TEMASEK JUNIOR COLLEGE

2014 Preliminary Examination
Higher 1

CANDIDATE NAME			
CIVICS GROUP		INDEX NUMBER	

PHYSICS

8866/02

Paper 2 Structured Questions

28 August 2014

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTION FIRST

Write your Civics group, index number and name 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.

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.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
Total	

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

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-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	=	ρgh
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 A hot air balloon was rising steadily at a speed of 10.0 m s^{-1}.

A sandbag was dropped from the balloon at time t = 0 s.

(a) Ignoring air resistance and taking g as 10 m s^{-2}, sketch on Fig. 1.1 the variation of the velocity v with time t of the sandbag from time t = 0 s to t = 5.0 s. Label this graph **A**. Appropriate values should be indicated.

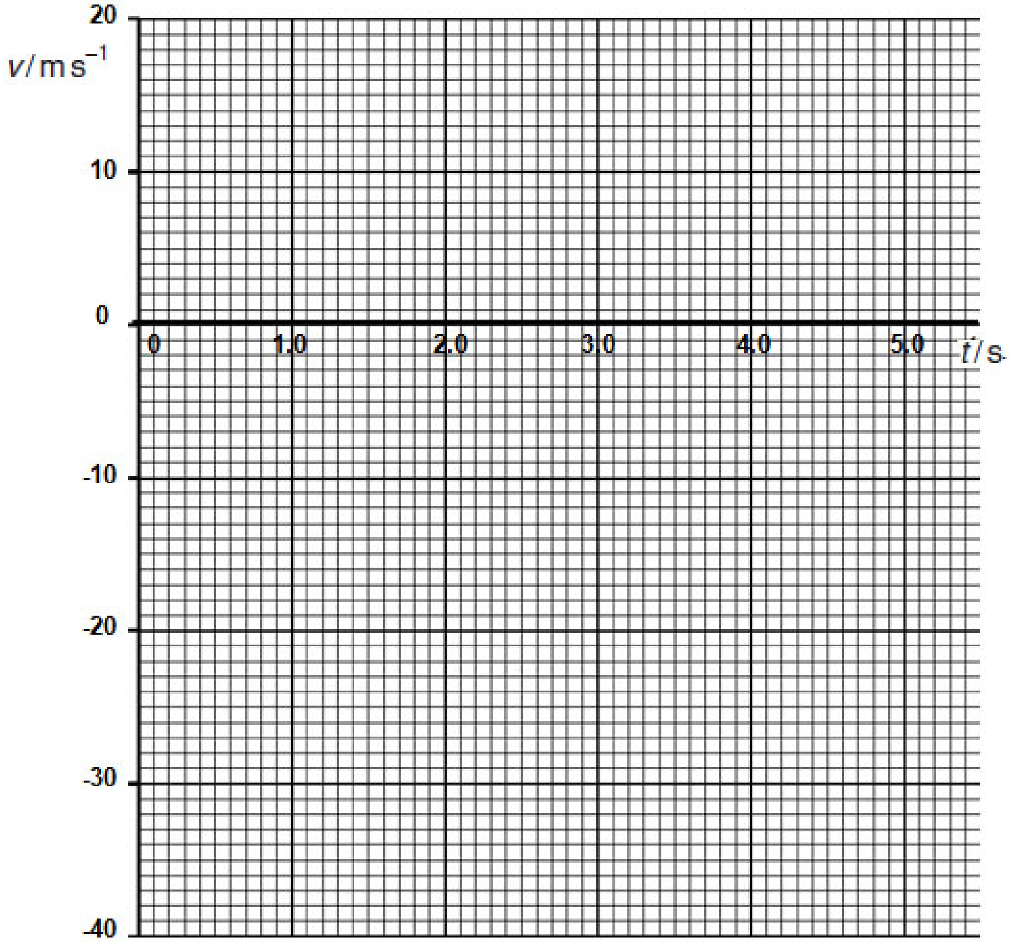

Fig. 1.1 [1]

(b) Another sandbag was dropped from the balloon at t = 2.0 s. On the same axes provided in Fig. 1.1, sketch the variation of the velocity v with time t of the second sandbag from time t = 0 s to t = 5.0 s. Label this graph **B**. Appropriate values should be indicated.

