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,	c	$= 3.00 \times 10^{8}$ m s^{-1}
elementary charge,	e	$= 1.60 \times 10^{-19}$ C
the Planck constant	h	$= 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	u	$= 1.66 \times 10^{-27}$ kg
rest mass of electron,	m_e	$= 9.11 \times 10^{-31}$ kg
rest mass of proton,	m_p	$= 1.67 \times 10^{-27}$ kg
acceleration of free fall,	g	$= 9.81$ 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	$= p\Delta V$
hydrostatic pressure,	p	$= \rho gh$
resistors in series,	R	$= R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$

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.

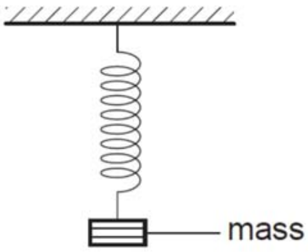

Fig. 1.1

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

....

....

.... [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.

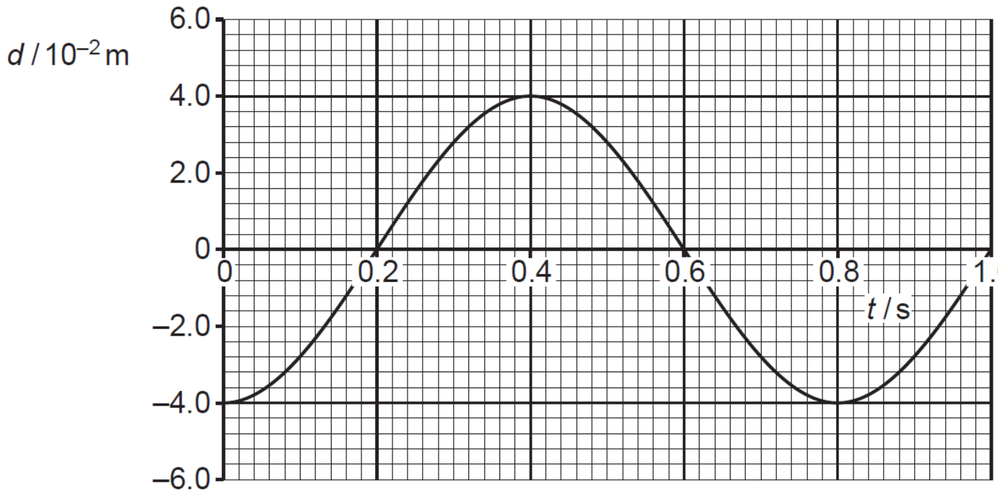

Fig. 1.2

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

time = ... s [1]

For Examiner's Use

(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.

