

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 unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
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.	$v = v_0 \cos \omega t$ $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
Doppler effect	$f_o = \frac{f_s v}{v \pm v_s}$
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	$W = \frac{1}{2}QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \dots$
Hall voltage	$V_H = \frac{BI}{ntq}$
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) Determine the SI base units of stress.
Show your working.

base units[2]

- (b) A beam PQ is clamped so that the beam is horizontal. A mass M of 500 g is hung from end Q and the beam bends slightly, as illustrated in Fig. 1.1.

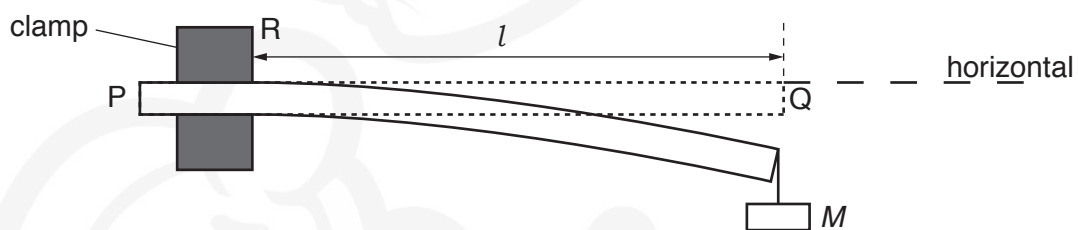


Fig. 1.1

The length l of the beam from the edge of the clamp R to end Q is 60.0 cm. The width b of the beam is 30.0 mm and the thickness d of the beam is 5.00 mm. The material of the beam has Young modulus E .

The mass M is made to oscillate vertically. The time period T of the oscillations is 0.58 s.

The period T is given by the expression

$$T = 2\pi \sqrt{\frac{4Ml^3}{Ebd^3}}.$$

- (i) Determine E in GPa.

$E = \dots\dots\dots$ GPa [3]

(ii) The quantities used to determine E should be measured with accuracy and with precision.

1. Explain the difference between accuracy and precision.

accuracy:

.....

precision:

.....

[2]

2. In a particular experiment, the quantities l and T are measured with the same percentage uncertainty. State and explain which of these two quantities contributes more to the uncertainty in the value of E .

.....

.....

.....[1]

[Total: 8]

2 (a) State the two conditions for a system to be in equilibrium.

1.
.....
2.
.....
- [2]

(b) A paraglider P of mass 95 kg is pulled by a wire attached to a boat, as shown in Fig. 2.1.

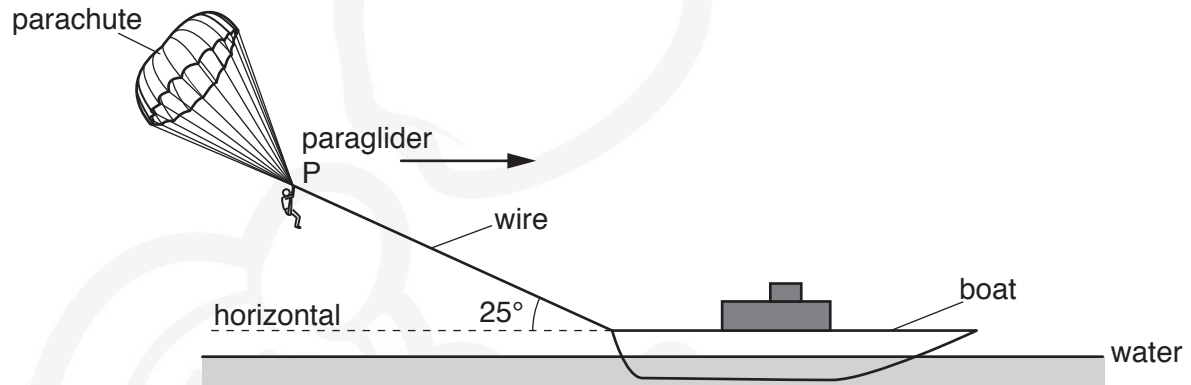


Fig. 2.1

The wire makes an angle of 25° with the horizontal water surface. P moves in a straight line parallel to the surface of the water.