[2]

(c) Using the graphs in Fig. 1.1 or otherwise, calculate the vertical distance between the two sandbags at t = 5.0 s.

vertical distance = ... m [3]

2 **(a)** State the conditions necessary for an object to be in static equilibrium.

....

....

....

.... [2]

(b) Fig. 2.1 shows a plank of length 2.00 m resting on two supports **A** and **B**, which are each placed at a distance 0.15 m from the edge of the plank. The plank is uniform and has a weight of 80 N. A painter of weight 650 N stands 0.55 m from one end.

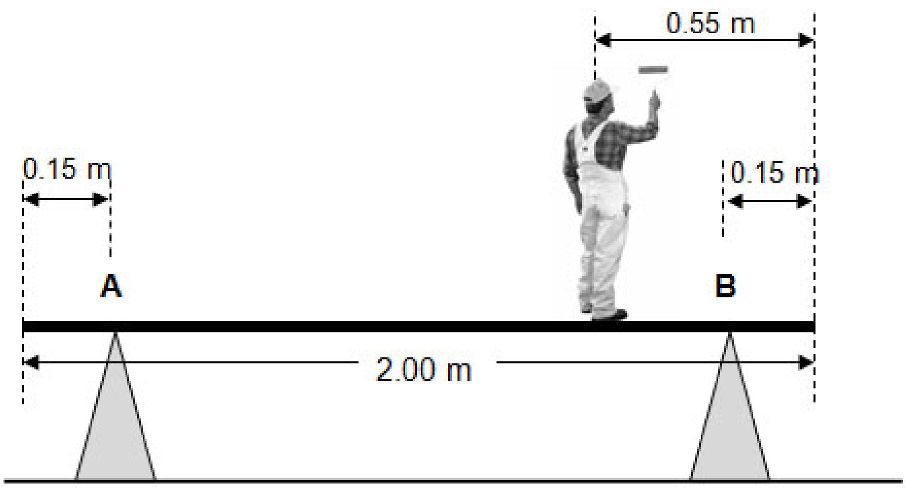

Fig. 2.1

(i) On Fig. 2.2, draw and label the forces acting on the plank. [2]

Fig. 2.2

(ii) Show that the force acting on the plank at support **B** is about 540 N.

[2]

(iii) Calculate the force acting on the plank at support **A**.

force = ... N [1]

3 Fig. 3.1 shows the *I-V* characteristics for two conductors. One is a piece of nichrome wire and the other is the tungsten filament of a lamp.

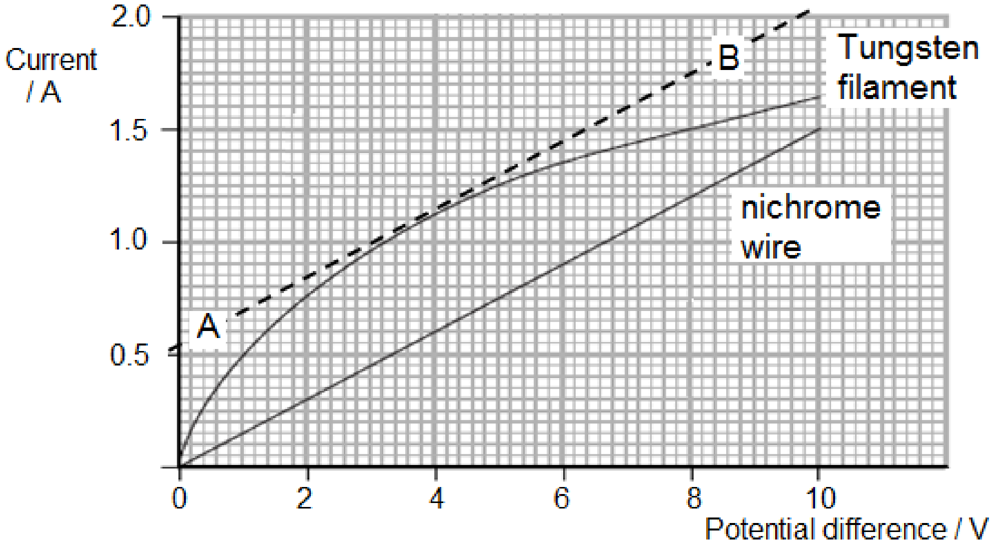

Fig 3.1

(a) Define the *ohm*.

