

INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME

CLASS

GROUP:

PHYSICS

8866/02

Paper 2 Structured Questions

23 August 2016

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer any **two** questions.

Please write down your answers in the spaces provided.

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

Marks will be deducted for using inappropriate number of significant figures or wrong value of g .

For Examiner's Use	
Section A	
1	7
2	5
3	6
4	7
5	5
6	10
Section B	
7	20
8	20
9	20
Significant Figures	
Total	80

This document consists of **26** printed pages.



Data

speed of light in free space,
 elementary charge,
 the Planck constant
 unified atomic mass constant,
 rest mass of electron,
 rest mass of proton,
 acceleration of free fall,

$$c = 3.00 \times 10^8 \text{ m s}^{-1}$$

$$e = 1.60 \times 10^{-19} \text{ C}$$

$$h = 6.63 \times 10^{-34} \text{ J s}$$

$$u = 1.66 \times 10^{-27} \text{ kg}$$

$$m_e = 9.11 \times 10^{-31} \text{ kg}$$

$$m_p = 1.67 \times 10^{-27} \text{ kg}$$

$$g = 9.81 \text{ m s}^{-2}$$

Formulae

uniformly accelerated motion,

 work done on/by a gas,
 hydrostatic pressure,
 resistors in series,
 resistors in parallel,

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

$$W = p\Delta V$$

$$p = \rho gh$$

$$R = R_1 + R_2 + \dots$$

$$1/R = 1/R_1 + 1/R_2 + \dots$$

Section A

Answer **all** the questions in this section.

- 1 One end of a spring is fixed to a support. A mass is attached to the other end of the spring. The arrangement is shown in Fig. 1.1.

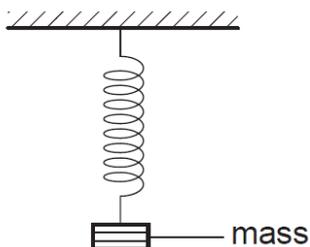


Fig. 1.1

- (a) The mass is in translational equilibrium. Explain, with reference to the forces acting on the mass, what is meant by translational equilibrium.

There is no net resultant force in all directions. [B1]

The weight downwards is equal to the tension upwards. [B1]

..... [2]

- (b) The mass is pulled down and then released at time $t = 0$. The mass oscillates up and down. The variation with t of the displacement of the mass d is shown in Fig. 1.2.

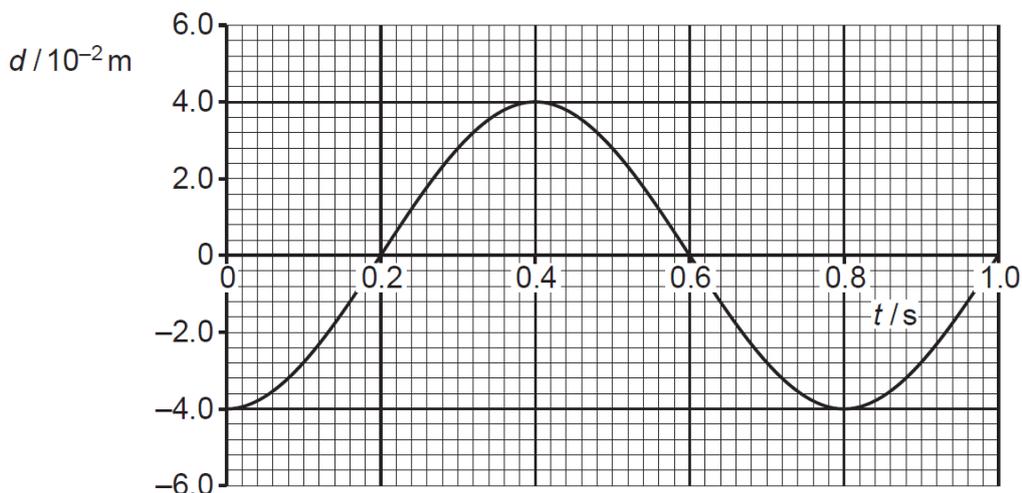


Fig. 1.2

Given that acceleration is directly proportional to displacement, d , state a time in Fig. 1.2 when the mass is in translational equilibrium.

0.2, 0.6, 1.0 s (any one of these values) [A1]

time = s [1]

- (c) The arrangement shown in Fig. 1.3 is used to determine the length l of a spring when different masses M are attached to it.

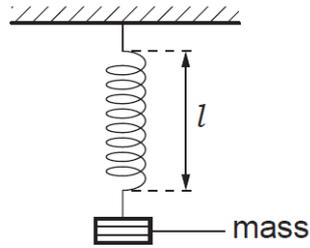


Fig. 1.3

The variation with mass M of l is shown in Fig. 1.4 below.

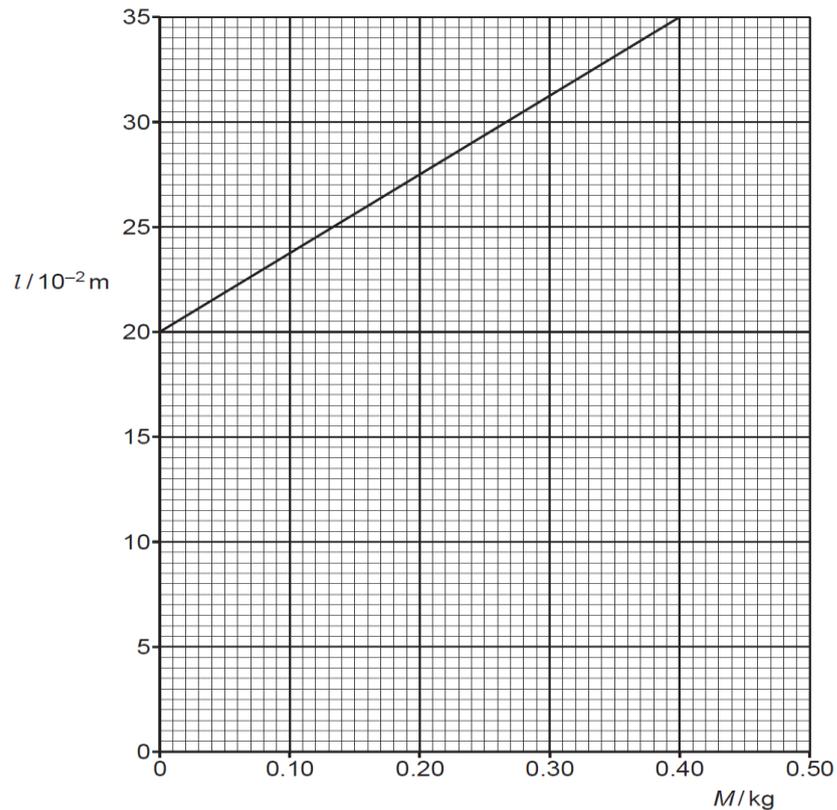


Fig. 1.4

- (i) State and explain whether the spring obeys Hooke's law.

The spring obeys Hooke's Law. [B1]

From the linear/straight line graph, it suggests that the mass is proportional to the extension, hence the applied force ($W=mg$) is proportional to extension. [B1]

.....

 [2]

- (ii) Show that the spring constant of the spring is 26 N m^{-1} .
Use of the gradient of F - x graph (not $F = kx$) [C1]

[2]

$$k = \frac{(0.40 \times 9.81) - 0}{(35 - 20) \times 10^{-2}} \quad \text{[M1]}$$

$$k = 26 \text{ N m}^{-1} \quad \text{[A0]}$$

- 2 In a pile driver, a steel hammerhead with mass 200 kg is lifted 3.0 m above the top of a vertical I-beam being driven into the ground as shown in Fig. 2.1. The hammer is then dropped from rest, driving the I-beam 7.4 cm further into the ground. The vertical railings that guide the hammerhead exert a constant frictional force of 60 N on the falling hammerhead.

