 m s^{-2} down the slope at all times. At time $t = 0$, M is at point P and has a velocity of 3.6 m s^{-1} up the slope. The total distance from P to Q and then to R is 6.0 m.

- (a) Calculate, for the motion of M from P to Q,

- (i) the time taken,

time = s [2]

- (ii) the distance travelled.

distance = m [1]

- (b) Show that the speed of M at R is 4.8 m s^{-1} .

[2]

(c) On Fig. 2.2, draw the variation with time t of the velocity v of M for the motion P to Q to R.

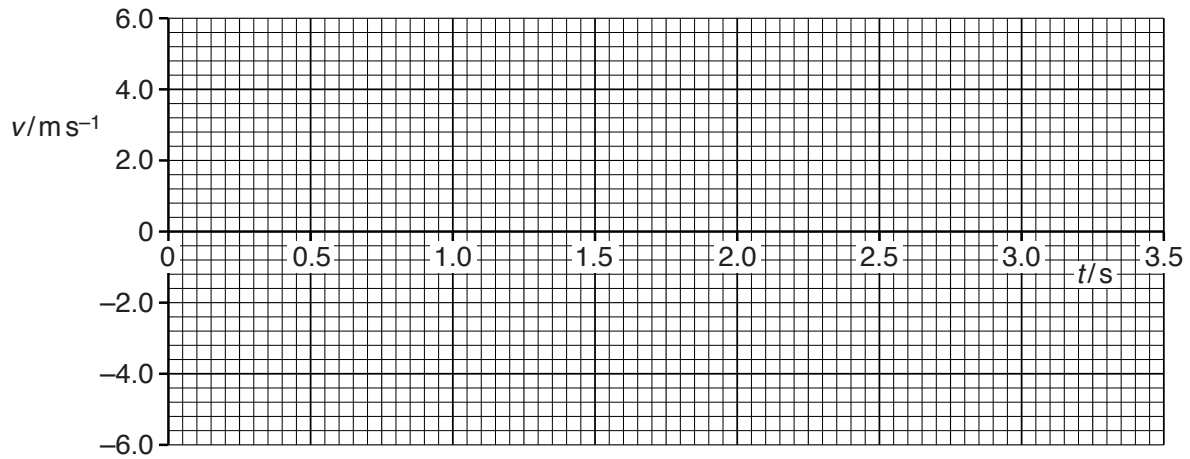


Fig. 2.2

[3]

(d) The mass of M is 450 g.

Calculate the difference in the kinetic energy of M at P and at R.

difference in kinetic energy = J [2]

- 3 A trolley T moves at speed 1.2 m s^{-1} along a horizontal frictionless surface. The trolley collides with a stationary block on the end of a fixed spring, as shown in Fig. 3.1.

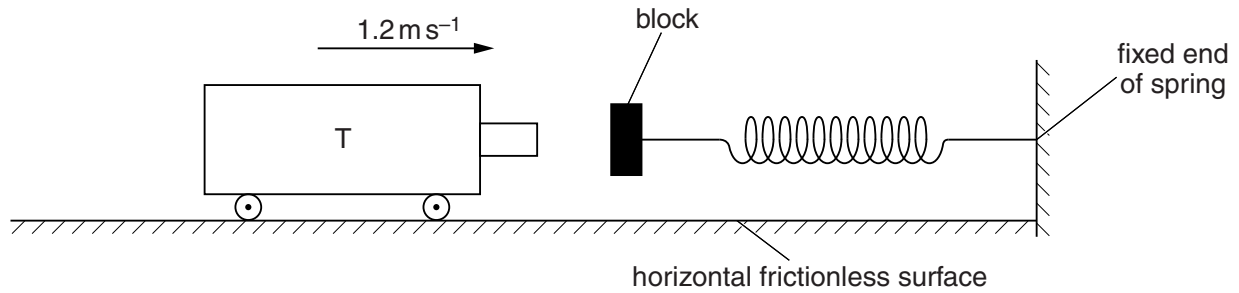


Fig. 3.1

The mass of T is 250 g. T compresses the spring by 5.4 cm as it comes to rest. The relationship between the force F applied to the block and the compression x of the spring is shown in Fig. 3.2.