....

....

.... [1]

(b) One student states that at V = 4.0 V, the resistance of tungsten filament is equal to that of the nichrome wire because the gradient of the *I-V* graph for the tungsten filament, given by the dotted line AB, is parallel to that of the nichrome wire at V = 4.0 V.

Comment on the validity of the statement.

....

....

....

....

.... [2]

(c) Both conductors are connected in series with a battery of e.m.f. 8.0 V and negligible internal resistance.

Use the graph in Fig. 3.1 to deduce the current that is drawn from the battery.

current = ... A [2]

(d) Both conductors are now connected in parallel with another battery of e.m.f. 8.0 V.

If the battery has internal resistance which is not negligible such that the terminal voltage of the battery drops to 6.0 V, calculate the value of the internal resistance of the battery.

internal resistance = ... Ω [2]

4 **(a)** A rigid wire is pivoted at point P so that it is free to move in a vertical plane, as shown in Fig. 4.1. The lower end of the wire dips into mercury which is contained in a conducting container. The arrangement is connected to a d.c. supply at the points P and Q as shown. A uniform magnetic field of flux density 4.0×10^{-2} T acts over the region ABCD and is directed perpendicularly into the page.

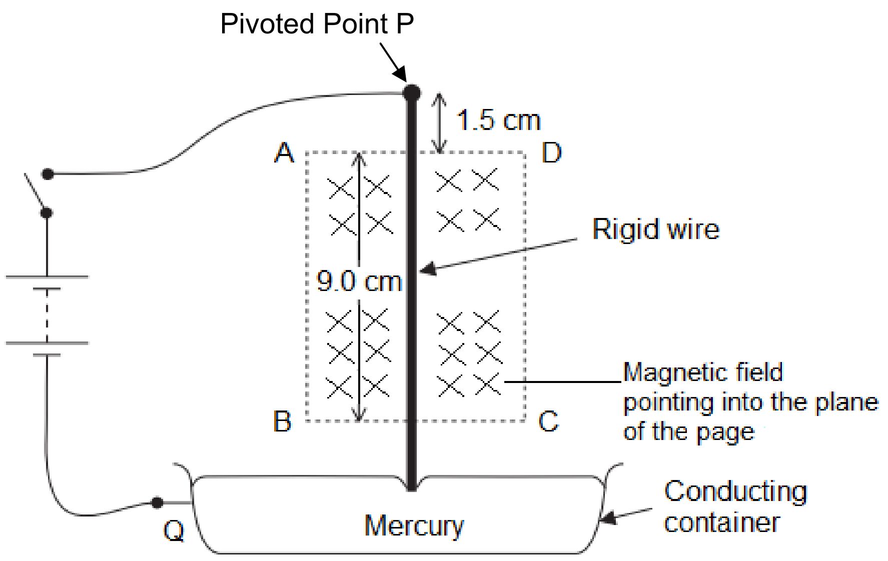

Fig. 4.1

When the switch is closed the wire is seen to continually 'kick' out of the mercury and then return to it. Explain, with reference to the moments that act on the wire, why it moves like this.

....

....

....

....

....

....

....

.... [3]

(b) The electromagnetic force on the wire may be assumed to act at the midpoint of the part of the wire which lies in the magnetic field. The initial moment of this force about P, produced when the switch is closed, is 5.0×10^{-4} N m.

Show that the magnitude of the force is 8.3×10^{-3} N.

[1]

(c) Calculate the current in the wire when the switch is closed.

current = ... A [2]

(d) If the diameter of the rigid wire is doubled and the length is kept constant, explain how the initial force on the rod changes, if any. Assume that the resistance of the rigid wire is much greater than other resistances of the closed circuit.