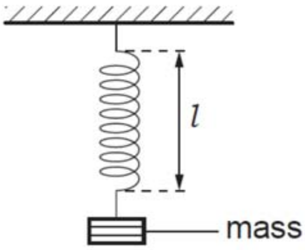

Fig. 1.3

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

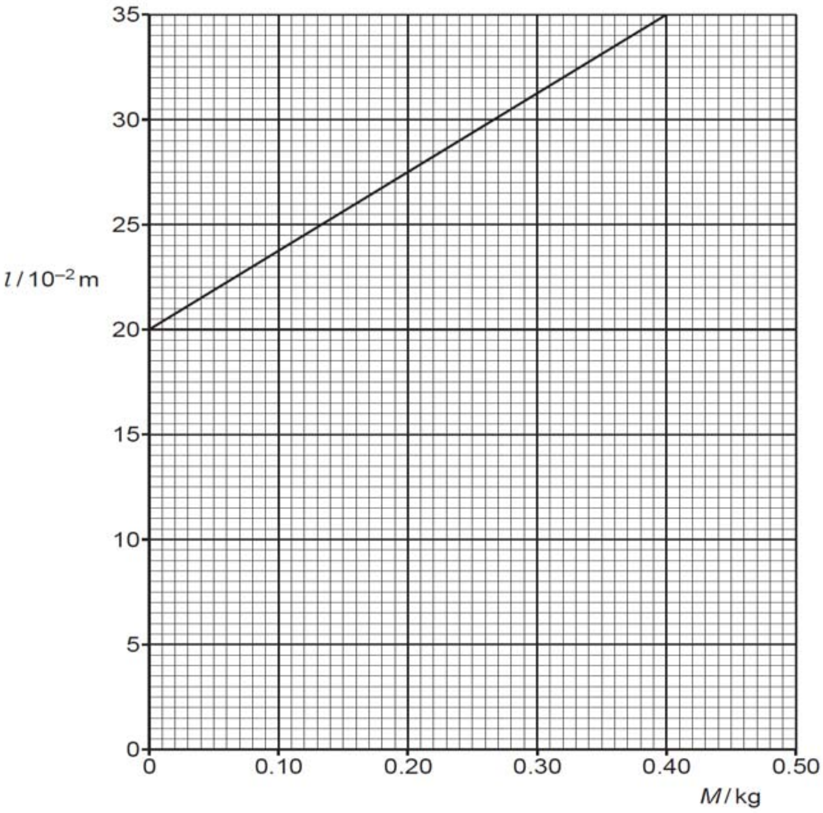

Fig. 1.4

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

………………………………………………………………………………………………

………………………………………………………………………………………………

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

(ii) Show that the spring constant of the spring is 26 N m^{-1}. [2]

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.

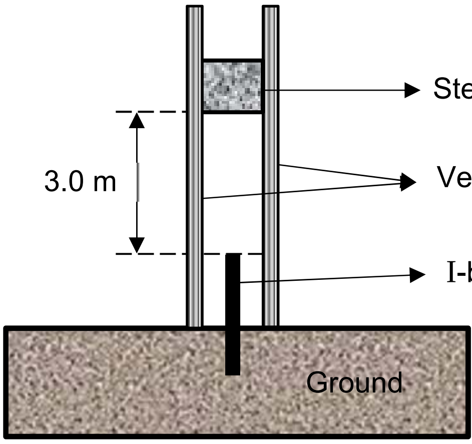

Fig 2.1

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

[2]

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

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.

F = …………………… N [2]

For Examiner's Use

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

[2]

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

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………… [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.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………… [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

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

This is shown in Fig. 4.1.

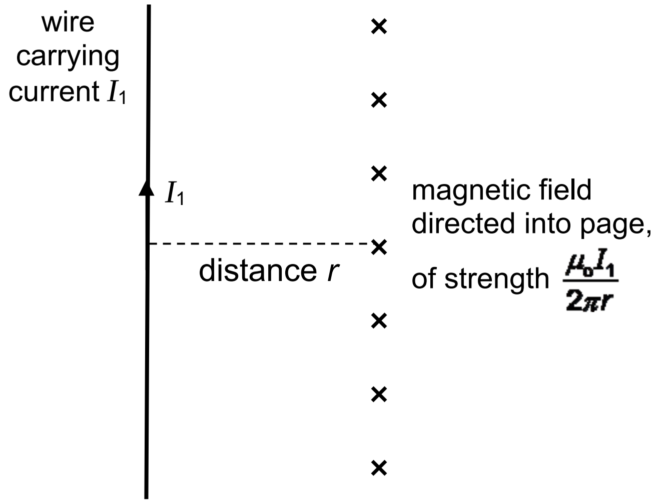

Fig. 4.1

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.

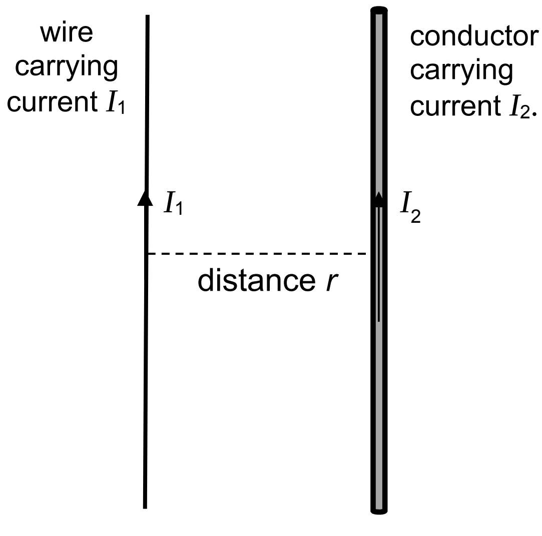

Fig. 4.2

For Examiner's Use

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

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

Explain your working.

