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PHYSICS

9702/21

Paper 2 AS Structured Questions

October/November 2015

1 hour

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.

You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [] at the end of each question or part question.

This document consists of **15** printed pages and **1** blank page.

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) State two SI base quantities other than mass, length and time.

1.

2.

[2]

- (b) A beam is clamped at one end and an object X is attached to the other end of the beam, as shown in Fig. 1.1.

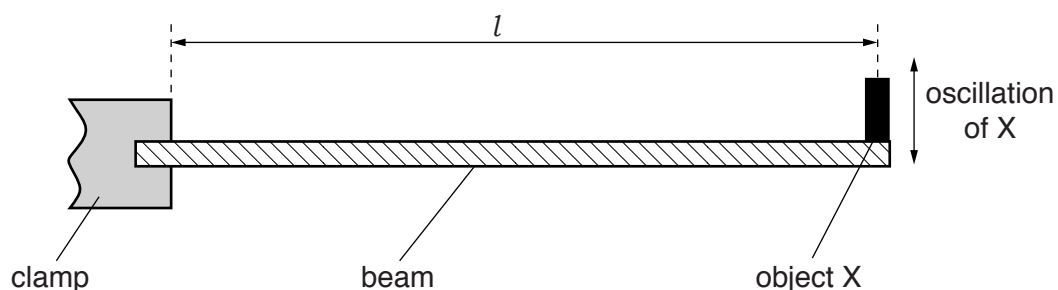


Fig. 1.1

The object X is made to oscillate vertically.

The time period T of the oscillations is given by

$$T = K \sqrt{\frac{Ml^3}{E}}$$

where M is the mass of X,

l is the length between the clamp and X,

E is the Young modulus of the material of the beam

and K is a constant.

- (i) 1. Show that the SI base units of the Young modulus are $\text{kg m}^{-1} \text{s}^{-2}$.

[1]

2. Determine the SI base units of K .

SI base units of K [2]

(ii) Data in SI units for the oscillations of X are shown in Fig. 1.2.

quantity	value	uncertainty
T	0.45	$\pm 2.0\%$
l	0.892	$\pm 0.2\%$
M	0.2068	$\pm 0.1\%$
K	1.48×10^5	$\pm 1.5\%$

Fig. 1.2

Calculate E and its actual uncertainty.

$E = \dots \pm \dots \text{ kg m}^{-1} \text{ s}^{-2}$ [4]

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- 2 The signal from a microwave detector is recorded on a cathode-ray oscilloscope (c.r.o.), as shown in Fig. 2.1.

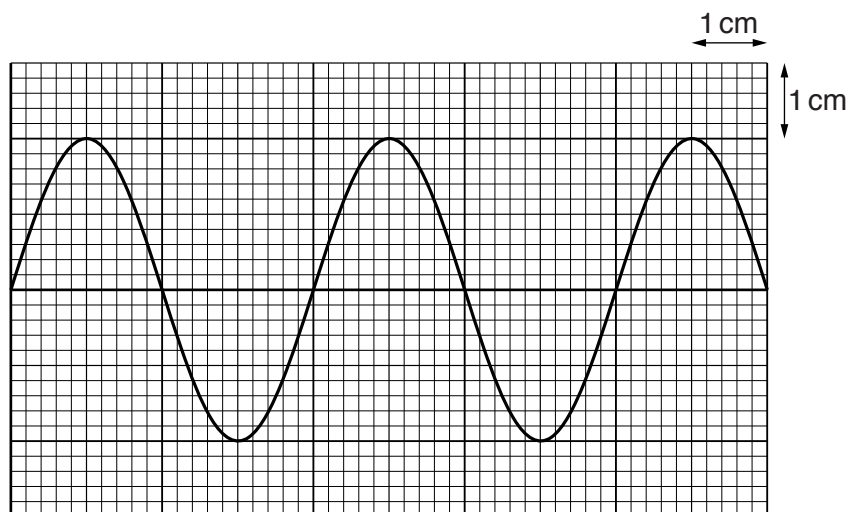


Fig. 2.1

The time-base setting on the c.r.o. is 50 ps cm^{-1} .

- (a) Using Fig. 2.1, determine the wavelength of the microwaves.

wavelength = ... m [4]

- (b) The signal from a radio wave detector is recorded on the same c.r.o.
The wavelength of the radio waves is $1.5 \times 10^3 \text{ m}$.

Determine the time-base setting required to display the same number of oscillations on the c.r.o. as shown in Fig. 2.1.

time-base setting = ... unit..... [2]

- 3 (a) An object is moved from point P to point R either by a direct path or by the path P to Q to R, as shown in Fig. 3.1.

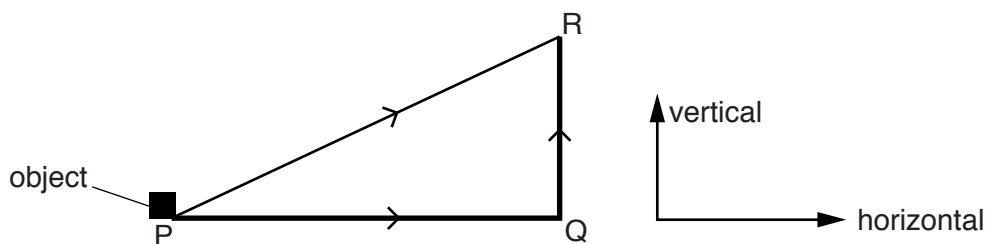


Fig. 3.1

P and Q are on the same horizontal level. R is vertically above Q.

Explain whether the work done moving the object against the gravitational field is the same or different along paths PR and PQR.

.....

[2]

- (b) A ball is thrown with an initial velocity V at an angle θ to the horizontal, as shown in Fig. 3.2.

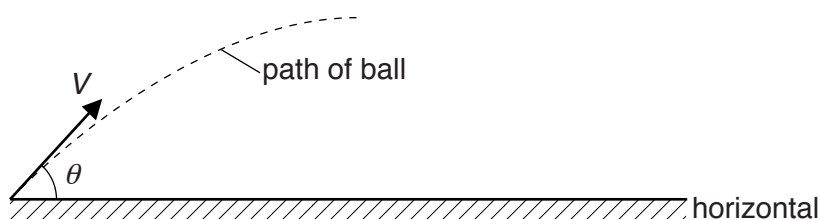


Fig. 3.2 (not to scale)

The variation with time t of the height h of the ball is shown in Fig. 3.3.