....

....

....

....

.... [2]

5 Low speed wind turbines windmills have been used since 1870 to pump water for irrigation on farms. One of such windmills is shown in Fig. 5.1

Fig 5.1

The turbine blades cover almost the whole surface of the wheel. Diameters of the wheel of the windmills of this type vary from about 2.0 m to a practical maximum of about 12 m. Because of this size limitation, they are not suited to large power outputs. They will start freely with wind speeds as low as 2.0 m s^{-1}. At these low speeds, the turbine blades produce large torques.

Fig. 5.2 shows how *P*, the output power of these windmills varies with the overall diameter of the wheel for different wind speeds, *v*.

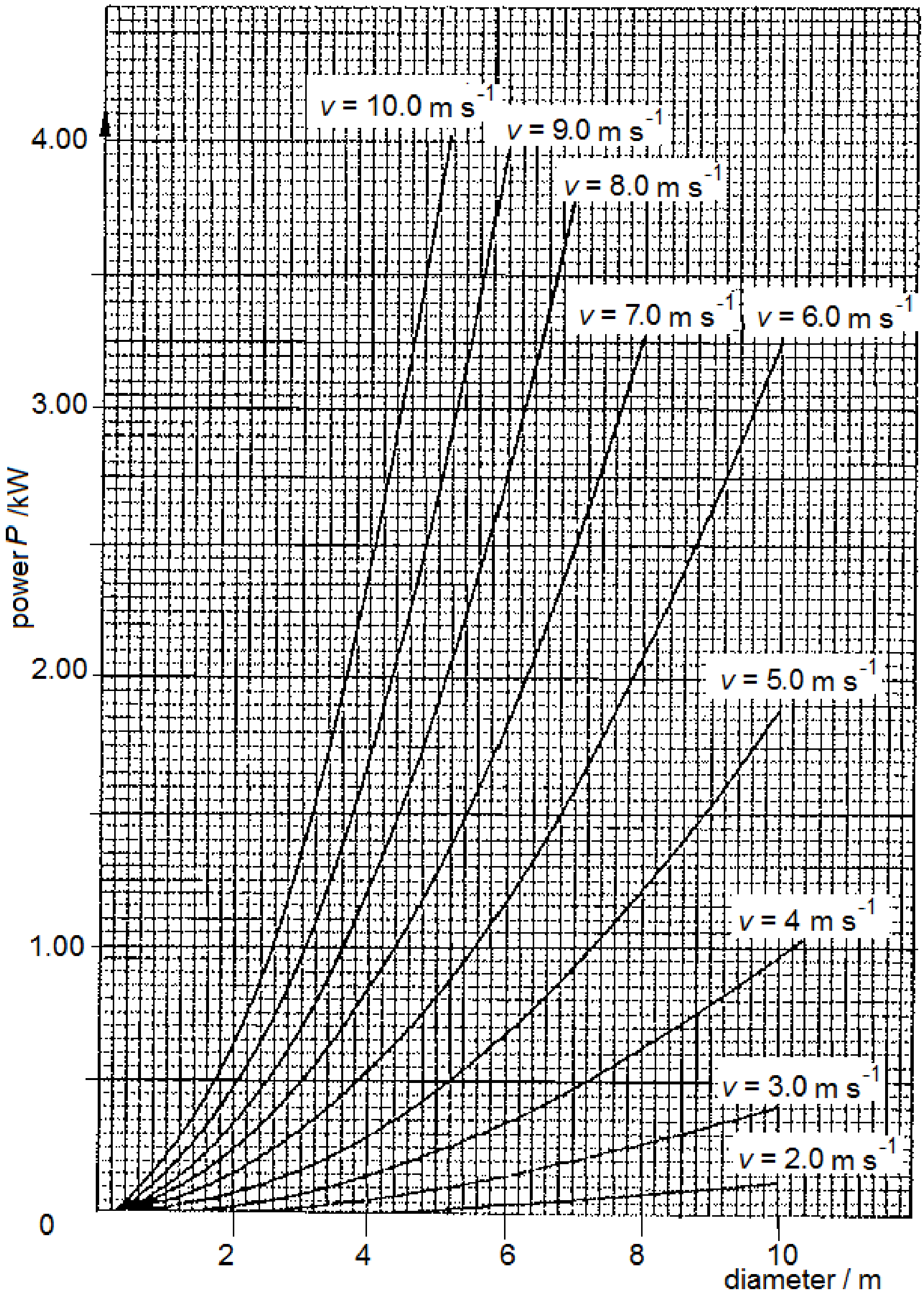

Fig. 5.2