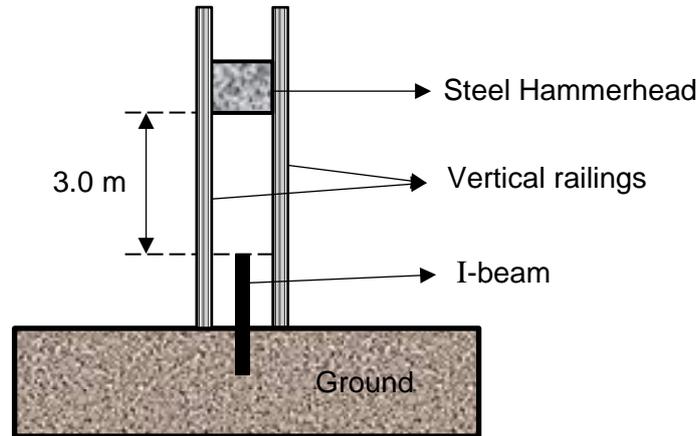


Fig 2.1

- (a) Show that the speed of the steel hammerhead just before it hits the I-beam is 7.55 m s^{-1} .

[2]

Method 1

By principle of conservation of energy,

Total mechanical energy of hammerhead at top (A) = total mechanical energy of hammerhead at point just above the pile (B) + energy dissipated to surrounding

$$P_A + K_A = P_B + K_B + W_{\text{dissipated}}$$

$$mgh + 0 = 0 + \frac{1}{2}mv^2 + fh \quad [\text{M1- for correct } W_{\text{dissipated}}]$$

$$(200)(9.81)(3) = \frac{1}{2}(200)v^2 + (60)(3) \quad [\text{M1-for correct PoCOE equation}]$$

$$v = 7.55 \text{ m s}^{-1}$$

Method 2

By consideration of the forces acting on hammerhead,
taking downwards to be positive,

$$F_{\text{net}} = W - f = ma$$

$$a = (200 \times 9.81 - 60) / 200 = 9.51 \text{ m s}^{-2} \quad [\text{M1-for correct } a]$$

$$v^2 = 0^2 + 2(9.51)(3) \quad [\text{M1-for correct application of kinematics equation}]$$

$$v = 7.55 \text{ m s}^{-1}$$

- (b) Calculate the change in kinetic energy of the hammerhead when it drives the I-beam further into the ground.

change in kinetic energy of hammerhead =

final KE – initial KE =

$$0 - \frac{1}{2}(200)(7.55)^2 =$$

$$-\frac{1}{2}(200)(7.55)^2 \quad (\text{M1- for correct determination of change in KE}) =$$

$$\begin{aligned} -5700.25 &= \\ -5700 & \text{ J} \end{aligned}$$

change in kinetic energy = J [1]

- (c) The work-energy theorem states that the net work done on an object is equal to the change in kinetic energy of the object.

Hence, using the work-energy theorem and your answer to (b), determine the average force, F , exerted by the I-beam on the steel hammerhead.

Using WET,

Net work done on hammerhead (during contact with I-beam) = change in kinetic energy of hammerhead

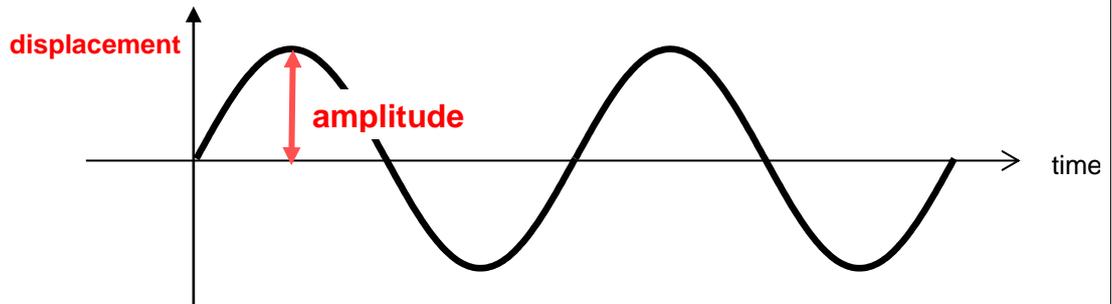
$$\begin{aligned} \text{Net work done on hammerhead} &= mgd - fd - Fd = \\ (200)(9.81)(0.074) - (60)(0.074) - F(0.074) &= -5700 \\ \text{(M1- for correct determination of net work done)} & \\ F &= 79000 \text{ N (A1)} \end{aligned}$$

$F =$ N [2]

- 3 (a) On Fig. 3.1, sketch and label a displacement-time graph of a wave, showing clearly what is meant by *period* and *amplitude*.



Fig. 3.1



[B1] for correct labelling of amplitude.
 [B1] for correct labelling of period.
 Marks are award only if the corresponding axes label is indicated correctly.

[2]

- (b) Explain why musical instruments that produce low frequency notes are larger in size than those that produce high frequency notes.

Lower frequency notes correspond to longer wavelength waves since $v = f\lambda$ and the speed of the waves is the same in air. [B1]

Since the length of the air column in the instrument is usually some fixed multiples of the wavelength of the sound wave for stationary waves to be formed, the instrument has to be longer. [B1]

.....

[2]

- (c) The speed of sound increases as the temperature rises. During a concert, the temperature of a concert hall increases. Musicians playing instruments such as the trumpets and flutes need to adjust the length of their instruments to keep the pitch (frequency) constant.

Explain how the length of their instruments should be changed to keep the pitch constant.

The instrument has to be adjusted to be longer. [B1]

When the temperature increases, the speed of sound wave in the air will increase (this is given in the question). For the same note (same frequency) to be played, the wavelength of the sound wave needs to be longer since $v = f\lambda$. With an increase in the wavelength of the sound wave, the instrument has to be **made longer**. [B1]

.....

.....

.....

..... [2]

- 4 (a) The strength of the magnetic field at a perpendicular distance r from a straight wire carrying current I_1 , is given by

$$B = \frac{\mu_0 I_1}{2\pi r}$$

This is shown in Fig. 4.1.

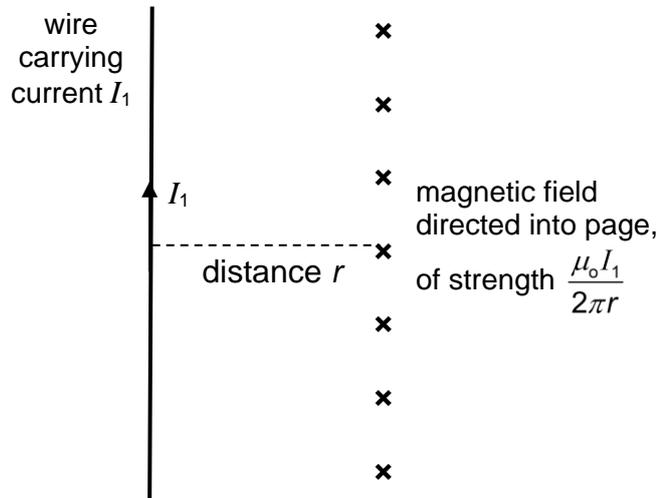


Fig. 4.1

Fig. 4.2 shows a conductor carrying current I_2 , placed at a distance r from the straight wire carrying current I_1 , and parallel to it.

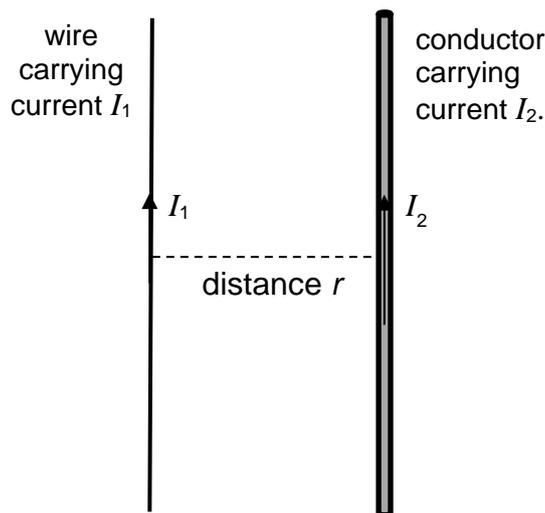


Fig. 4.2

- (i) Using the formula for magnetic field strength in (a), show the force per unit length experienced by the conductor carrying current I_2 at a distance r from the straight wire carrying current I_1 as shown in Fig. 4.2, is:

$$\frac{F_B}{L} = \frac{\mu_0 I_1 I_2}{2\pi r}$$

Explain your working.