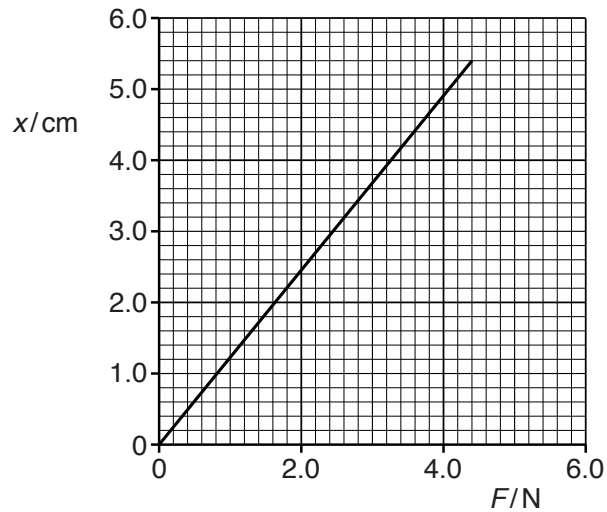


Fig. 3.2

- (a) Use Fig. 3.2 to determine
- (i) the spring constant of the spring,

spring constant = N m^{-1} [2]

- (ii) the work done by T compressing the spring by 5.4 cm.

work done = J [2]

- (b) The spring then expands and causes T to move in a direction opposite to its initial direction. At the time that T loses contact with the block, it is moving at a speed of 0.75 m s^{-1} .

From the time that T is in contact with the block,

- (i) describe the energy changes,

.....
.....
.....
..... [2]

- (ii) determine the change in momentum of T.

change in momentum = N s [2]

4 (a) Define *moment of a force*.

.....
[1]

(b) An arrangement for lifting heavy loads is shown in Fig. 4.1.

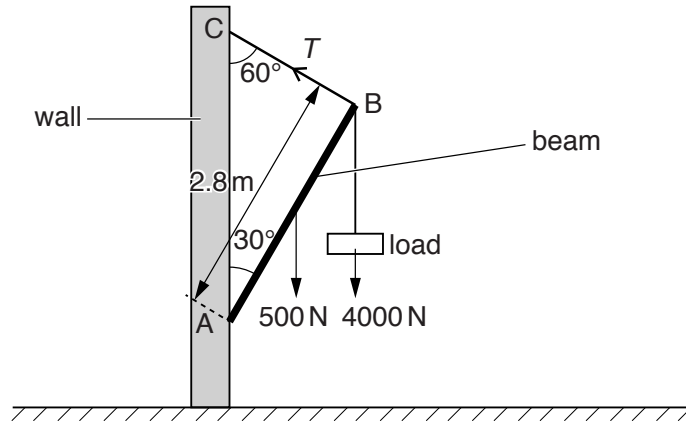


Fig. 4.1

A uniform metal beam AB is pivoted on a vertical wall at A. The beam is supported by a wire joining end B to the wall at C. The beam makes an angle of 30° with the wall and the wire makes an angle of 60° with the wall.

The beam has length 2.8m and weight of 500 N. A load of 4000 N is supported from B. The tension in the wire is T . The beam is in equilibrium.

(i) By taking moments about A, show that T is 2.1 kN.

[2]

(ii) Calculate the vertical component T_v of the tension T .

$T_v = \dots\dots\dots$ N [1]

(iii) State and explain why T_v does not equal the sum of the load and the weight of the beam although the beam is in equilibrium.

.....
[2]

- 5 A 240V power supply S with negligible internal resistance is connected to four resistors, as shown in Fig. 5.1.