[2]

(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.

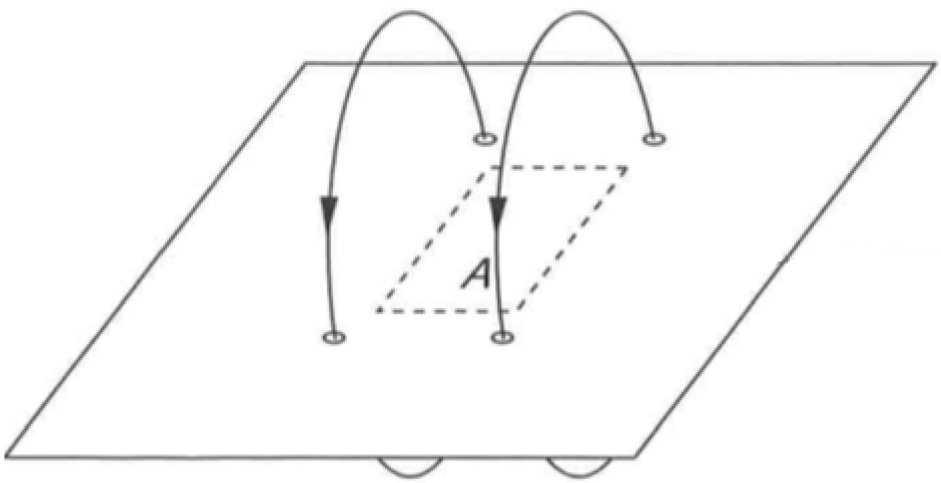

Fig. 4.3

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.

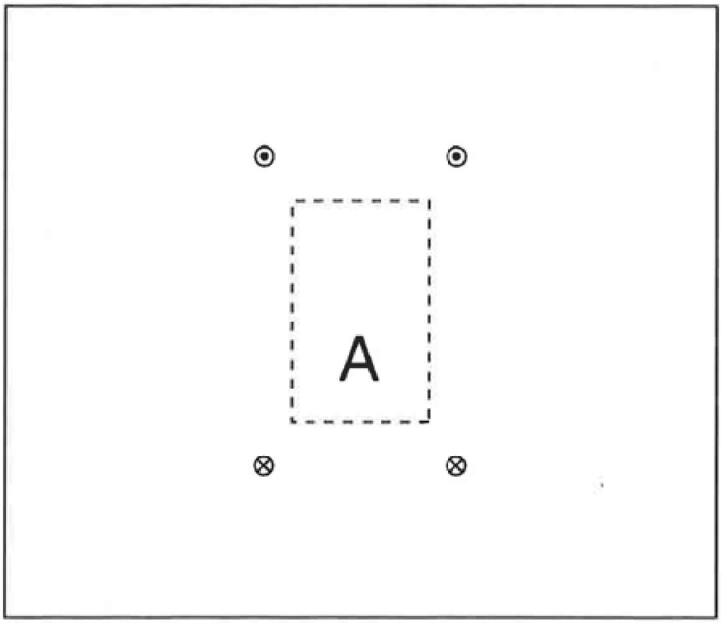

Fig. 4.4

[4]

For Examiner's Use

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.

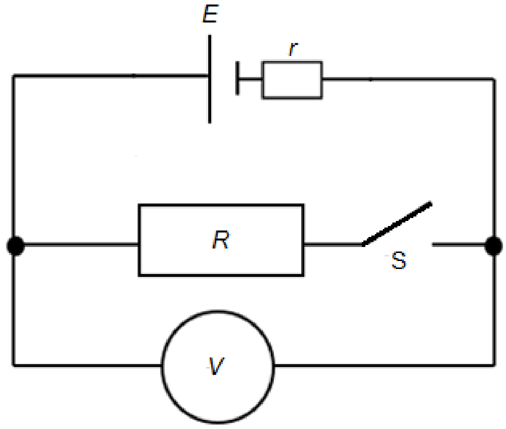

Fig. 5.1

(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]

(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.

power dissipated = …………………….. W [2]

For Examiner's Use

(ii) A few minutes after closing switch S, the current through the thermistor increased to 45 mA.