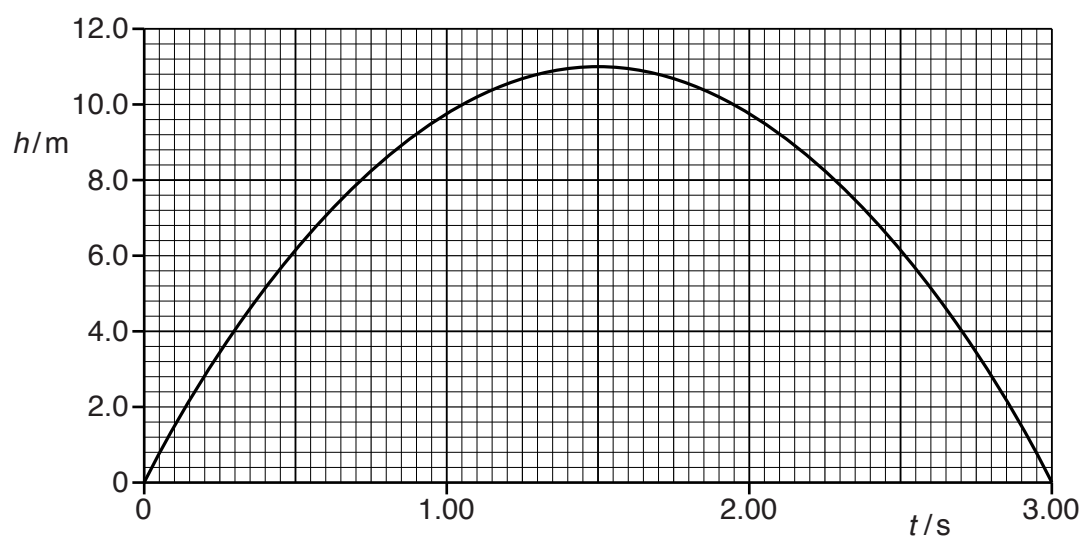


Fig. 3.3

Air resistance is negligible.

- (i) Use the time to reach maximum height to determine the vertical component V_v of the velocity of the ball for time $t = 0$.

$$V_v = \dots\dots\dots \text{ms}^{-1} \quad [2]$$

- (ii) The horizontal displacement of the ball at $t = 3.00 \text{ s}$ is 25.5 m .
On Fig. 3.4, draw the variation with t of the horizontal displacement x of the ball.

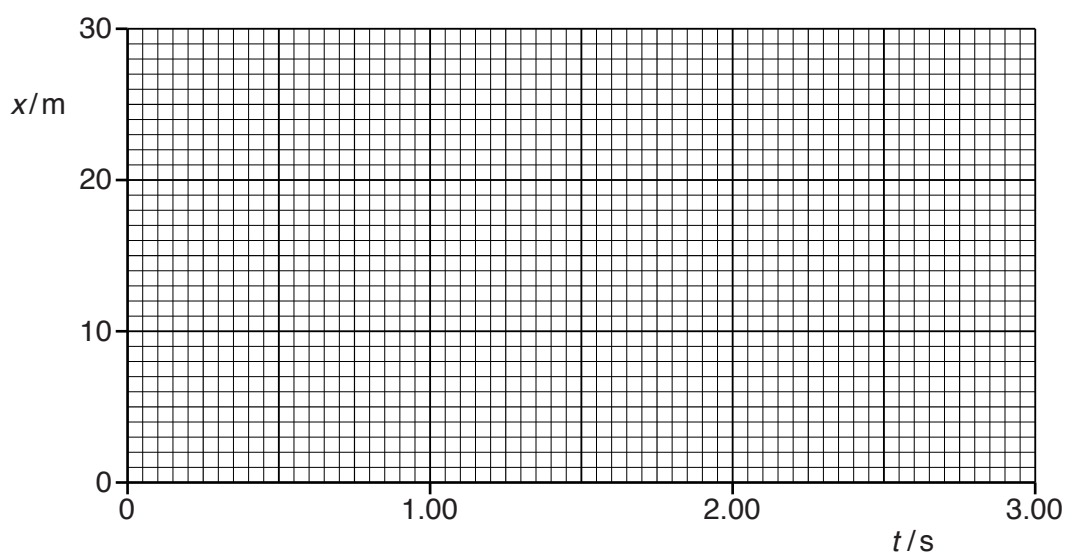


Fig. 3.4

[1]

- (iii) For the ball at maximum height, calculate the ratio

$$\frac{\text{potential energy of the ball}}{\text{kinetic energy of the ball}}.$$

$$\text{ratio} = \dots\dots\dots [3]$$

- (iv) In practice, air resistance is not negligible. State and explain the effect of air resistance on the time taken for the ball to reach maximum height.

.....

 [2]

- 4 Fig. 4.1 shows a metal cylinder of height 4.5 cm and base area 24 cm^2 .

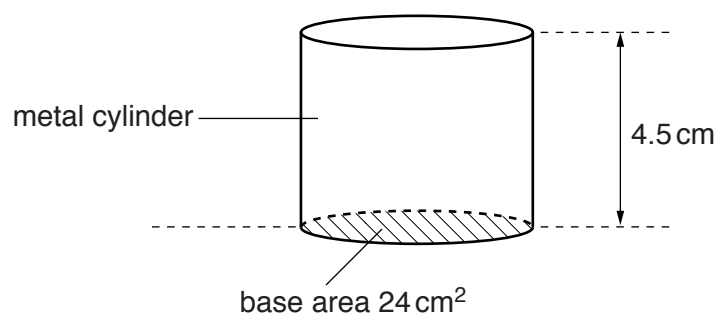


Fig. 4.1

The density of the metal is 7900 kg m^{-3} .

- (a) Show that the mass of the cylinder is 0.85 kg.

[2]

- (b) The cylinder is placed on a plank, as shown in Fig. 4.2.

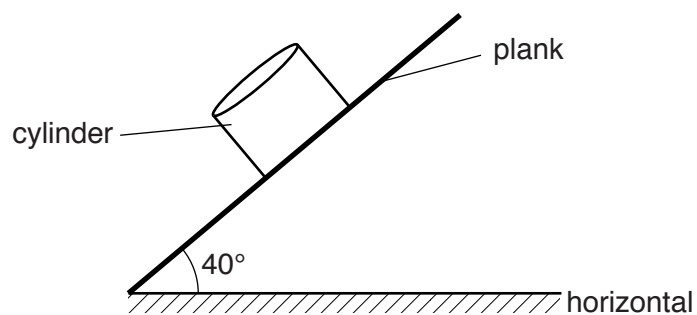


Fig. 4.2

The plank is at an angle of 40° to the horizontal.

Calculate the pressure on the plank due to the cylinder.

pressure = ... Pa [3]

- (c) The cylinder then slides down the plank with a constant acceleration of 3.8 m s^{-2} .
A constant frictional force f acts on the cylinder.

Calculate the frictional force f .