[2]

Force experienced by conductor carrying I_2 ,

$$F_2 = B_{\text{at location of conductor}} I_{\text{conductor}} L_{\text{conductor}} \quad [\text{M1}]$$

Since the conductor is at a distance r from wire carrying I_1 ,

$$B_{\text{at location of conductor}} = \frac{\mu_0 I_1}{2\pi r}$$

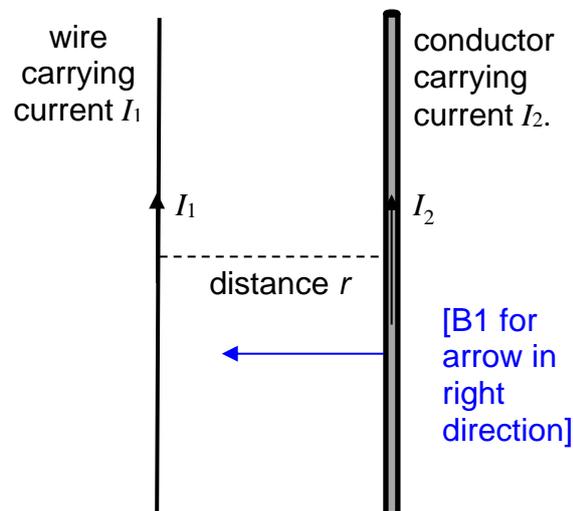
$$I_{\text{conductor}} = I_2$$

$$F_2 = \left(\frac{\mu_0 I_1}{2\pi r} \right) (I_2) L_{\text{conductor}} \quad [\text{M1 with explanation underlined above}]$$

$$\frac{F_2}{L_{\text{conductor}}} = \frac{\mu_0 I_1 I_2}{2\pi r} \quad [\text{shown}]$$

- (ii) Draw an arrow in Fig. 4.2. showing the direction of the magnetic force experienced by the conductor carrying current I_2 .

[1]



- (b) The currents in two identical coils are equal. Fig. 4.3 shows the coils mounted next to each other and passing through a horizontal board.

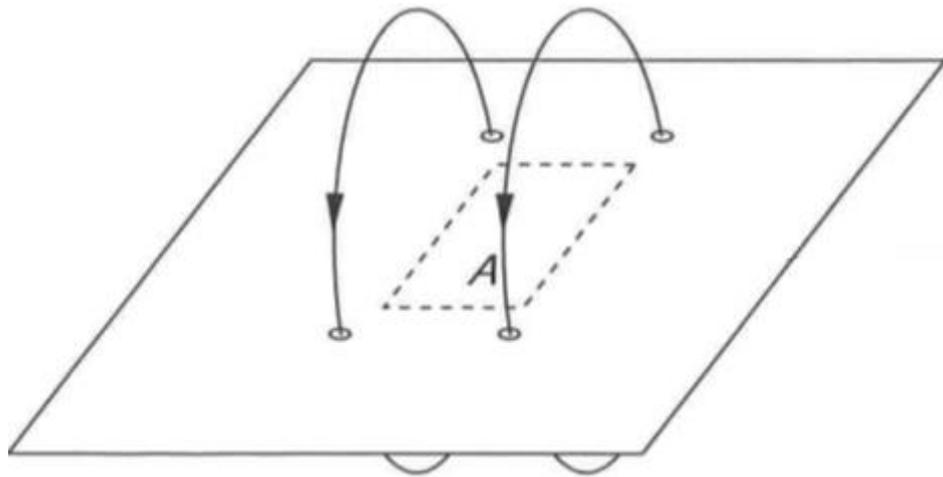


Fig. 4.3

The separation of the two coils is equal to their radii and the magnetic field in the area labelled A is uniform.

On Fig. 4.4 draw the magnetic field pattern due to the currents over the whole area of the board.

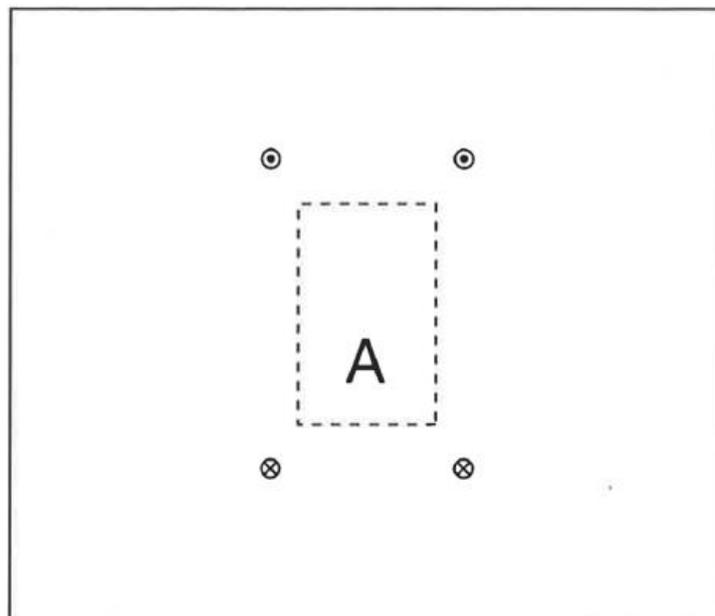
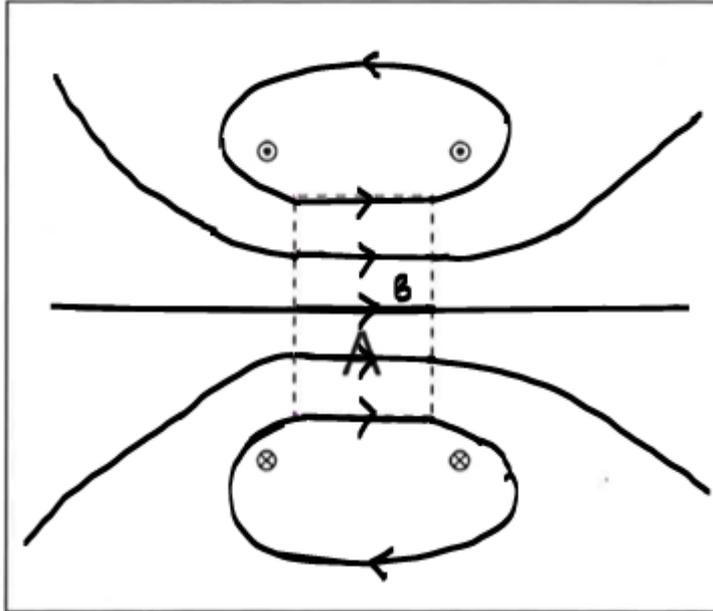


Fig. 4.4



Field lines in the **correct direction** i.e. from left to right. [B1]

Note: The question had specified that the **magnetic field in region A is uniform**. Hence the **field lines in region A have to be spaced equally apart**, since the density of the field lines indicate the strength of the magnetic field. [B1]

Field lines **less dense as we move towards the outer regions, away from region A** [B1]

Symmetrical about centre line passing through region A [B1]

[4]

- 5 A power supply with e.m.f. E has an internal resistance r . To measure the internal resistance, the circuit in Fig. 5.1 below is used. R is a fixed resistor of known resistance.

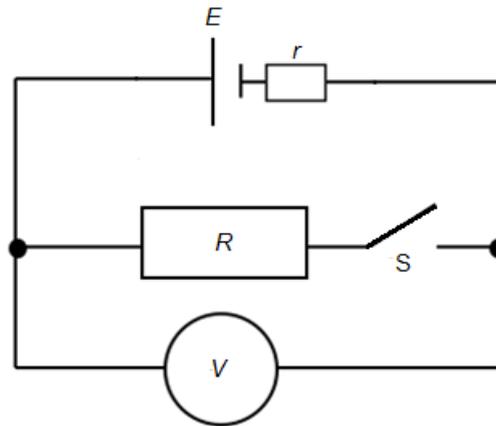


Fig. 5.1

- (a) Given that

$$V = IR = E - Ir$$

where V is the voltmeter reading and I is the total current flowing in the circuit.

Show that

$$r = R \left(\frac{E}{V} - 1 \right)$$

[2]

$$V = \frac{R}{R+r} E \quad \text{M1}$$

$$R+r = \frac{RE}{V}$$

$$r = \frac{RE}{V} - R = R \left(\frac{E}{V} - 1 \right) \quad \text{A1}$$

- (b) It is subsequently determined that the power supply has an e.m.f. of 6.0 V and an internal resistance of 2.5 Ω .

The fixed resistor R in Fig. 5.1 is removed and replaced by a thermistor.