Explain why the current increased.

……………………………………………………………………………………….

………………………..………………………………………………………………

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

For Examiner's Use

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.

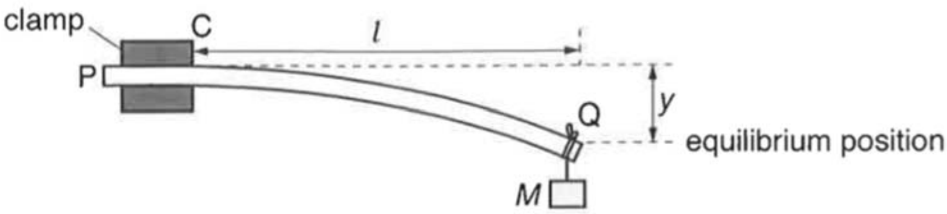

Fig. 6.1

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 / m)	ln(l / 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		
0.021	0.400	–3.863	–0.916

Fig. 6.2

The set of readings for *y* is for a beam thickness *d* of 5.00×10^{-3} m.

(i) Complete Fig. 6.2 for l = 0.500 m [2]

(ii) A graph of some of the data showing the variation of ln (y / m) with ln (l / m) is shown in Fig. 6.3 below.

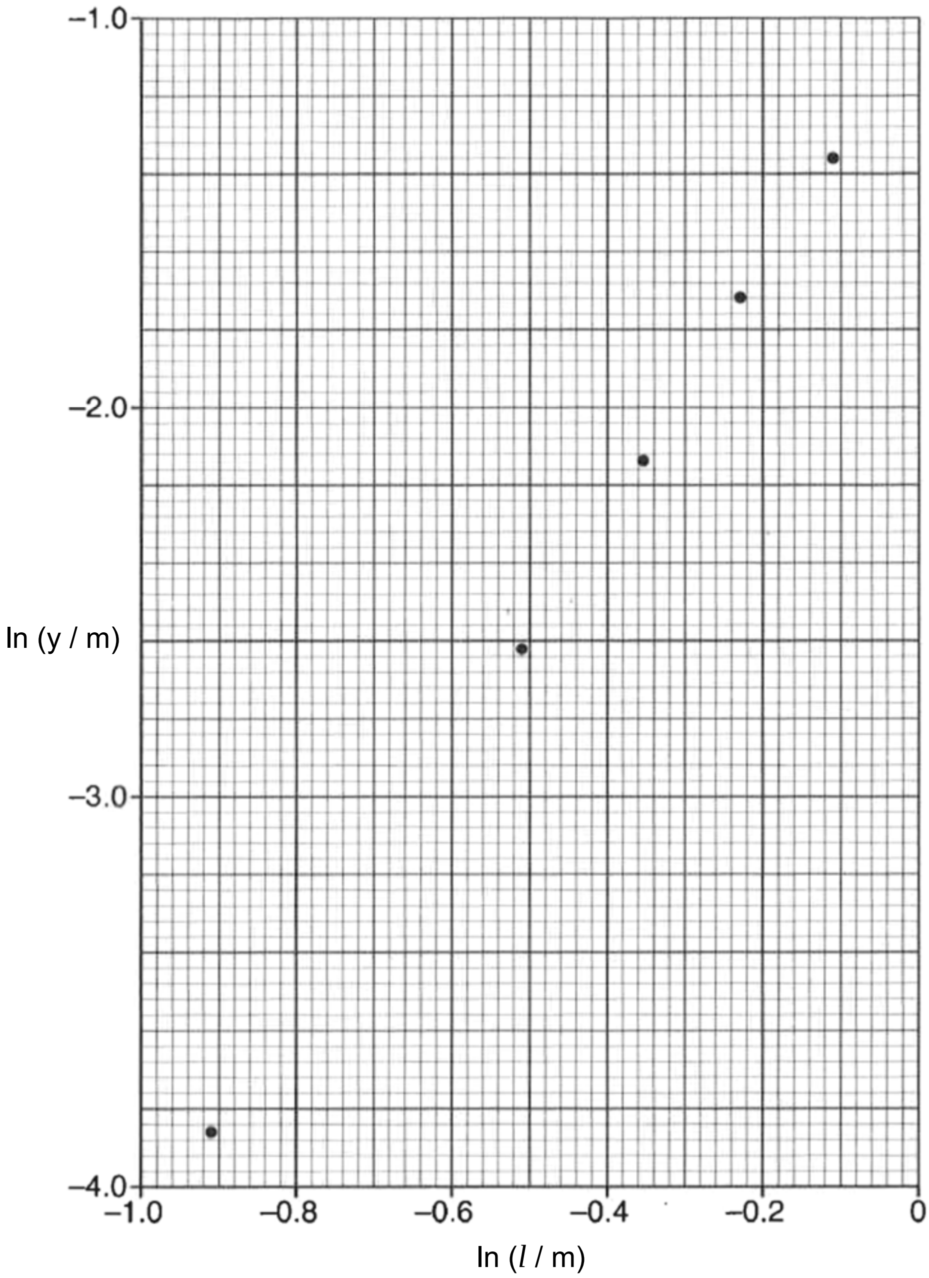

Fig. 6.3