$f = \dots\dots\dots$ N [3]

- 5 (a) A progressive wave transfers energy. A stationary wave does not transfer energy. State two other differences between progressive waves and stationary waves.

1.

.....

2.

.....

[2]

- (b) A stationary wave is formed on a stretched string between two fixed points A and B. The variation of the displacement y of particles of the string with distance x along the string for the wave at time $t = 0$ is shown on Fig. 5.1.

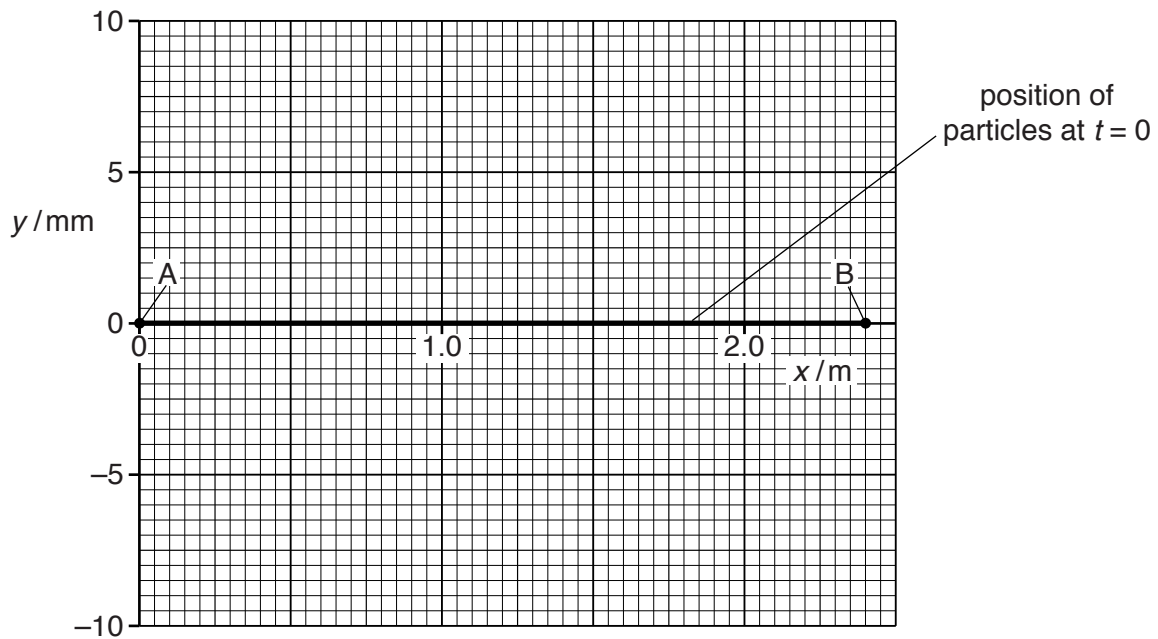


Fig. 5.1

The wave has a period of 20 ms and a wavelength of 1.2 m. The maximum amplitude of the particles of the string is 5.0 mm.

- (i) On Fig. 5.1, draw a line to represent the position of the string at $t = 5.0$ ms. [2]

- (ii) State the phase difference between the particles of the string at $x = 0.40$ m and at $x = 0.80$ m.

phase difference = ... unit [1]

- (iii) State and explain the change in the kinetic energy of a particle at an antinode between $t = 0$ and $t = 5.0$ ms. A numerical value is not required.

.....

.....

.....

..... [2]

- 6 (a) Define electromotive force (e.m.f.) for a battery.

.....
 [1]

- (b) A battery of e.m.f. 6.0 V and internal resistance $0.50\ \Omega$ is connected in series with two resistors X and Y, as shown in Fig. 6.1.

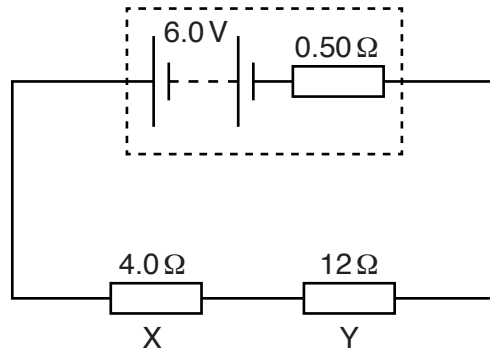


Fig. 6.1

The resistance of X is $4.0\ \Omega$ and the resistance of Y is $12\ \Omega$.

Calculate

- (i) the current in the circuit,

current = ... A [2]

- (ii) the terminal potential difference (p.d.) across the battery.

p.d. = ... V [1]

- (c) A resistor Z is now connected in parallel with resistor Y in the circuit in (b). The new arrangement is shown in Fig. 6.2.

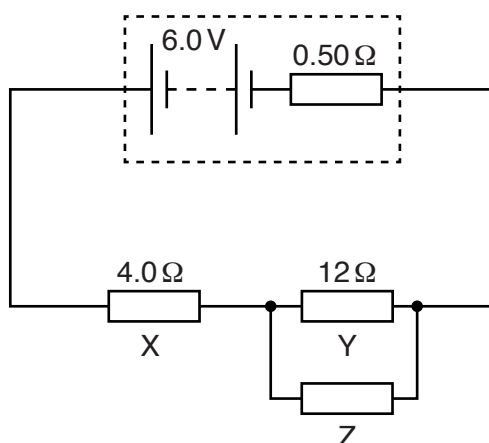


Fig. 6.2

Resistor Y is made from a wire of length l and diameter d . Resistor Z is a wire made from the same material as Y. The length of the wire for Z is $l/2$ and the diameter is $d/2$.

- (i) Calculate the resistance R of the combination of resistors Y and Z.

$$R = \dots\dots\dots \Omega \quad [3]$$

- (ii) State and explain the effect on the terminal p.d. across the battery.

A numerical value is not required.

.....

 [2]

(d) For the circuits given in (b) and (c), show that the ratio

$$\frac{\text{power developed in the external circuit in Fig. 6.1}}{\text{power developed in the external circuit in Fig. 6.2}}$$

is approximately 0.8.

[3]

- 7 Two parallel, vertical metal plates in a vacuum are connected to a power supply and a switch, as shown in Fig. 7.1.