The variation with time t of the velocity v of P is shown in Fig. 2.2.

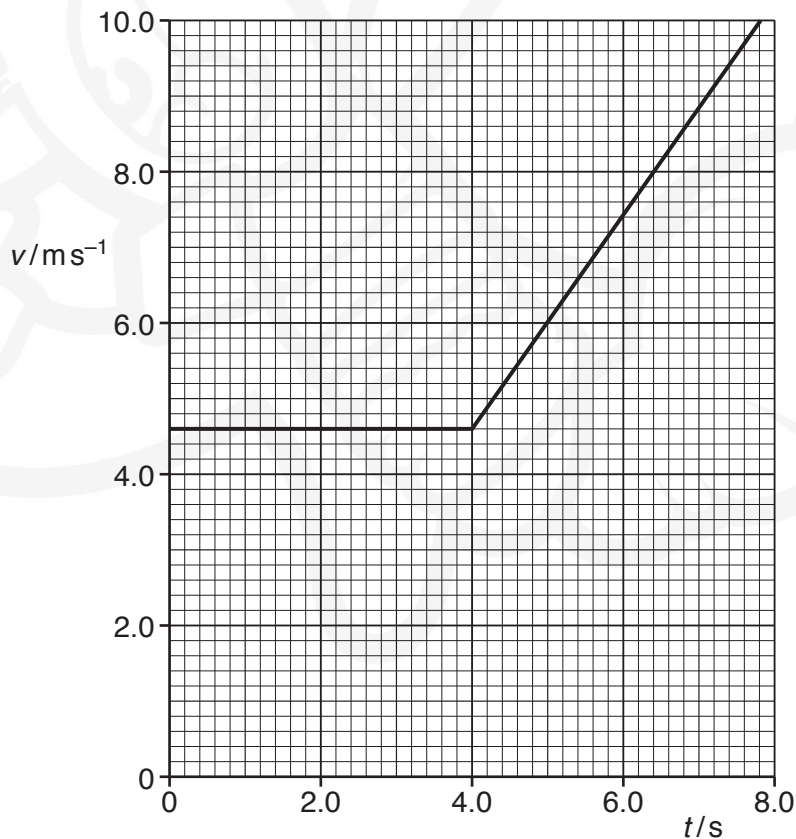


Fig. 2.2

7

- (i) Show that the acceleration of P is 1.4 ms^{-2} at time $t = 5.0 \text{ s}$.

[2]

- (ii) Calculate the total distance moved by P from time $t = 0$ to $t = 7.0 \text{ s}$.

distance =m [2]

- (iii) Calculate the change in kinetic energy of P from time $t = 0$ to $t = 7.0 \text{ s}$.

change in kinetic energy =J [2]

- (iv) The tension in the wire at time $t = 5.0 \text{ s}$ is 280 N .

Calculate, for the horizontal motion,

1. the vertical lift force F supporting P,

$F = \dots\dots\dots \text{ N}$ [3]

2. the force R due to air resistance acting on P in the horizontal direction.

$R = \dots\dots\dots \text{ N}$ [3]

[Total: 14]

- 3 (a) A cylinder is made from a material of density 2.7 g cm^{-3} . The cylinder has diameter 2.4 cm and length 5.0 cm .

Show that the cylinder has weight 0.60 N .

[3]

- (b) The cylinder in (a) is hung from the end A of a non-uniform bar AB, as shown in Fig. 3.1.