(a) A student proposes that the output P varies linearly with the wind speed v^n.

For a wheel of diameter 6.0 m, tabulate and complete the corresponding values of output power in Table 5.3.

Wind speed v / m s^{-1}	Output Power P / kW	ln (P / kW)	ln (v / m s^{-1})
2.0	0.05	-3.00	0.69
3.0	0.15	-1.90	1.10
4.0	0.35	-1.05	1.39
5.0			
6.0	1.15	0.140	1.79
7.0	1.85	0.615	1.95
8.0	2.80	1.030	2.08

Table 5.3 [2]

(b) Fig. 5.4 is a plot of some of the data in Table 5.3.

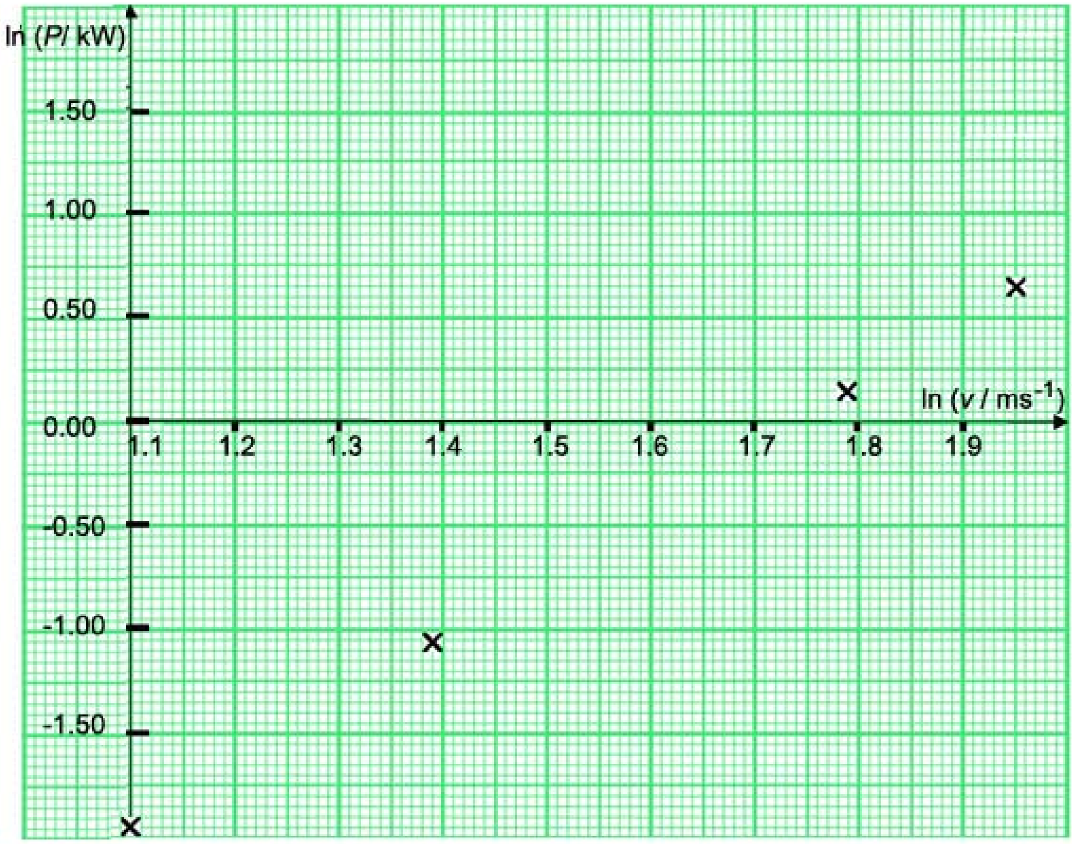

Fig. 5.4

Complete Fig. 5.4 using your data in Table 5.3. [1]

(c) The proposal of the variation with P of v for diameter of 6.0 m is the expression

$$P = k\,v^n$$

where both k and n are constant

(i) Explain why the graph of Fig. 5.4 supports this proposal.