When switch S is first closed, the current through the thermistor is 30 mA.

- (i) Calculate the power dissipated in the thermistor.

$$\text{Potential difference across thermistor} = 6.0 - 2.5(0.030) = 5.925 \text{ V} \quad \text{M1}$$

$$\text{Power dissipated in thermistor} = (0.030)(5.925) = 0.178 \text{ W} \quad \text{A1}$$

- power dissipated = W [2]
- (ii) A few minutes after closing switch S, the current through the thermistor increased to 45 mA.

Explain why the current increased.

As current passes through the thermistor, its temperature increases and its resistance decreases.

Total resistance of the circuit decreases. Hence there is an increase in the current. [B1]

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

- 6 A beam PQ is clamped at end P so that the beam is horizontal. A load of mass M is hung from end Q, as shown in Fig. 6.1 below.

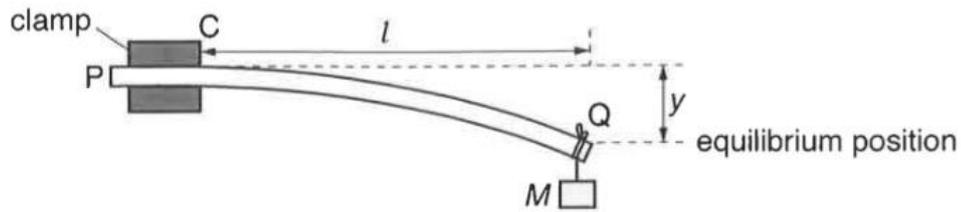


Fig. 6.1

The length of the beam from the edge C of the clamp to the end Q of the beam is l . The thickness of the beam is d and the width of the beam is b .

The beam bends due to the load of mass M , and the vertical displacement of the end Q is y .

- (a) The variation of y is given by the expression

$$y = kMgl^r d^s b^{-1}$$

where k is a constant, g is the acceleration of free fall, and r and s are integers.

An experiment is carried out to determine k , r and s . The values of M and b are kept constant.

Fig. 6.2 below shows the readings obtained.

y / m	l / m	$\ln(y / \text{m})$	$\ln(l / \text{m})$
0.257	0.900	-1.359	-0.105
0.178	0.800	-1.726	-0.223
0.118	0.700	-2.137	-0.357
0.073	0.600	-2.617	-0.511
0.042	0.500	-3.170	-0.693
0.021	0.400	-3.863	-0.916

Fig. 6.2

The set of readings for y is for a beam thickness d of $5.00 \times 10^{-3} \text{ m}$.

- (i) Complete Fig. 6.2 for $l = 0.500 \text{ m}$ [2]

Both calculations correct: B2
One correct: B1

- (ii) A graph of some of the data showing the variation of $\ln(y / \text{m})$ with $\ln(l / \text{m})$

is shown in Fig. 6.3 below.

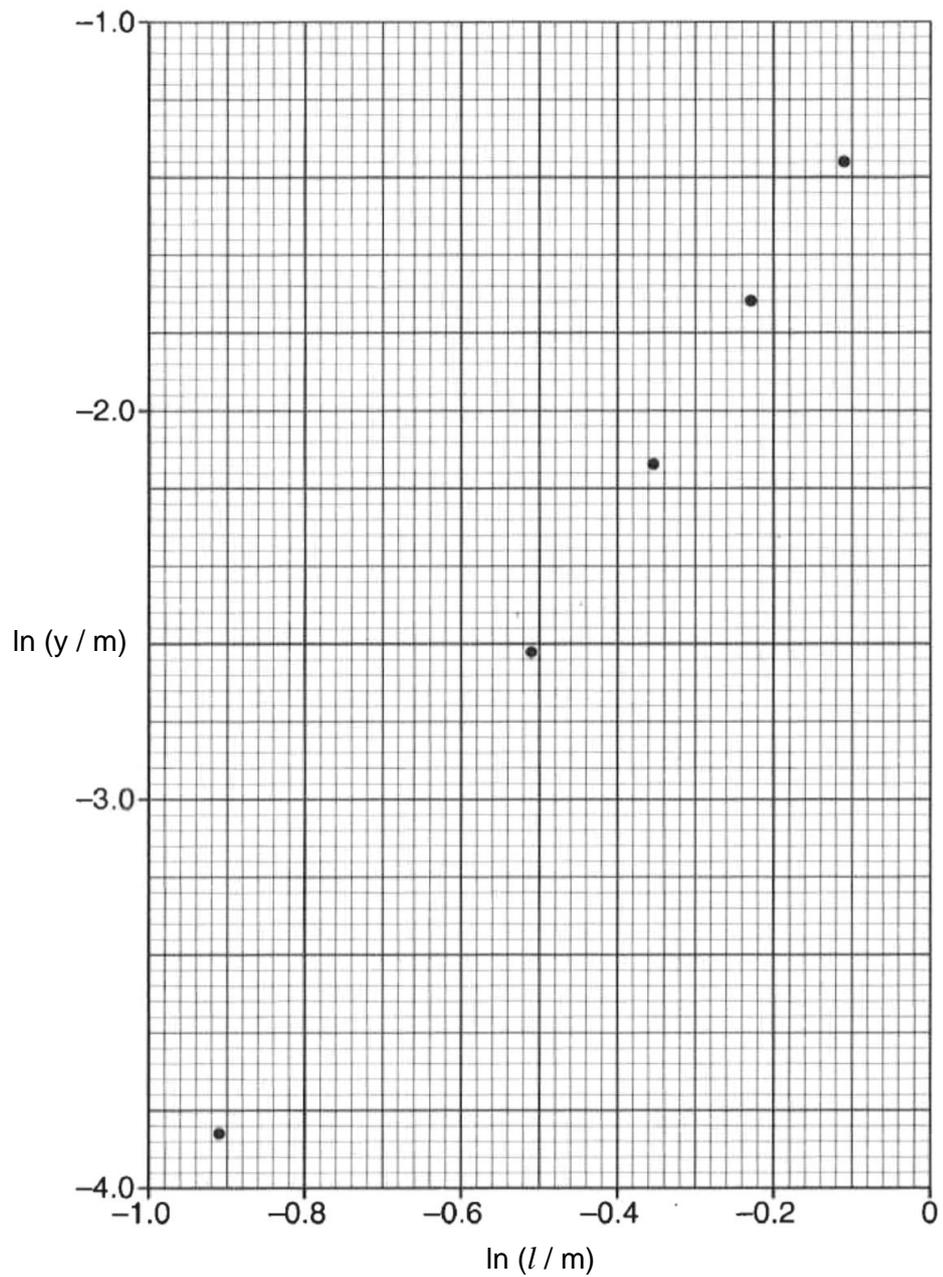
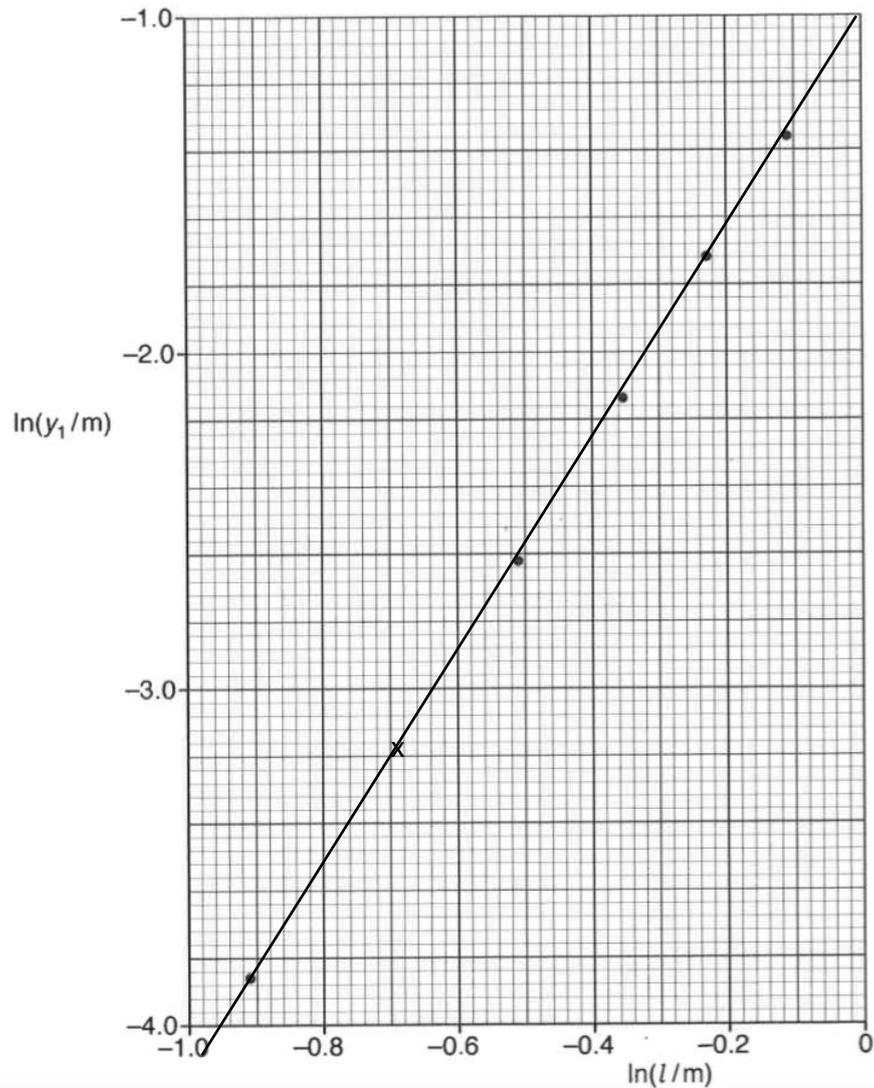