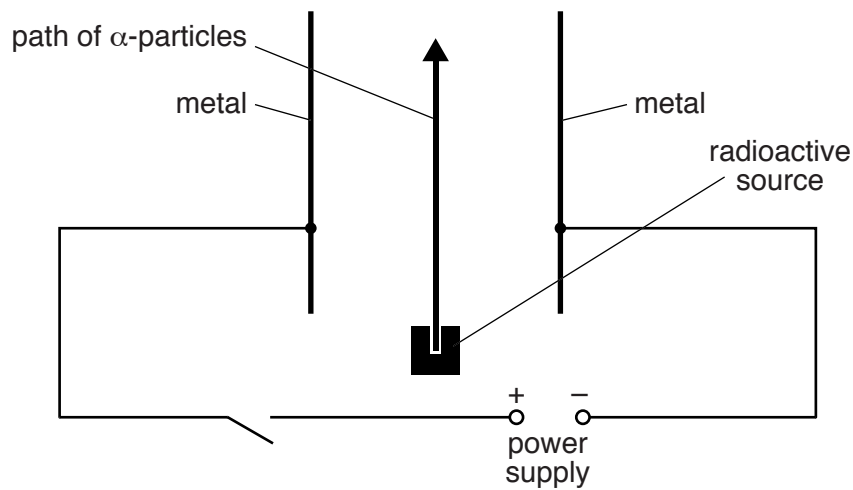


Fig. 7.1

A radioactive source emitting α -particles is placed below the plates. The path of the α -particles is shown on Fig. 7.1. The switch is closed producing a potential difference (p.d.) across the plates. This gives rise to a uniform electric field between the plates.

The separation of the plates is 12 mm.

- (a) (i) On Fig. 7.1, draw the path of the α -particles. [1]

- (ii) Explain why the metal plates are placed in a vacuum.

.....
 [1]

- (iii) Calculate the p.d. required to produce an electric field of 140 MV m^{-1} .

p.d. = ... MV [2]

- (b) The α -particle source is replaced by a β -particle source. By reference to the properties of α -radiation and β -radiation, suggest three possible differences in the deflection observed with β -particles.

1.

.....

2.

.....

3.

.....

[3]

- (c) Complete Fig. 7.2 to show the changes in the proton number Z and the nucleon number A of different radioactive nuclei when either an α -particle or a β -particle is emitted.

emitted particle	change in Z	change in A
α -particle		
β -particle		

Fig. 7.2

[1]

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hydrostatic pressure,

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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.

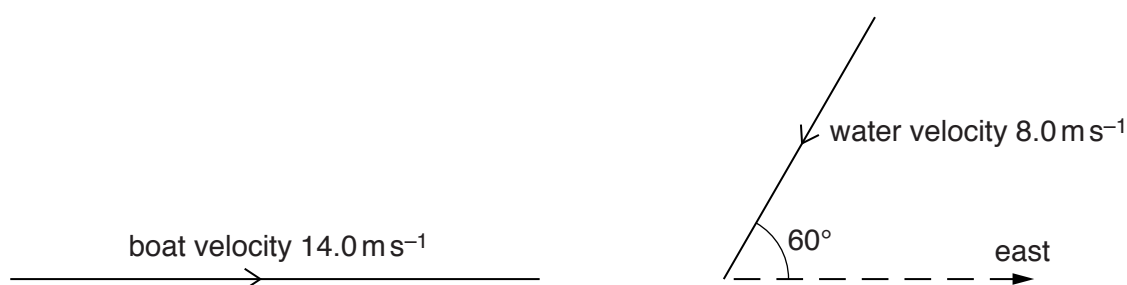


Fig. 1.1

The velocity of the boat in still water is 14.0 ms^{-1} to the east. The velocity of the water is 8.0 ms^{-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.

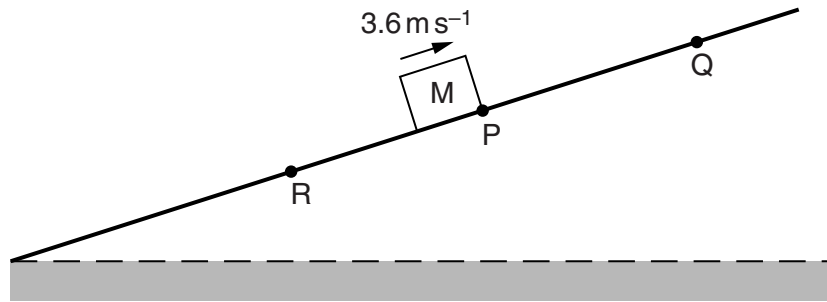


Fig. 2.1

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.

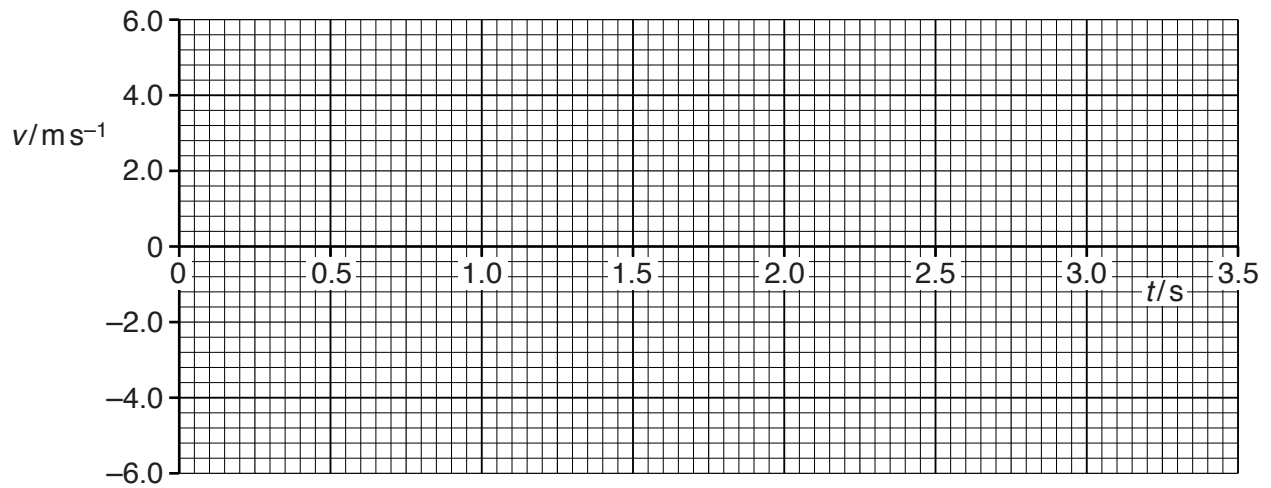


Fig. 2.2

[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 ms^{-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.