....

....

.... [2]

(ii) Use Fig. 5.4 to determine the constant n.

n = ... [2]

(d) The density of air is 1.3 kg m^{-3}. Calculate the power (kinetic energy per second) of the volume of moving air when the diameter of wheel is 6.0 m and the wind speed is 6.0 m s^{-1}.

power = ... W [2]

(e) In **(d)**, you have calculated the power (kinetic energy per second) arriving at the wheel. Use this together with data from Fig. 5.2 to find the fraction of this power converted into useful output power.

fraction of power = ... [1]

(f) In practice, it has been found difficult to scale up a windmill such as this, say to a wheel of 30 m diameter, to achieve the power output of the order of megawatts.

Suggest two reasons for this.

....

....

....

....

.... [2]

Section B

Answer **two** questions in this section.

6 **(a)** State Newton's second law of motion.

....

....

.... [1]

(b) Fig. 6.1 shows a frictionless pulley and two buckets A and B attached together by a rope of negligible mass.

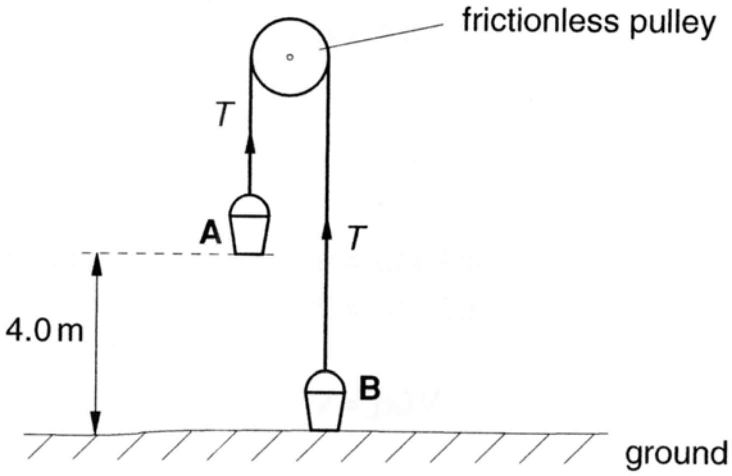

Fig. 6.1

The mass of bucket A is greater than the mass of bucket B. Bucket B is held on the ground and bucket A is at a vertical height of 4.0 m above the ground. Bucket B is released. The tension on the rope is T. You may assume that air resistance is negligible.

(i) Explain why the acceleration of bucket A is less than the acceleration of free fall g.

....

....

.... [1]

(ii) Show that the acceleration a of bucket A is given by the expression

$$a = \frac{m_A - m_B}{m_A + m_B} g$$

where m_A is the mass of bucket A, m_B is the mass of bucket B and g is the acceleration of free fall.

[2]

(iii) The mass of bucket A is 5.0 kg and the mass of bucket B is 3.6 kg.

Calculate the time taken by bucket A to reach the ground.

time = ... s [2]

(c) A spring is placed on a flat surface and different weights are placed on it, as shown in Fig. 6.2.

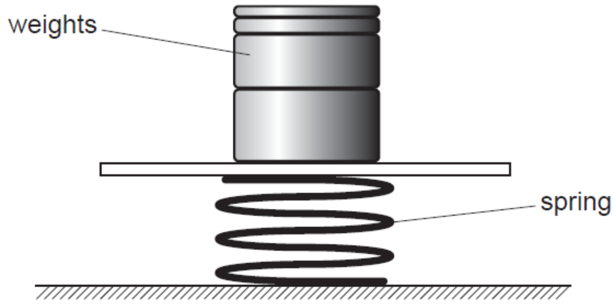

Fig. 6.2

The variation with weight of the compression of the spring is shown in Fig. 6.3.