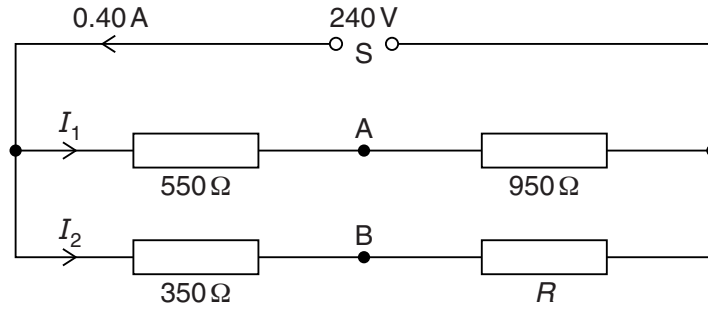


Fig. 5.1

Two resistors of resistance $550\ \Omega$ and $950\ \Omega$ are connected in series across S. Two resistors of resistance $350\ \Omega$ and R are also connected in series across S.

The current supplied by S is $0.40\ \text{A}$.
 Currents I_1 and I_2 in the circuit are shown in Fig. 5.1.

(a) Calculate

(i) current I_1 ,

$$I_1 = \dots\dots\dots \text{ A [2]}$$

(ii) resistance R ,

$$R = \dots\dots\dots \Omega [2]$$

(iii) the ratio

$$\frac{\text{power transformed in resistor of resistance } 350\ \Omega}{\text{power transformed in resistor of resistance } 550\ \Omega}$$

$$\text{ratio} = \dots\dots\dots [2]$$

(b) Two points are labelled A and B, as shown in Fig. 5.1.

(i) Calculate the potential difference V_{AB} between A and B.

$V_{AB} = \dots\dots\dots$ V [2]

(ii) The resistance R is increased.

State and explain the effect on V_{AB} .

.....
.....
.....[1]

- 6 A 12V battery with internal resistance $0.50\ \Omega$ is connected to two identical filament lamps L_1 and L_2 as shown in Fig. 6.1.

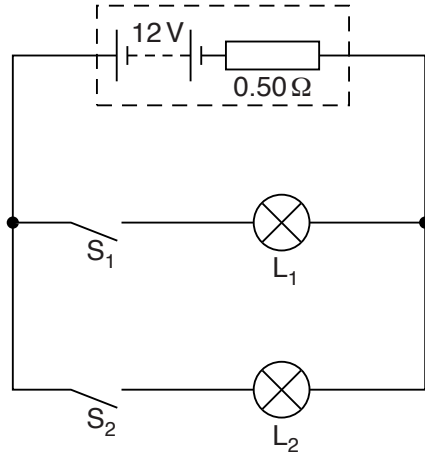


Fig. 6.1

The lamps are connected to the battery via switches S_1 and S_2 . The power rating of each lamp is 48W for a potential difference of 12V.

- (a) S_1 is closed and S_2 open.

State and explain whether the power transformed in L_1 is 48W.

.....

[2]

- (b) S_2 is now also closed.

- (i) State and explain the effect on the current in L_1 .

.....

[1]

- (ii) State and explain the effect on the resistance of L_1 .

.....

[1]

- 7 An arrangement that is used to demonstrate interference with waves on the surface of water is shown in Fig. 7.1.