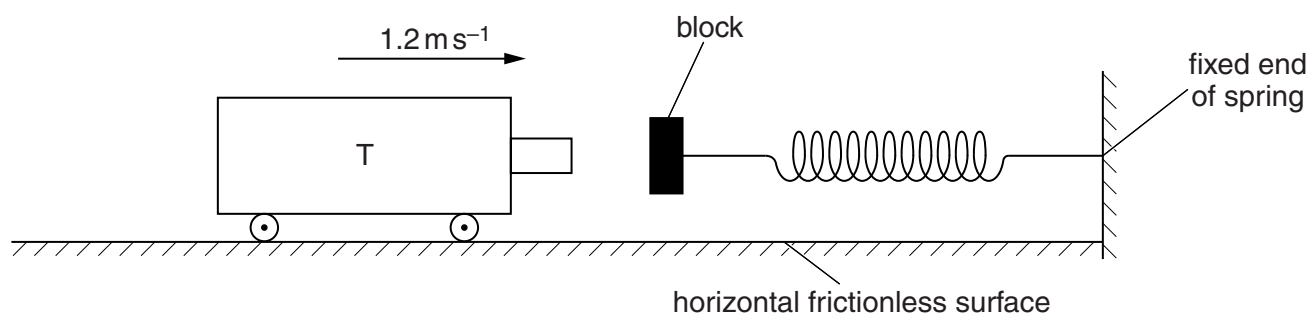


Fig. 3.1

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.

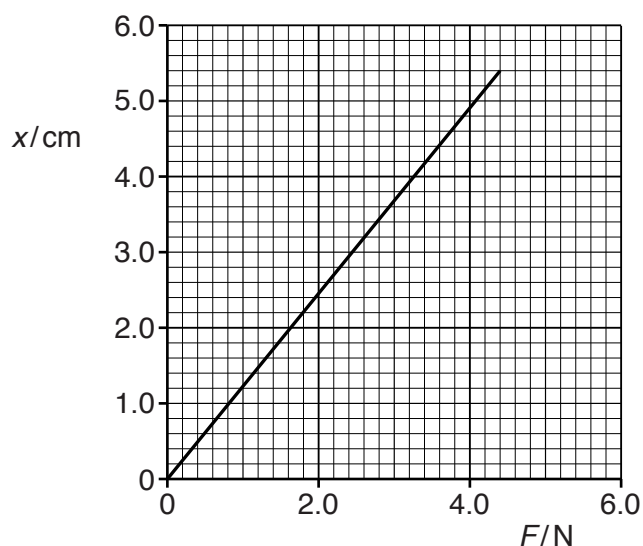


Fig. 3.2

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

spring constant = ... Nm^{-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.

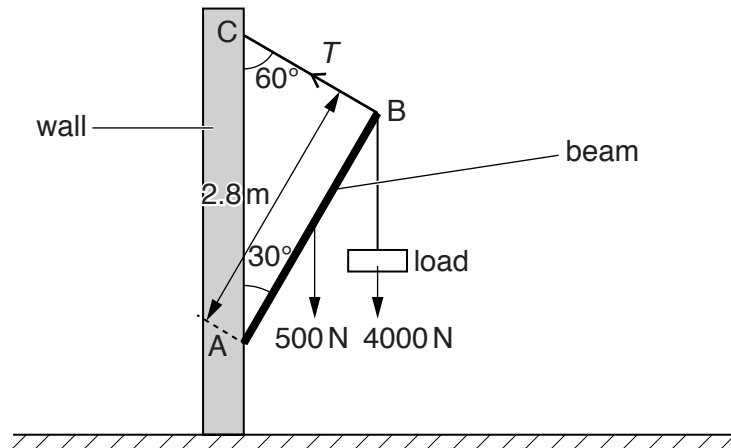


Fig. 4.1

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 2.8 m 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 .

$$T_v = \dots\dots\dots \text{ N [1]}$$

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

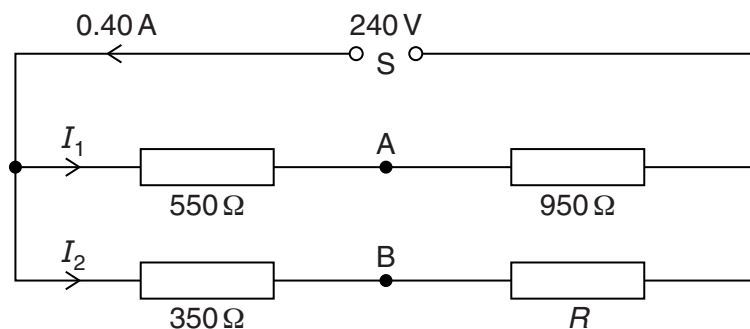


Fig. 5.1

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.

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

(ii) The resistance R is increased.

State and explain the effect on V_{AB} .

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

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

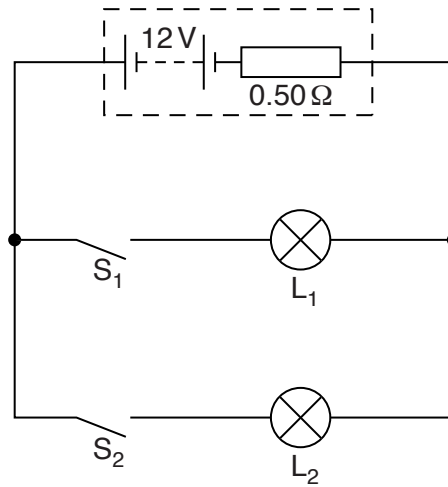


Fig. 6.1

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.

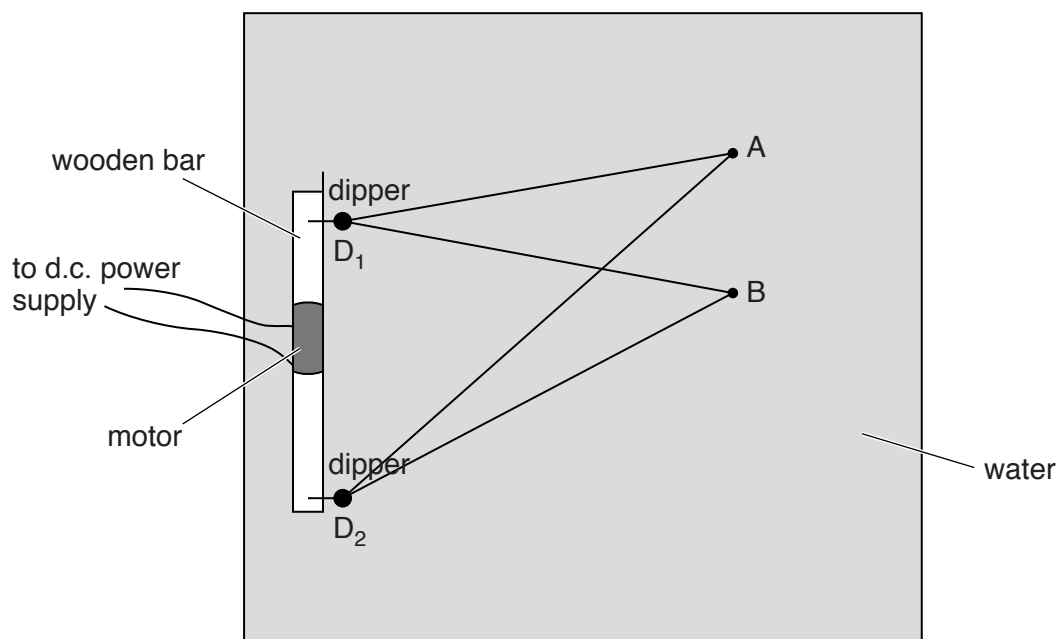


Fig. 7.1 (view from above)

- (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.