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]

For Examiner's Use

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

....

....

.... [2]

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

r = ... [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]

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.

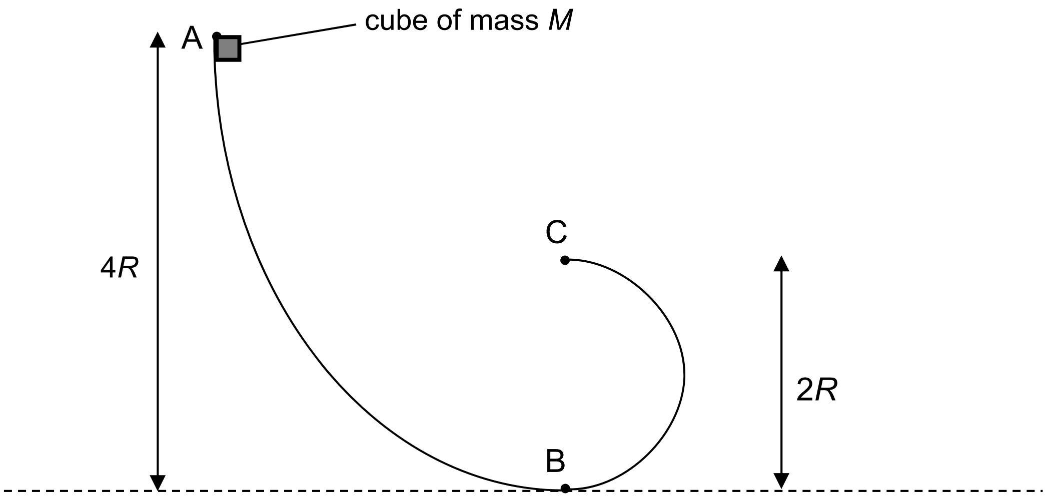

Fig. 7.1

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

1. at B,

speed of block at B = …………………….. m s^{-1} [2]

2. at C.

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.

....

....

.... [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.

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....

....

.... [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.