Fig. 6.3

On Fig. 6.3,

1. plot the point corresponding to $l = 0.500$ m,
2. draw the line of best fit for all the points.

[2]



Pt plotted to half sq accuracy B1,
and BFL drawn: B1

- (iii) Explain why the graph of Fig. 6.3 supports the expression given in (a).

$$y = kMg l^r d^s b^{-1}$$

$$\ln y = \ln(kMg l^r d^s b^{-1})$$

$$\ln y = \ln(l^r) + \ln(kMgd^s b^{-1})$$

$$\ln y = r \ln(l) + \ln(kMgd^s b^{-1})$$

M1

Hence by plotting $\ln y$ vs $\ln l$, a straight line can be obtained, with gradient r and y intercept of $\ln(kMgd^s b^{-1})$ A1

.....
 [2]

(iv) Using the graph of Fig. 6.3, determine integer r .

$$r = \text{Gradient} = \frac{-1.0 - (-4.0)}{0 - (-0.95)} \quad \text{M1}$$

$$r = 3.2 \quad \text{A1}$$

$$r = \dots\dots\dots [2]$$

(b) The fixed value of mass M is 0.500 kg, the fixed value of width b is 3.00×10^{-2} m and the value of s is -3 .

Use Fig. 6.3 and the expression given in (a) to show that the constant k is about 3.0×10^{-10} when expressed in SI base units.

[2]

$$\text{y-intercept} = \ln(kMgd^s b^{-1}) = -1.0$$

$$kMgd^s b^{-1} = e^{-1.0}$$

$$k(0.500)(9.81)(5.00 \times 10^{-3})^{-3} (3.00 \times 10^{-2})^{-1} = 0.36788 \quad \text{M1}$$

$$k = 2.81 \times 10^{-10} \gg 3.0 \times 10^{-10} \quad \text{A1}$$

Section B

Answer **two** of the questions in this section.

- 7 (a) A block of mass M slides down a curved track as shown in Fig 7.1. It starts from rest at point A which is at a height of $4R$, where R is the radius of the circular loop from point B to point C. The block slides down the track and around the circular loop.

The block is very small compared to the radius of curvature of the track. You may also assume the track to be frictionless.

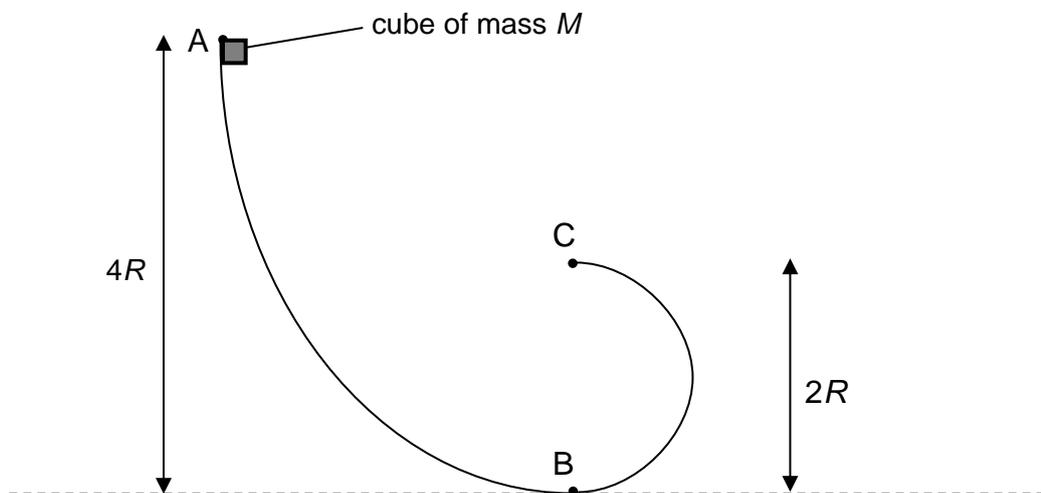


Fig. 7.1

- (i) Determine, in terms of R , the speed of the block

1. at B,

By principle of conservation of energy,

$$KE_A + PE_A = KE_B + PE_B$$

$$0 + mgh_A = \frac{1}{2}mv_B^2 + 0$$

OR Gain in KE = loss in GPE

$$\frac{1}{2}mv_B^2 - 0 = mgh_A - 0$$

$$v^2 = 2g(4R)$$

$$v = \sqrt{(8gR)}$$

$$= 8.86\sqrt{R}$$

Comments: Final answers should be expressed in decimal places.

speed of block at B = m s⁻¹ [2]

2. at C.

By principle of conservation of energy,

$$KE_A + PE_A = KE_C + PE_C$$

$$0 + mgh_A = \frac{1}{2}mv_C^2 + mgh_C$$

$$\text{OR } \Delta KE + \Delta PE = 0$$

Gain in KE = loss in GPE

$$\frac{1}{2}mv_C^2 - 0 = mgh_A - mgh_C$$

$$v^2 = 2g(4R - 2R)$$

$$v = \sqrt{4gR}$$

$$= 4.43\sqrt{R}$$

See above

speed of block at C = m s⁻¹ [2]

- (ii) Describe the trajectory of the block after it passes point C on the circular loop.

The cube leaves the track moving along the direction of the tangent at the point C (or moves in a horizontal direction towards to left after leaving point C) [B1], and then moves in a projectile motion (or experience vertical downwards acceleration of 9.81 m s⁻²) [B1] and land on track again.

.....

 [2]

- (iii) Explain how would the horizontal range of the block, after passing point C on the circular track, change if the track had not been frictionless.

If the track is not frictionless, the cube that moves down the track will lose energy due to work done against friction. The horizontal speed of the cube at point C will then be lesser [M1] and the range will be shorter.[A1]

.....
 [2]

- (b) The track in Fig. 7.1 is modified to the one shown in Fig. 7.2. The block now leaves the track with a speed of 23.4 m s^{-1} , at an angle of 60° with respect to the horizontal.