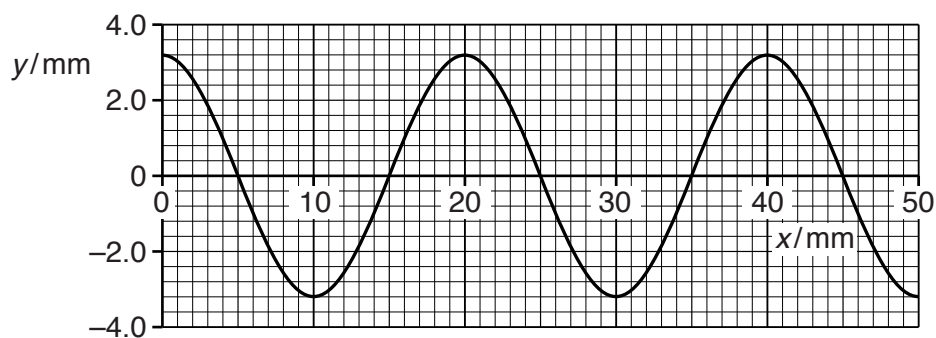


Fig. 7.2

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
5.0 cm	7.0 cm	5.0 cm	6.0 cm

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 $2.8 \times 10^{-14}\text{ m}$. The diameter of the atom is $2.3 \times 10^{-10}\text{ m}$.

Calculate the ratio

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

ratio = ... [3]

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NUMBER

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PHYSICS

9702/23

Paper 2 AS Structured Questions

October/November 2015

1 hour

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.

You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [] at the end of each question or part question.

This document consists of **16** printed pages.

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 intensity of a progressive wave is defined as the average power transmitted through a surface per unit area.

Show that the SI base units of intensity are kg s^{-3} .

[2]

- (b) (i) The intensity I of a sound wave is related to the amplitude x_0 of the wave by

$$I = K\rho cf^2x_0^2$$

where ρ is the density of the medium through which the sound is passing,
 c is the speed of the sound wave,
 f is the frequency of the sound wave
 and K is a constant.

Show that K has no units.

[2]

(ii) Calculate the intensity, in pW m^{-2} , of a sound wave where

$$K = 20,$$

$$\rho = 1.2 \text{ in SI base units,}$$

$$c = 330 \text{ in SI base units,}$$

$$f = 260 \text{ in SI base units}$$

and $x_0 = 0.24 \text{ nm}.$

intensity = ... pW m^{-2} [3]

- 2 A signal generator is connected to two loudspeakers L_1 and L_2 , as shown in Fig. 2.1.

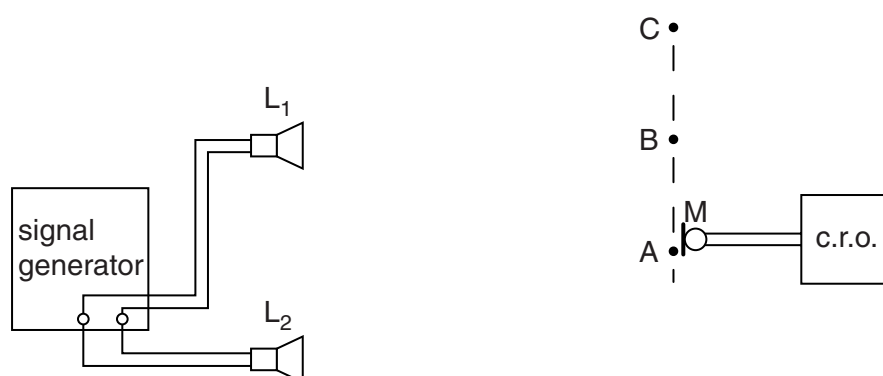
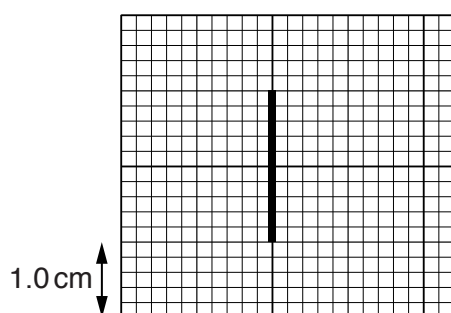


Fig. 2.1

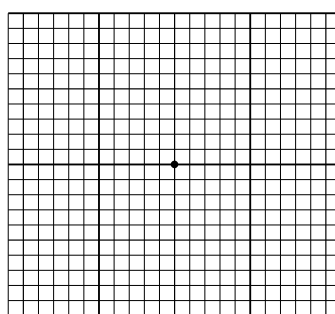
A microphone M, connected to the Y-plates of a cathode-ray oscilloscope (c.r.o.), detects the intensity of sound along the line ABC.
 The distances L_1A and L_2A are equal.
 The time-base of the c.r.o. is switched off.

The traces on the c.r.o. when M is at A, then at B and then at C are shown on Fig. 2.2, Fig. 2.3 and Fig. 2.4 respectively.



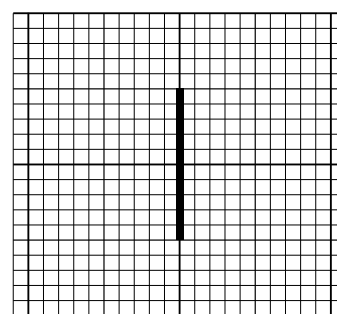
M at A

Fig. 2.2



M at B

Fig. 2.3



M at C

Fig. 2.4

For these traces, 1.0 cm represents 5.0 mV on the vertical scale.

- (a) (i) Explain why coherent waves are produced by the loudspeakers.

.....

[1]

(ii) Use the principle of superposition to explain the traces shown with M at

1. A,

.....

.....

.....[1]

2. B,

.....

.....

.....[1]

3. C.

.....

.....

.....[1]

(b) The sound emitted from L_1 and L_2 has frequency 500Hz. The time-base on the c.r.o. is switched on.

The microphone M is placed at A.

On Fig. 2.5, draw the trace seen on the c.r.o.

On the vertical scale, 1.0cm represents 5.0mV. On the horizontal scale, 1.0cm represents 0.10ms.