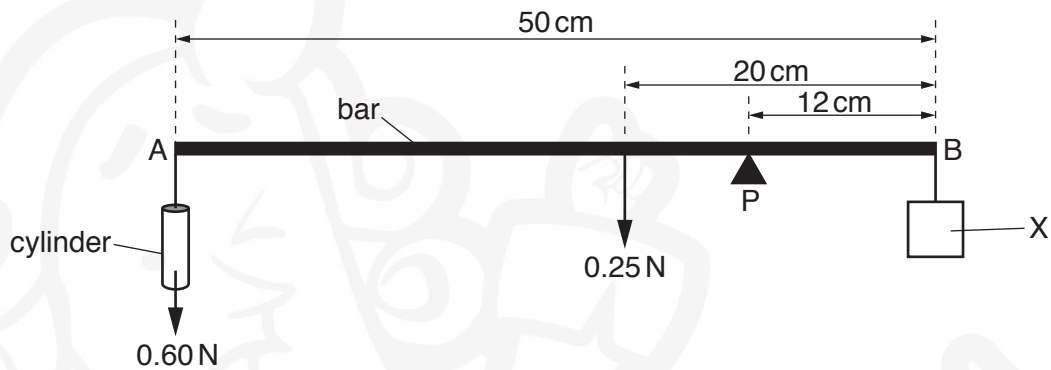


Fig. 3.1

The bar has length 50 cm and has weight 0.25 N . The centre of gravity of the bar is 20 cm from B. The bar is pivoted at P. The pivot is 12 cm from B.

An object X is hung from end B. The weight of X is adjusted until the bar is horizontal and in equilibrium.

- (i) Explain what is meant by *centre of gravity*.

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

- (ii) Calculate the weight of X.

weight of X = N [3]

- (c) The cylinder is now immersed in water, as illustrated in Fig. 3.2.

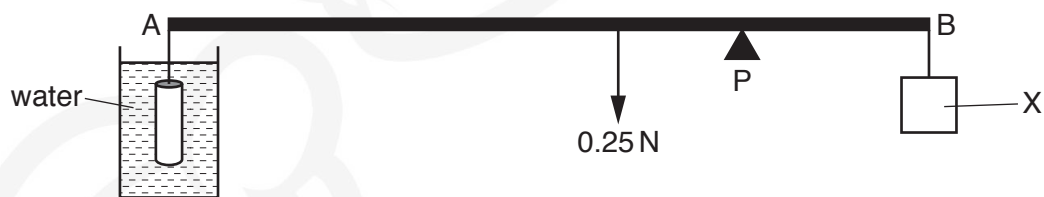


Fig. 3.2

An upthrust acts on the cylinder and the bar is not in equilibrium.

- (i) Explain the origin of the upthrust.

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

- (ii) Explain why the weight of X must be reduced in order to obtain equilibrium for AB.

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

[Total: 10]

- 4 (a) State the conditions required for the formation of stationary waves.

.....

.....

.....[2]

- (b) One end of a string is attached to a vibrator. The string is stretched by passing the other end over a pulley and attaching a load, as illustrated in Fig. 4.1.

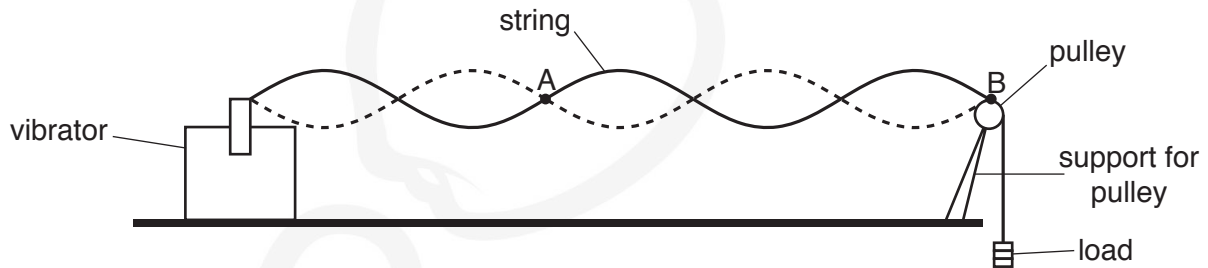


Fig. 4.1

The frequency of vibration of the vibrator is adjusted to 250 Hz and a transverse wave travels along the string with a speed of 12 m s^{-1} . The wave is reflected at the pulley and a stationary wave forms on the string.

Fig. 4.2 shows the string between points A and B at time $t = t_1$.