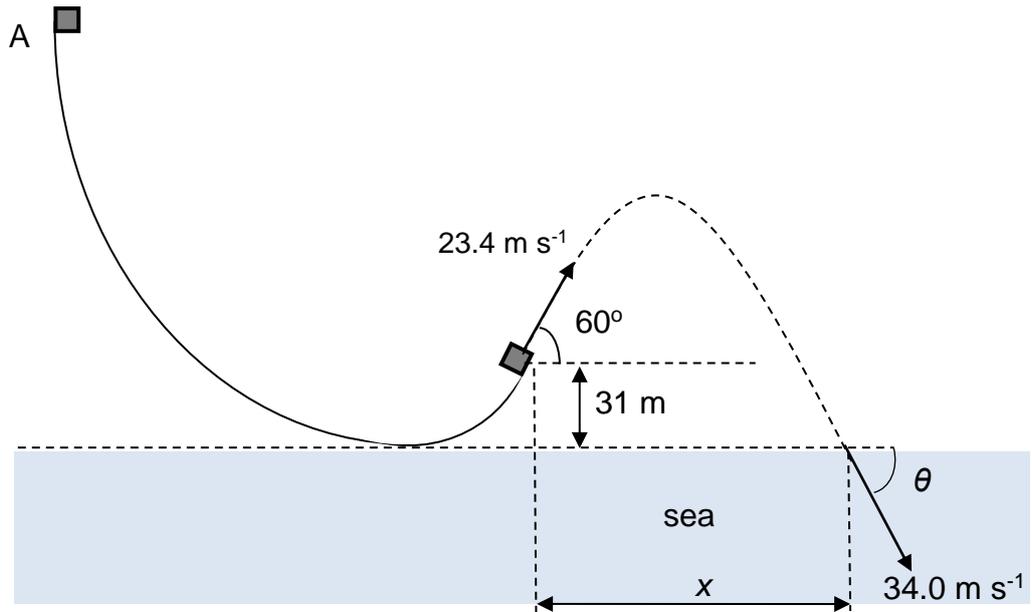


Fig. 7.2

The cube subsequently enters the sea with a speed of 34.0 m s^{-1} , at an angle θ below the horizontal. You may assume air resistance to be negligible.

- (i) Determine

- the vertical component of the cube's velocity just before it enters the sea,

Consider the vertical component of motion

Taking upwards positive,

$$v_y^2 = u_y^2 + 2a_y s_y$$

$$v_y^2 = (23.4 \sin 60^\circ)^2 + 2(-9.81)(-31) \text{ [M1]}$$

$$v_y = -31.9 \text{ m s}^{-1}$$

$$= -32 \text{ m s}^{-1} \text{ [A1]}$$

vertical component of velocity = m s^{-1} [2]

- the angle θ at which the cube enters the sea,

$$\theta = \sin^{-1}\left(\frac{31.92}{34.0}\right)$$

$$= 69.9^\circ = 70^\circ$$

Allow e.c.f.

angle $\theta = \dots\dots\dots^\circ$ [1]

23

3. the horizontal distance travelled, x .

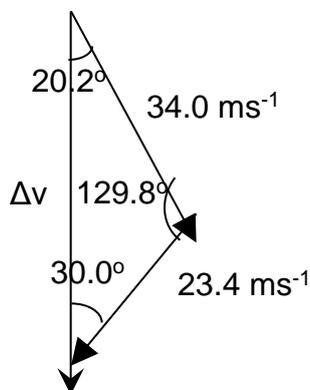
$$\begin{aligned}
 \text{Time of flight} &= \frac{v-u}{a} \\
 &= \frac{(-31.9)-(23.4 \sin 60^\circ)}{-9.81} \\
 &= 5.32 \text{ s [M1]} \\
 \text{Horizontal distance travelled} &= 23.4 \cos 60^\circ * 5.31 \\
 &\text{[M1]} \\
 &= 62.1 \text{ m} = 62 \text{ m [A1]}
 \end{aligned}$$

$$x = \dots\dots\dots \text{ m [3]}$$

- (ii) Draw a vector diagram to illustrate the change in the cube's velocity, ΔV , from the point it leaves the track to the instant just before it enters the sea.

Label in your diagram all known velocities and angles.

[3]



- (iii) Using the answer to (b)(ii), determine the change in velocity, ΔV .

$$\begin{aligned}
 &\text{Using cosine rule for the vector triangle,} \\
 \Delta v^2 &= 34.0^2 + 23.4^2 - 2(34.0)(23.4)\cos(129.8^\circ) \\
 \Delta v &= 52.2 \text{ ms}^{-1}
 \end{aligned}$$

$$\Delta V = \dots\dots\dots \text{ m s}^{-1} [1]$$

- (iv) Describe and explain the cube's motion after it enters the water.

You may assume that the cube will sink to the seabed, and that upthrust acting on the cube is negligible.

As the cube enters the water with splashes, some of kinetic energy of cube is transferred to kinetic energy and potential energy of the splashed water hence entering the water at a speed less than 34 m s⁻¹. [B1]

2 possible scenarios can occur upon entry into the water:

- 1) drag force acting on the cube is larger than the weight of the cube, causing the object to decelerate until the drag force balances with the weight and eventually reach a terminal speed [B1] OR
- 2) drag force acting on cube is smaller than the weight of the cube, causing the object to accelerate until the drag force balances with the weight and eventually reach a terminal speed. [B1]

.....

..... [2]

- 8 (a) Explain what is meant by photoelectric effect.
The emission of electrons from a metal caused by illuminating its surface with [B1]

.....
 EM wave of with frequency higher than threshold frequency of the metal [B1]
 (Also accept explanation using photon energy higher than work function)

..... [2]

- (b) When monochromatic light of wavelength 5.00×10^{-7} m incidents on a clean potassium plate placed within an evacuated tube as shown in Fig. 8.1, electrons are emitted from the plate. The work function of potassium is 2.23 eV.

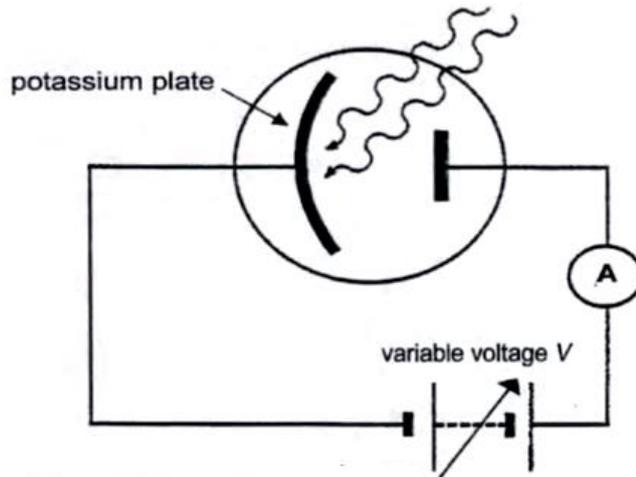


Fig. 8.1

- (i) Explain what is meant by the *work function* of a metal.
 The work function of a metal refers to the minimum amount of energy required to remove a free electron from the surface of the metal. [B1]

..... [1]

- (ii) Calculate the energy of each photon which incidents on the potassium plate.

$$\begin{aligned} \text{Energy} &= \frac{hc}{\lambda} \\ &= \frac{6.63 \times 10^{-34} \times 3.00 \times 10^8}{5.00 \times 10^{-7}} && \text{M1} \\ &= 3.98 \times 10^{-19} \text{ J} = 2.49 \text{ eV} && \text{A1} \end{aligned}$$

energy of photon = eV [2]

- (iii) Calculate the maximum kinetic energy of the photoelectrons emitted from the potassium plate.

$$\begin{aligned}
 KE_{\max} &= hc/\lambda - \phi \\
 &= 3.98 \times 10^{-19} - 2.23 \times (1.6 \times 10^{-19}) \quad \text{M1} \\
 &= 4.12 \times 10^{-20} \text{ J} \quad \text{A1}
 \end{aligned}$$

maximum kinetic energy = J [2]

- (iv) Sketch on Fig. 8.2, the variation of the photocurrent I with the voltage applied across the plates, V . Label this graph as **A**.