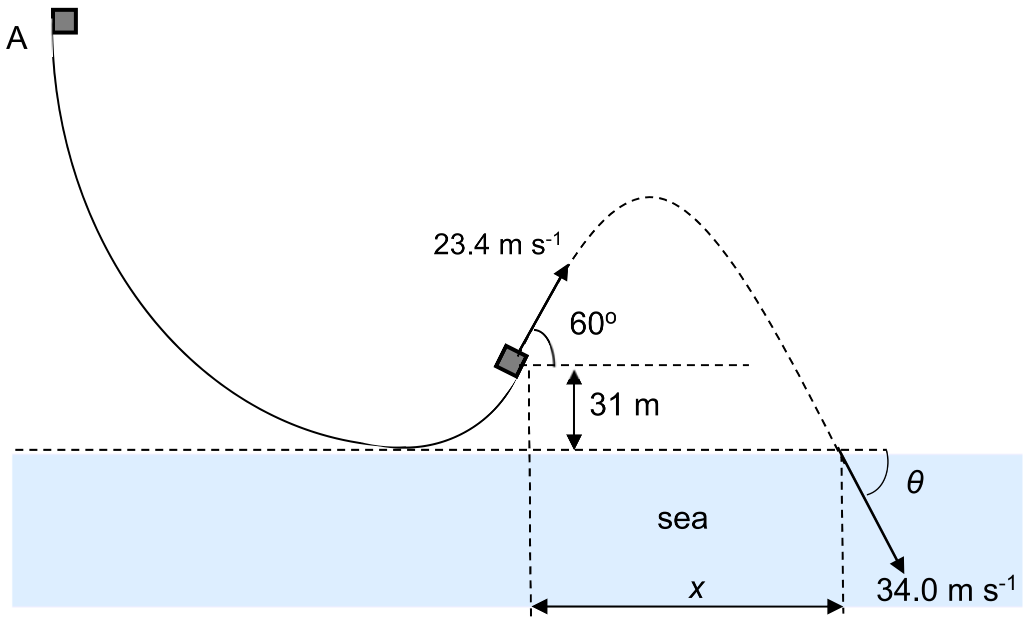

Fig. 7.2

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

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

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

2. the angle θ at which the cube enters the sea,

angle θ = …………………….. ° [1]

3. the horizontal distance travelled, x.

x = …………………….. 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 .

ΔV = …………………….. 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.

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………………………………………………………………………………. [2]

8 **(a)** Explain what is meant by photoelectric effect.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………….. [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.

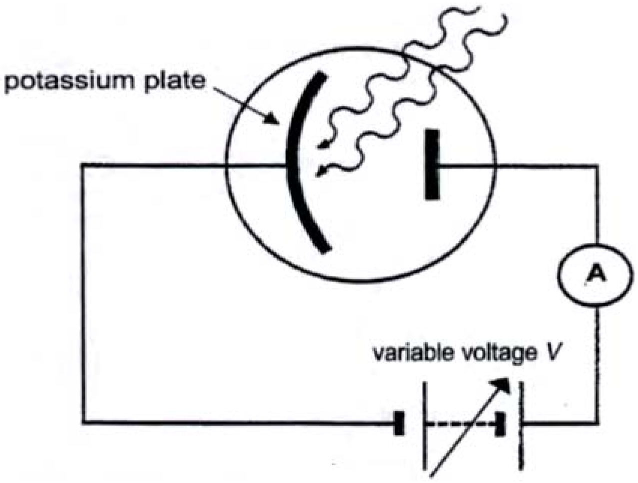

Fig. 8.1

(i) Explain what is meant by the *work function* of a metal.

………………………………………………..……………………………………

………………………………………………..…………………………….. [1]

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

energy of photon = …………………….. eV [2]

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

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**.

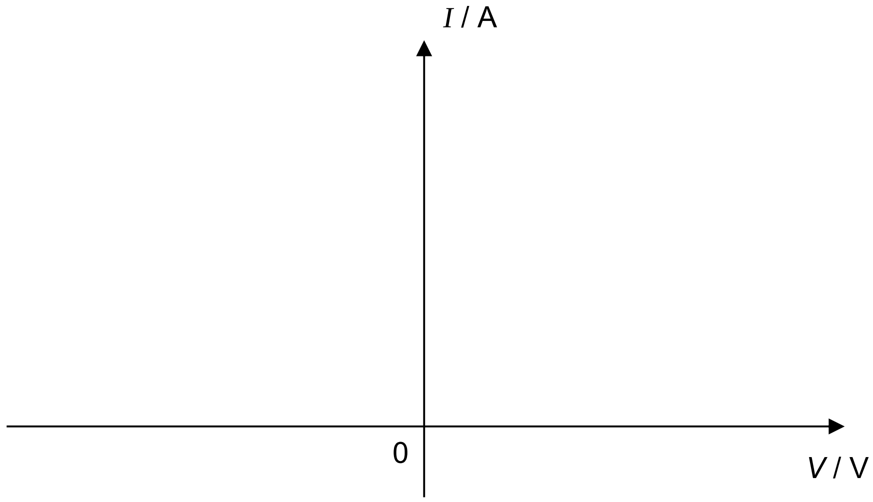

Fig. 8.2

[2]

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

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………… [2]

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

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]

(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.