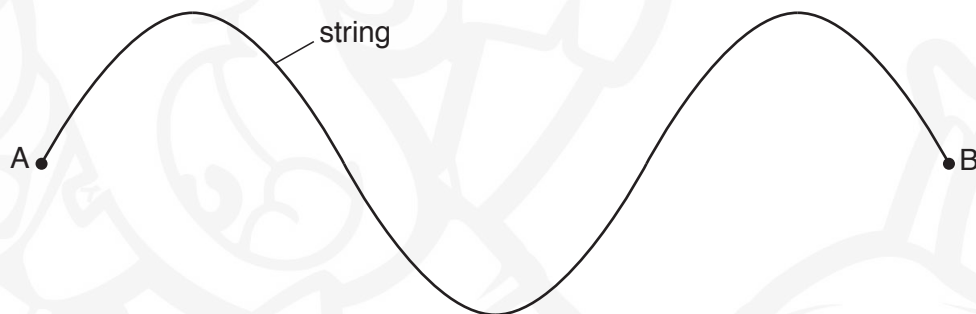


Fig. 4.2

At time $t = t_1$ the string has maximum displacement.

- (i) Calculate the distance AB.

distance =m [2]

(ii) On Fig. 4.2, sketch the position of the string between A and B at times

1. $t = t_1 + 2.0 \text{ ms}$ (label this line P),
2. $t = t_1 + 5.0 \text{ ms}$ (label this line Q).

[3]

[Total: 7]





- 5 (a) Describe the Doppler effect.

.....

.....

.....[1]

- (b) A car travels with a constant velocity along a straight road. The car horn with a frequency of 400 Hz is sounded continuously. A stationary observer on the roadside hears the sound from the horn at a frequency of 360 Hz.
The speed of sound is 340 m s^{-1} .

Determine the magnitude v , and the direction, of the velocity of the car relative to the observer.

$v = \text{.....} \text{ m s}^{-1}$
direction [3]

[Total: 4]

- 6 (a) Define the *ohm*.

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

- (b) A cell X of electromotive force (e.m.f.) 1.5 V and negligible internal resistance is connected in series to three resistors A, B and C, as shown in Fig. 6.1.

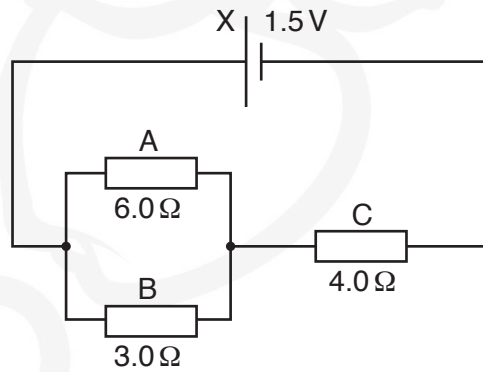


Fig. 6.1

Resistors A and B have resistances 6.0Ω and 3.0Ω respectively and are connected in parallel. Resistor C has resistance 4.0Ω and is connected in series with the parallel combination.

Calculate

- (i) the current in the circuit,

current =A [3]

- (ii) the current in resistor B,

current =A [1]

(iii) the ratio

$$\frac{\text{power dissipated in resistor B}}{\text{power dissipated in resistor C}}$$

ratio =[2]

(c) The resistors A, B and C in (b) are wires of the same material and have the same length.

(i) Explain how the resistors may be made with different resistance values.

.....[1]

(ii) Calculate the ratio

$$\frac{\text{average drift speed of the charge carriers in resistor B}}{\text{average drift speed of the charge carriers in resistor C}}$$

ratio =[2]

(d) A cell of e.m.f. 1.5 V and negligible internal resistance is connected in parallel with cell X in Fig. 6.1 with their positive terminals together.

State the change, if any, to the current in

(i) cell X,

.....[1]

(ii) resistor C.

.....[1]

[Total: 12]

7 (a) Use the quark model to show that

(i) the charge on a proton is $+e$,

.....[1]

(ii) the charge on a neutron is zero.

.....[1]

(b) A nucleus of ${}^{90}_{38}\text{Sr}$ decays by the emission of a β^- particle. A nucleus of ${}^{64}_{29}\text{Cu}$ decays by the emission of a β^+ particle.

(i) In Fig. 7.1, state the nucleon number and proton number for the nucleus produced in each of these decay processes.

	nucleus formed by β^- decay	nucleus formed by β^+ decay
nucleon number		
proton number		

Fig. 7.1

[1]

(ii) State the name of the force responsible for β decay.

.....[1]

(iii) State the names of the leptons produced in each of the decay processes.

β^- decay:

β^+ decay:

[1]

[Total: 5]

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