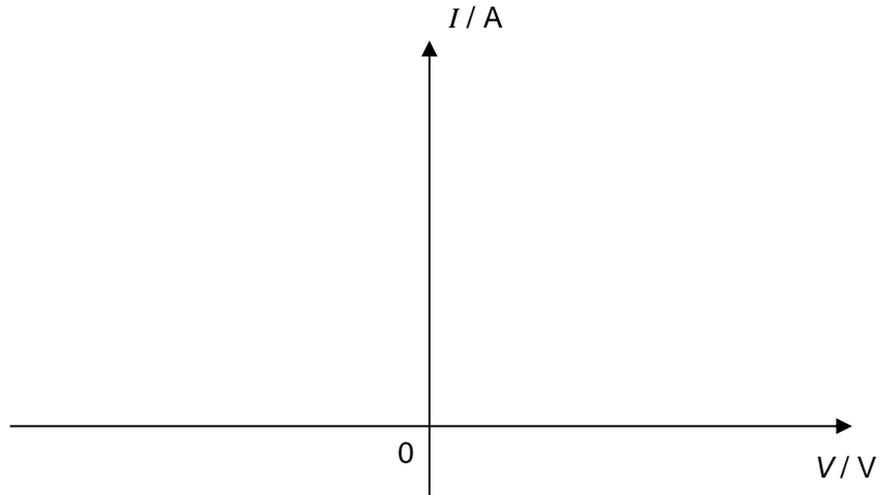
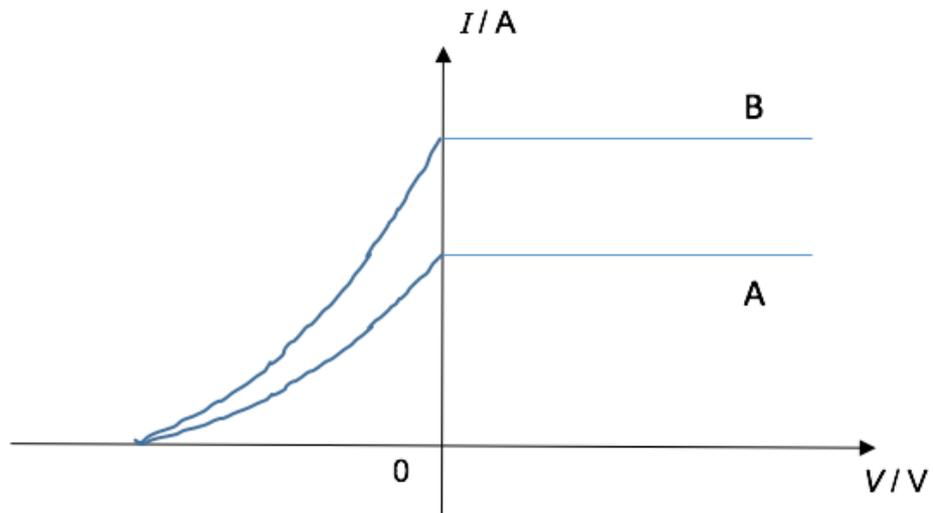


Fig. 8.2



Constant current when V is positive: B1
 Current decreases to zero as V is decreased to negative: B1

[2]

- (v) State and explain the physical quantity given by the horizontal intercept of the graph in (b)(iv).

The horizontal intercept V_s refers to the stopping potential. [B1]

Stopping potential V_s is the minimum value of the repelling potential difference applied across the collector and emitter so that the photocurrent just drops to zero. [B1]

.....

 [2]

(vi) Determine the value of the horizontal intercept of the graph in (b)(iv).

Gain in EPE = Loss in KE
 $|eV_s| = |0 - KE_{\max}| = 4.12 \times 10^{-20} \text{ J}$ [M0]
 $V_s = 0.257 \text{ V}$ [A1]

value of intercept = V [1]

(vii) Sketch on Fig. 8.2, the new variation of the photocurrent I with voltage V when the intensity of the monochromatic light incident on the potassium plate is doubled.

Label this new graph as B.

[2]

Constant current should be visually twice that of A's: B1 (apply BOD)
 Stopping potential unchanged: B1

(d) Vega is the fifth brightest star in the night sky and has been extensively studied by astronomers. Fig. 8.3 shows part of the visible spectrum of Vega that was recorded.

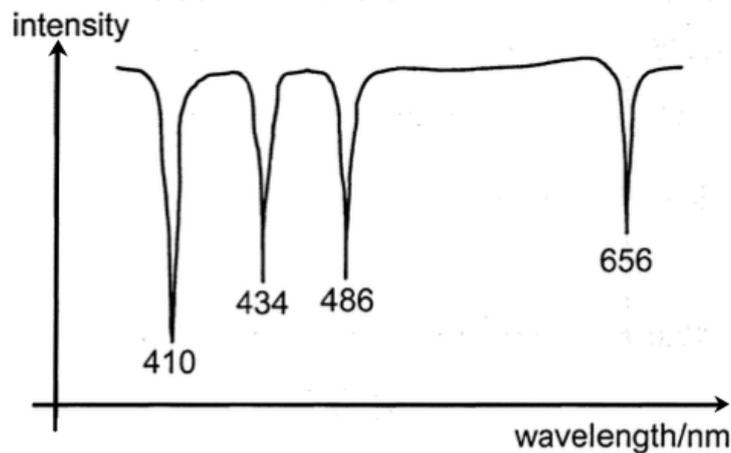


Fig. 8.3

The absorption lines i.e. the dips in intensity at 410 nm, 434 nm, 486 nm and 656 nm, are due to excited hydrogen atoms in Vega.

(i) Explain how the absorption lines are produced by the excited hydrogen atoms

Energy levels in the hydrogen atom are discrete. [B1]

Hence, as electromagnetic radiation passes through hydrogen gas in Vega, photons of energy corresponding to the exact difference between two energy levels in the atom are absorbed. [B1]

leading to these wavelengths being absent from the spectrum after passing through the gas.

.....

..... [2]

- (ii) By reference to Fig. 8.3, and how an emission spectrum is formed, draw and label on Fig. 8.4 the emission spectrum of hydrogen.

The axes have been drawn for you.

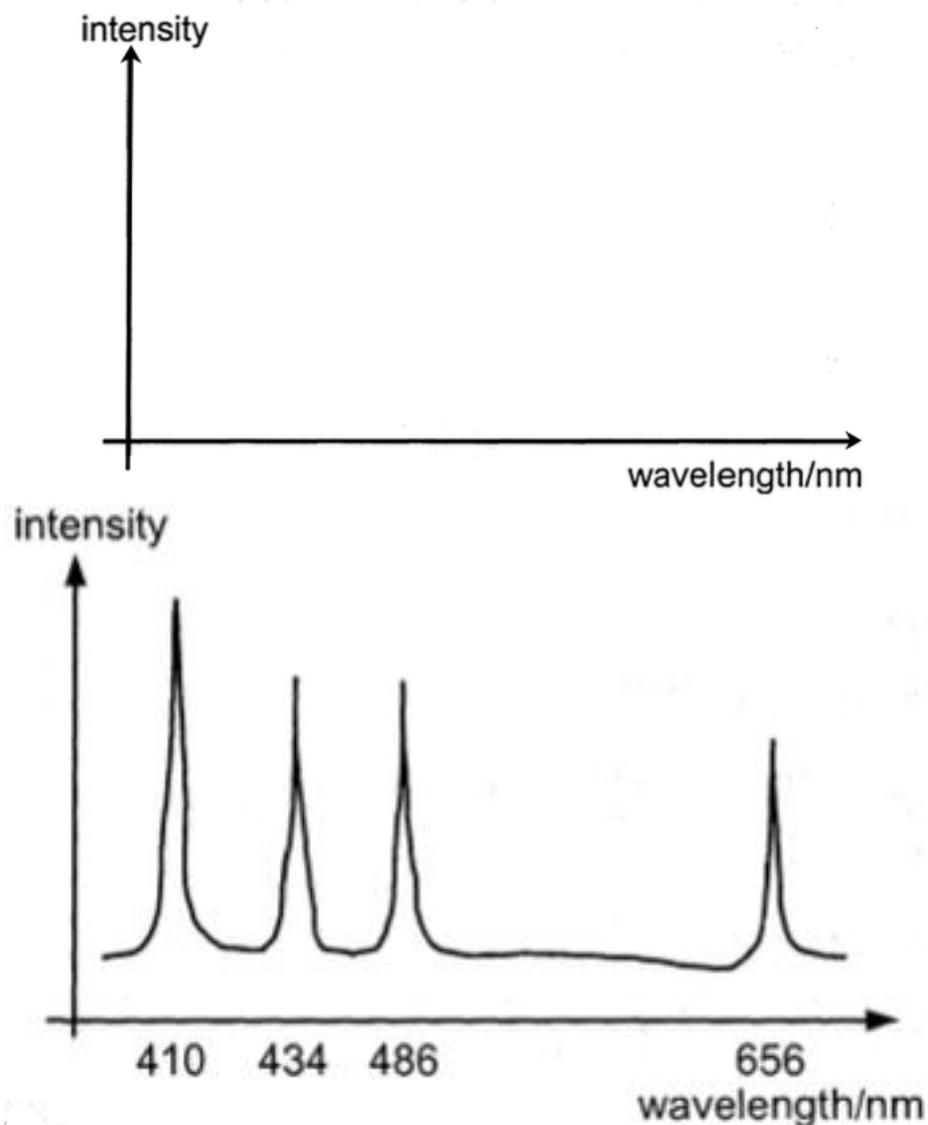


Fig. 8.4

4 peaks present, with correct relative intensities and labels: B1

[1]

(iii) Fig. 8.5 shows the first six energy levels of the hydrogen atom.