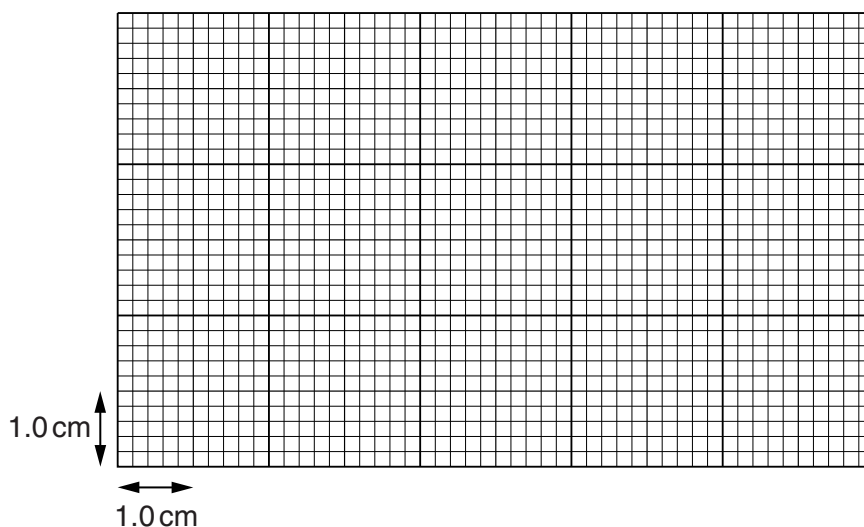


Fig. 2.5

[3]

- 3 A steel ball falls from a platform on a tower to the ground below, as shown in Fig. 3.1.

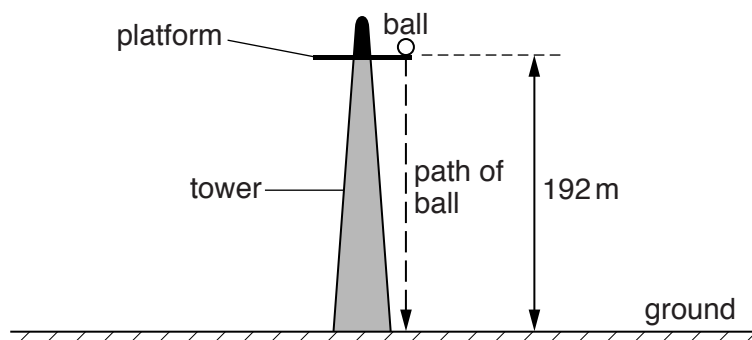


Fig. 3.1

The ball falls from rest through a vertical distance of 192 m. The mass of the ball is 270 g.

- (a) Assume air resistance is negligible.

- (i) Calculate

1. the time taken for the ball to fall to the ground,

time taken = ... s [2]

2. the maximum kinetic energy of the ball.

maximum kinetic energy = ... J [2]

- (ii) State and explain the variation of the velocity of the ball with time as the ball falls to the ground.

.....
 [1]

- (iii) Show that the velocity of the ball on reaching the ground is approximately 60 m s^{-1} .

- (b) In practice, air resistance is not negligible. The variation of the air resistance R with the velocity v of the ball is shown in Fig. 3.2.

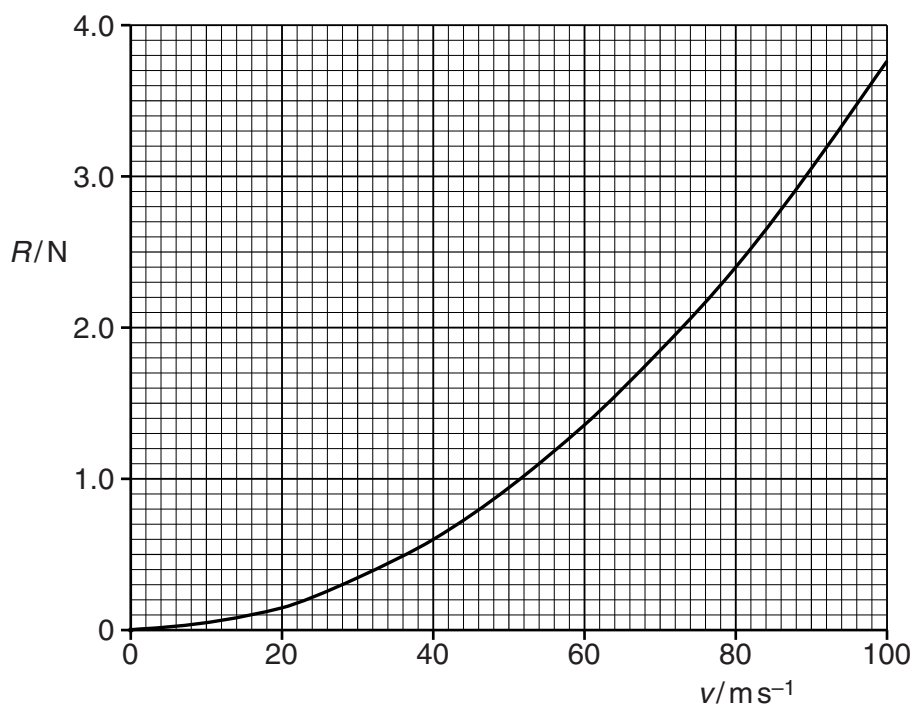


Fig. 3.2

- (i) Use Fig. 3.2 to state and explain qualitatively the variation of the acceleration of the ball with the distance fallen by the ball.

.....

[3]

- (ii) The speed of the ball reaches 40 ms^{-1} . Calculate its acceleration at this speed.

acceleration = ... ms^{-2} [2]

- (iii) Use information from (a)(iii) and Fig. 3.2 to state and explain whether the ball reaches terminal velocity.

.....

[2]

- 4 A block is pulled on a horizontal surface by a force P as shown in Fig. 4.1.

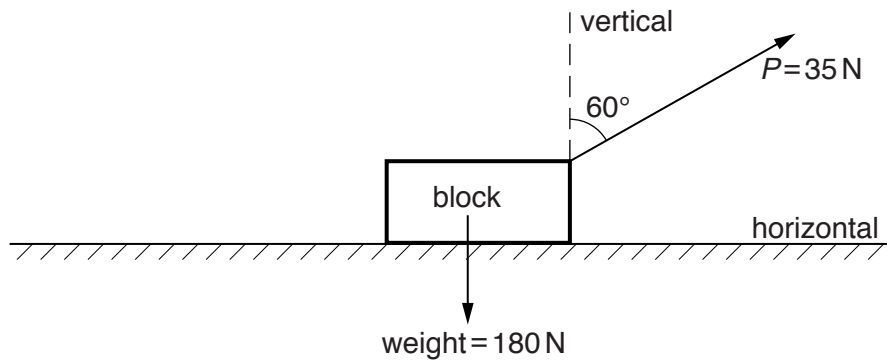


Fig. 4.1

The weight of the block is 180 N. The force P is 35 N at 60° to the vertical.
The block moves a distance of 20 m at constant velocity.