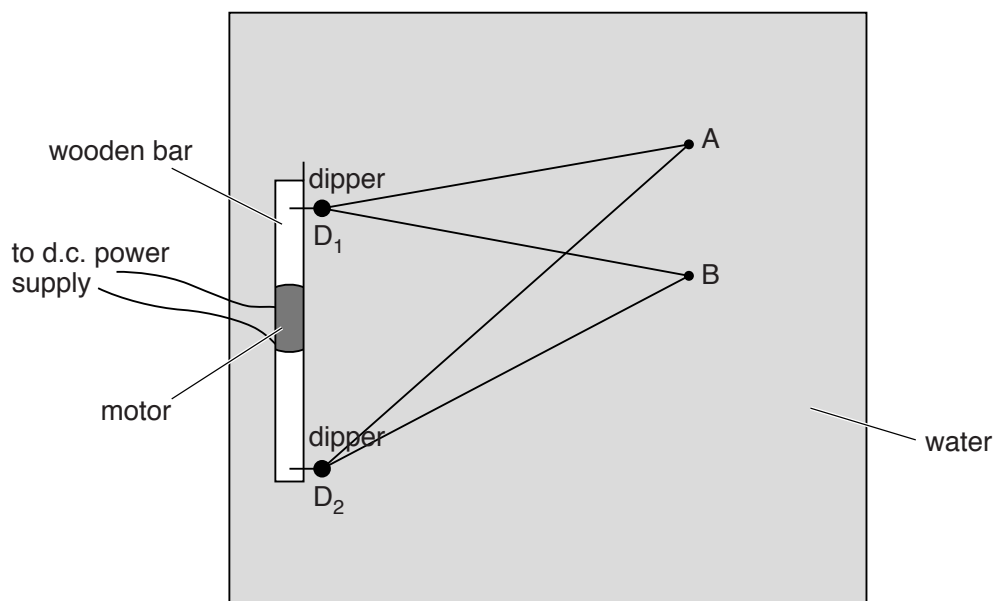


Fig. 7.1 (view from above)

- (a) Two dippers D_1 and D_2 are connected to a motor and a d.c. power supply. Initially only D_1 vibrates on the water surface to produce waves. The variation with distance x from D_1 of the displacement y of the water at one instant of time is shown in Fig. 7.2.

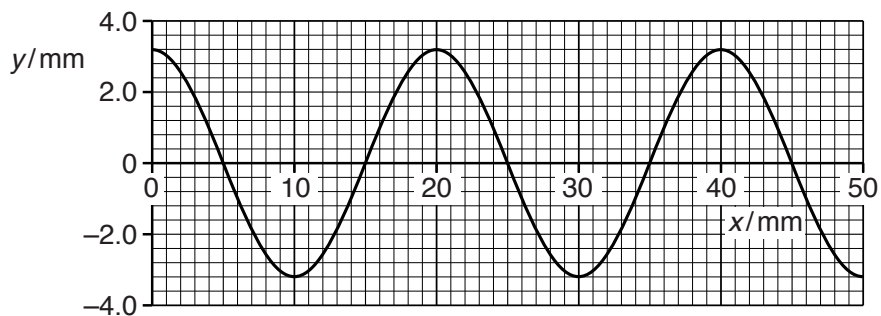


Fig. 7.2

Using Fig. 7.2, determine

- (i) the amplitude of the wave,

amplitude = mm [1]

- (ii) the wavelength of the wave.

wavelength = mm [1]

(b) The two dippers D_1 and D_2 are made to vibrate and waves are produced by both dippers on the water surface.

(i) State and explain whether these waves are stationary or progressive.

.....
[1]

(ii) Explain why D_1 and D_2 are connected to the same motor.

.....
[1]

(c) The points A and B on Fig. 7.1 are at the distances from D_1 and D_2 shown in Fig. 7.3.

D_1A	D_2A	D_1B	D_2B
5.0cm	7.0cm	5.0cm	6.0cm

Fig. 7.3

State and explain the variation with time of the displacement of the water on the surface at

(i) A,

.....

[2]

(ii) B.

.....

[1]

- 8 (a) The results of the α -particle scattering experiment gave evidence for the structure of the atom.

State two results and the associated conclusions.

result 1:

.....

conclusion 1:

.....

result 2:

.....

conclusion 2:

.....

[4]

- (b) In a model of a copper atom of the isotope ${}^{63}_{29}\text{Cu}$, the atom and its nucleus are assumed to be spherical.

The diameter of the nucleus is 2.8×10^{-14} m. The diameter of the atom is 2.3×10^{-10} m.

Calculate the ratio

$$\frac{\text{density of the nucleus}}{\text{density of the atom}}$$

ratio =[3]

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