Photons in the visible spectrum are produced when excited electrons fall to E_2 .

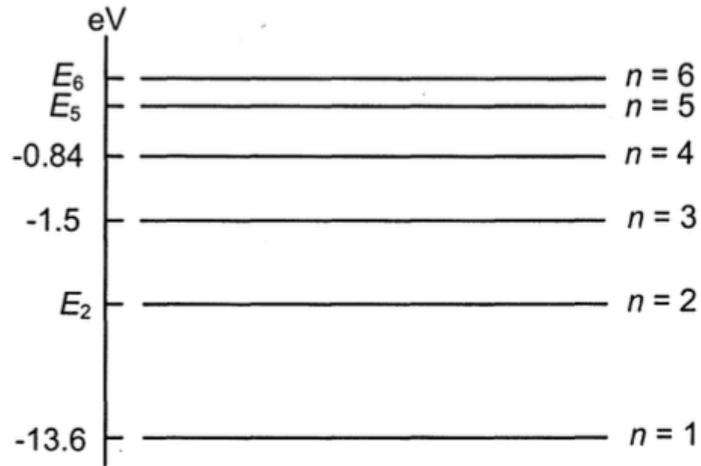
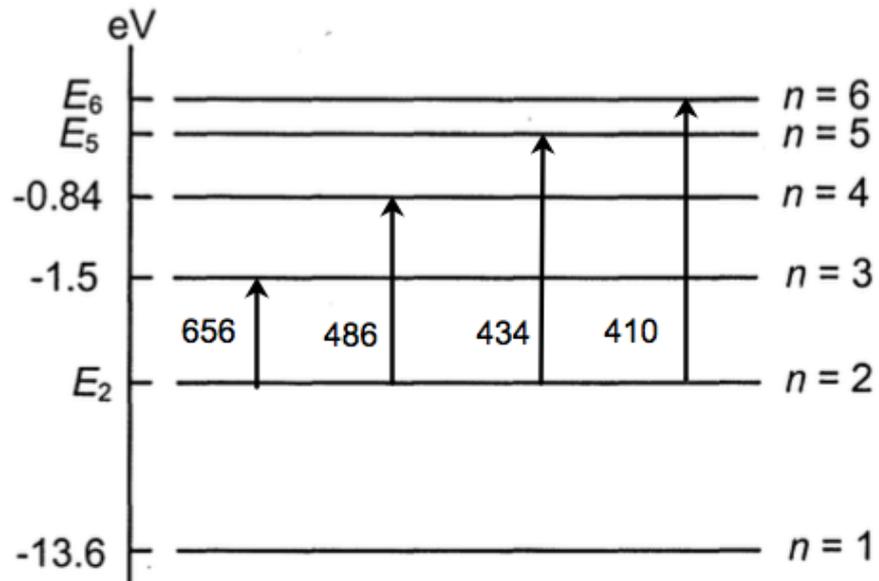


Fig. 8.5



4 upward arrows present, with correct labels: B1

Draw on Fig. 8.5, arrows representing the electronic transitions that give rise to the **absorption lines** shown in Fig. 8.3.

Label the transitions with the corresponding wavelengths.

[1]

(iv) Hence, calculate the values of E_2 and E_6 in Fig. 8.5.

$$DE = \frac{hc}{\lambda}$$

$$E_3 - E_2 = (-1.5) - E_2 = \frac{6.63 \times 10^{-34} (3.0 \times 10^8)}{656 \times 10^{-9} (1.6 \times 10^{-19})} \quad \text{M0}$$

$$E_2 = -3.4 \text{ eV} \quad \text{A1}$$

$$E_6 - E_2 = E_6 - (-3.4) = \frac{6.63 \times 10^{-34} (3.0 \times 10^8)}{410 \times 10^{-9} (1.6 \times 10^{-19})} \quad \text{M0}$$

$$E_6 = -0.37 \text{ eV} \quad \text{A1}$$

$$E_2 = \dots\dots\dots \text{ eV}$$

$$E_6 = \dots\dots\dots \text{ eV} \quad [2]$$

- 9 (a) (i) Define *charge* and the *coulomb*, making clear the distinction between the two.

Charge is
..... [1]

The coulomb is
..... [1]

Definition of charge – it is the product of current and time. [B1]
Definition of coulomb – it is the amount of charge when a current of 1 ampere flows through for a time of 1 second. [B1]

- (ii) Define *potential difference* and the *volt*, making clear the distinction between the two.

Potential difference is
..... [1]

The volt is
..... [1]

Definition of potential difference – it is the energy per unit charge converted from electrical to other forms. [B1]
Definition of volt – it is the potential difference between two points when 1 joule of electrical energy is converted from electrical to other forms for 1 coulomb of charge. [B1]

- (b) In 1890, New York had a 120 V direct current electricity supply. Electric power was supplied to the community using two copper cables each of radius 0.85 cm and length 2.00 km. The resistivity of copper is $1.70 \times 10^{-8} \Omega \text{ m}$. The two cables were connected in series.

- (i) Calculate the total resistance of the two cables between the power station and the community.

$$\text{Resistance of each wire} = \frac{\rho L}{A} = \frac{(1.70 \times 10^{-8})(2000)}{\pi(0.85 \times 10^{-2})^2}$$

$$R = 0.1498 \Omega \quad [\text{M1}]$$

$$\text{Total resistance of the 2 cables} = 2 \times 0.1498 \quad [\text{M1}]$$

$$= 0.2996 \approx 0.30 \Omega \quad [\text{A1}]$$

resistance = Ω [3]

- (ii) In 1890, the demand for electrical power was small. For a power of 18 kW supplied from the power station, calculate

1. the current in the cables,

$$\begin{aligned} \text{Using } P &= VI, \\ I &= P/V = 18000 \div 120 \quad [\text{M1}] \\ I &= 150 \text{ A} \quad [\text{A1}] \end{aligned}$$

$$\text{current} = \dots\dots\dots \text{ A} \quad [2]$$

2. the power wasted due to heating of the cables,

$$\begin{aligned} \text{Power wasted heating the cables} &= I^2R = 150^2 \times 0.30 \quad [\text{M1}] \\ P &= 6750 \text{ W} \quad [\text{A1}] \end{aligned}$$

$$\text{power wasted} = \dots\dots\dots \text{ W} \quad [2]$$

3. the actual potential difference available for use to the community,

$$\begin{aligned} \text{Potential difference available to the community} \\ &= \text{supply voltage} - (\text{p.d. across cables}) \\ &= 120 - (150 \times 0.30) \quad [\text{M1}] \\ &= 75 \text{ V} \quad [\text{A1}] \end{aligned}$$

$$\text{potential difference} = \dots\dots\dots \text{ V} \quad [2]$$

4. the percentage efficiency of the distribution system.

$$\begin{aligned} \text{Percentage efficiency} &= (\text{p.d. available}) \div (\text{supply voltage}) \times 100\% \\ &= 75/120 \times 100 \quad [\text{M1}] \\ &= 62.5\% \quad [\text{A1}] \end{aligned}$$

$$\text{efficiency} = \dots\dots\dots \% \quad [2]$$

- (c) The power distribution system described in (b) was very inefficient, and the efficiency decreased as more power was required by the community.

- (i) Explain why increasing the power station's output voltage could have helped improve the efficiency of the system.

With a higher output voltage but still the same power output, the supply current would be smaller (since $P = VI$). [B1]

With a smaller supply current, less power will be wasted in the cables [B1] and hence more power and p.d. will be available to the community [B1], hence increasing the efficiency.

.....
.....

.....
.....
.....
..... [3]

- (ii) It was suggested that thicker cables could be used to improve the efficiency of the system.

Explain how using thicker cables could increase the efficiency of the system, and why this suggestion is less preferred to that in (c)(i).

Another way to improve efficiency is to reduce the resistance of the cables by making them thicker. [B1] This would incur extremely high costs due to the additional conductor material needed for making the 2 thick cables over 2 km. [B1]
(Note: Since this is a d.c. supply, transformers cannot be used.)

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