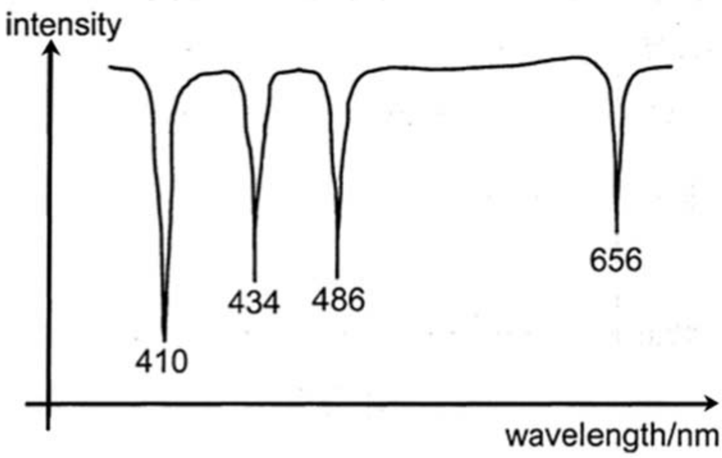

Fig. 8.3

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

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [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.

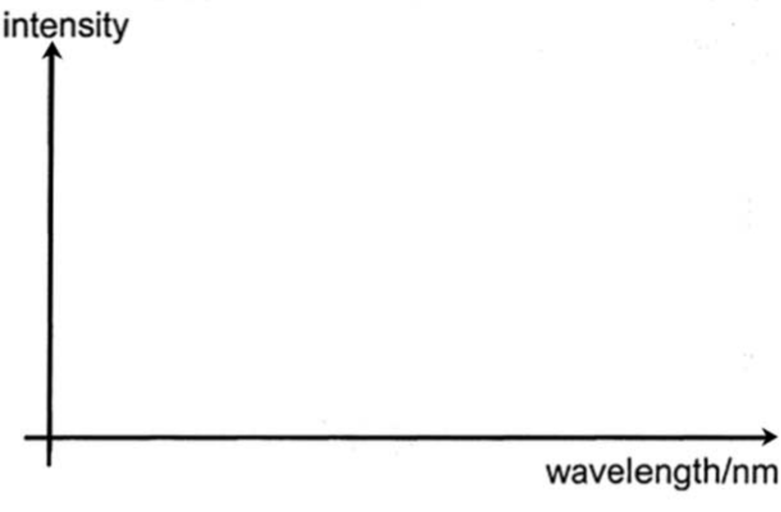

Fig. 8.4

[1]

For Examiner's Use

(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.

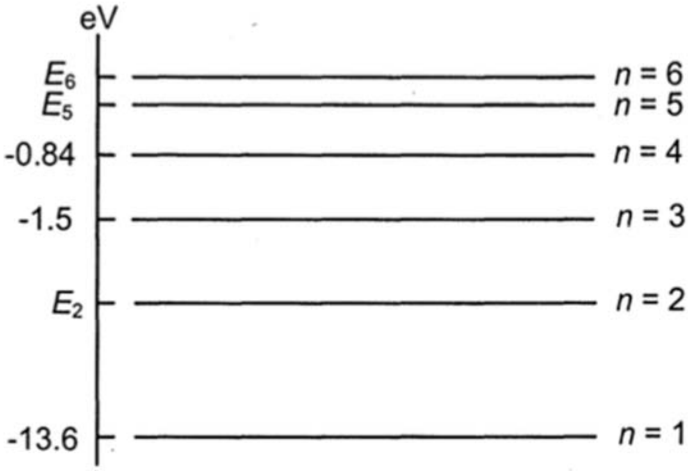

Fig. 8.5

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.

E_2 = ……………………. eV

E_6 = ……………………. eV [2]

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

Charge is ……..…………..………………………………………………………………

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

The coulomb is ……………………………………………………………….............

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

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

Potential difference is …………………..……………………………………………..

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

The volt is ………………………………………………………………………..……

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

(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 1.70×10^{-8} Ω m. The two cables were connected in series.

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

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,

current = ……………………. A [2]

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

power wasted = ……………………. W [2]

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

potential difference = ……………………. V [2]

4. the percentage efficiency of the distribution system.

efficiency = ……………………. % [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.

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....

.... [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)**.

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....

....

.... [2]