(a) Calculate

- (i)** the vertical force that the surface applies to the block (normal reaction force),

force = ... N [2]

- (ii)** the work done by force P .

work done = ... J [2]

- (b) (i) Explain why the block continues to move at constant velocity although work is done on the block by force P .

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

- (ii) Explain, in terms of the forces acting, why the block remains in equilibrium.

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

- 5 (a) The I - V characteristic of a semiconductor diode is shown in Fig. 5.1.

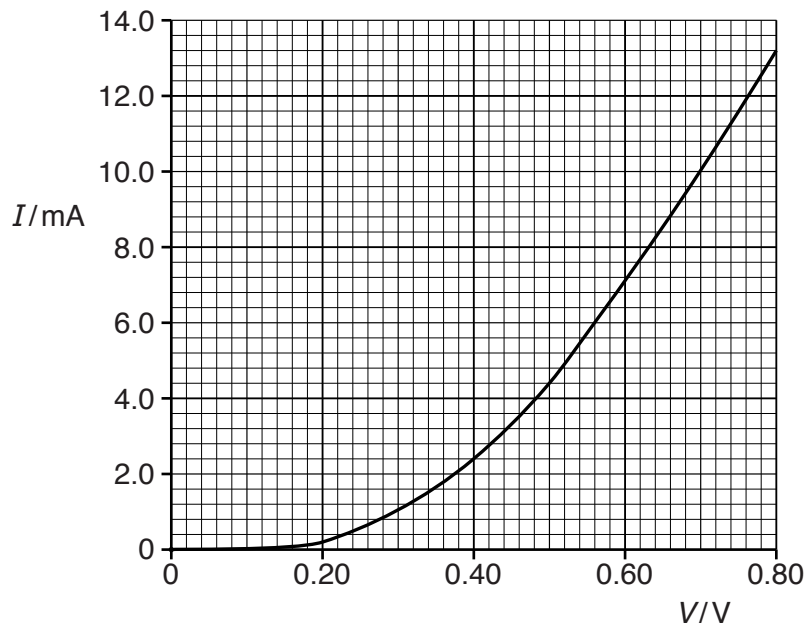


Fig. 5.1

- (i) Use Fig. 5.1 to explain the variation of the resistance of the diode as V increases from zero to 0.8V.

.....

[3]

- (ii) Use Fig. 5.1 to determine the resistance of the diode for a current of 4.4 mA.

resistance = ... Ω [2]

- (b) A cell of e.m.f. 1.2V and negligible internal resistance is connected in series to a semiconductor diode and a resistor R_1 , as shown in Fig. 5.2.

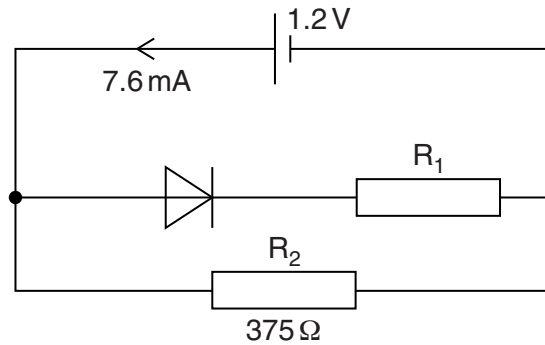


Fig. 5.2

A resistor R_2 of resistance 375Ω is connected across the cell.

The diode has the characteristic shown in Fig. 5.1. The current supplied by the cell is 7.6 mA.

Calculate

- (i) the current in R_2 ,

current = ... A [1]

- (ii) the resistance of R_1 ,

resistance = ... Ω [2]

- (iii) the ratio

$$\frac{\text{power dissipated in the diode}}{\text{power dissipated in } R_2} .$$

ratio = ... [2]

- 6 An arrangement for producing stationary waves in air in a tube that is closed at one end is shown in Fig. 6.1.

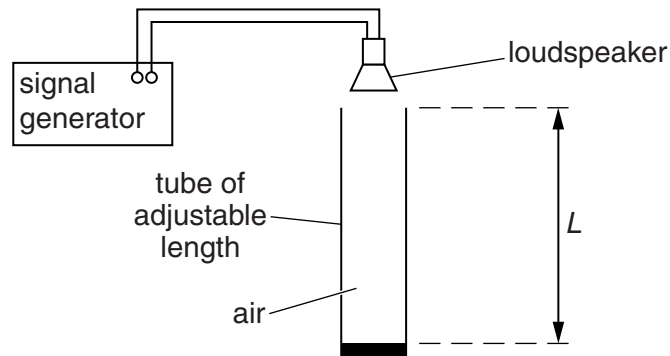


Fig. 6.1

A loudspeaker produces sound waves of wavelength 0.680 m in the tube. For some values of the length L of the tube, stationary waves are formed.

- (a) Explain how stationary waves are formed in the tube.

.....

 [2]

- (b) The length L is adjusted between 0.200 m and 1.00 m .

- (i) Calculate two values of L for which stationary waves are formed.

$L = \dots\dots\dots\text{ m}$ and $L = \dots\dots\dots\text{ m}$ [2]

- (ii) On Fig. 6.2, label the positions of the antinodes with an **A** and the nodes with an **N** for the least value of L for which a stationary wave is formed.



Fig. 6.2

[1]

- 7 A steel wire of cross-sectional area 15 mm^2 has an ultimate tensile stress of $4.5 \times 10^8 \text{ N m}^{-2}$.

(a) Calculate the maximum tension that can be applied to the wire.

tension = ... N [2]

(b) The steel of the wire has density 7800 kg m^{-3} . The wire is hung vertically.

Calculate the maximum length of the steel wire that could be hung vertically before the wire breaks under its own weight.

length = ... m [3]

**Please turn over for
Question 8.**

- 8 (a) State the quantities, other than momentum, that are conserved in a nuclear reaction.

.....
[2]

- (b) A stationary nucleus of uranium-238 decays to a nucleus of thorium-234 by emitting an α -particle. The kinetic energy of the α -particle is $6.69 \times 10^{-13} \text{ J}$.

- (i) Show that the kinetic energy E_k of a mass m is related to its momentum p by the equation

$$E_k = \frac{p^2}{2m}.$$

[1]

- (ii) Use the conservation of momentum to determine the kinetic energy, in keV, of the thorium nucleus.

kinetic energy = ... keV [3]

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