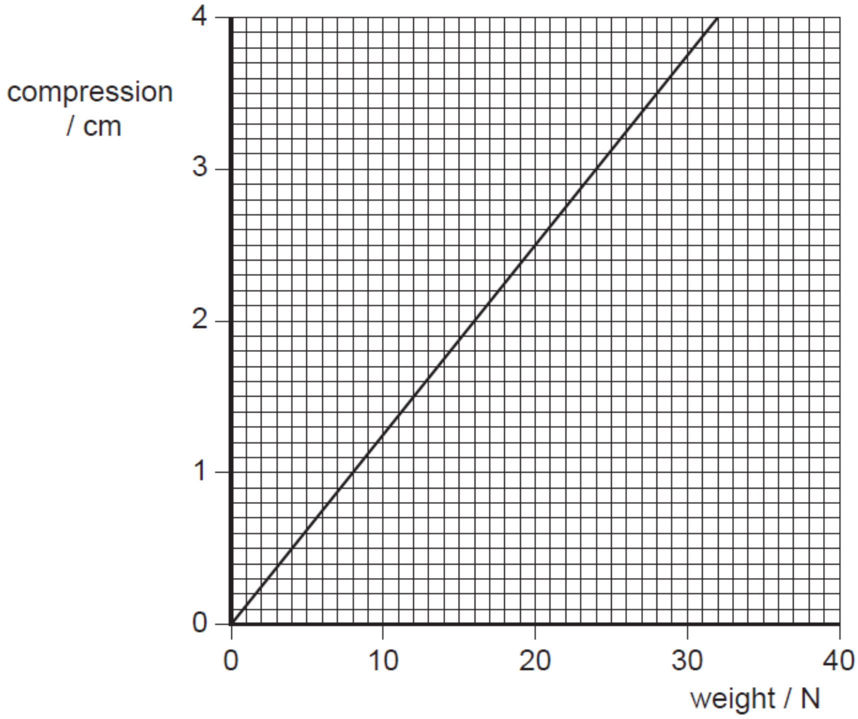

Fig. 6.3

The elastic limit of the spring has not been exceeded.

(i) Determine the spring constant k of the spring.

k = ... N m^{-1} [2]

(ii) Calculate the amount of elastic potential energy that is stored in the spring for a compression of 3.5 cm.

elastic potential energy = ... J [2]

(d) Two trolleys, of masses 800 g and 2400 g, are free to move on a horizontal table. The spring in **(c)** is placed between the trolleys and the trolleys are tied together using thread so that the compression of the spring is 3.5 cm, as shown in Fig. 6.4.

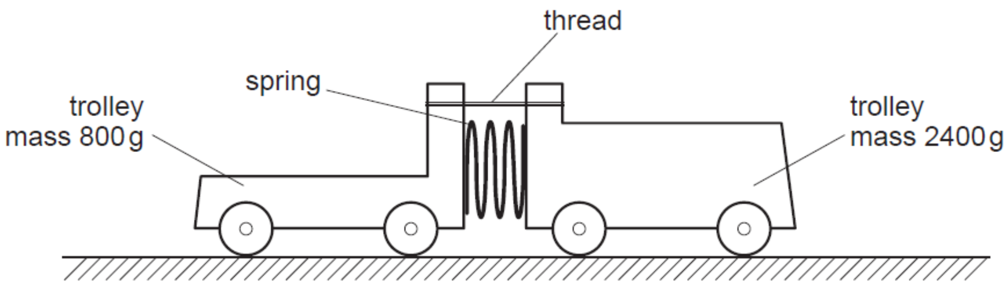

Fig. 6.4

Initially, the trolleys are not moving.

The thread is then cut and the trolleys move apart.

(i) State the principle of conservation of momentum.

....

....

.... [2]

(ii) Determine the ratio of

$$\frac{\text{speed of trolley of mass 800 g}}{\text{speed of trolley of mass 2400 g}}.$$

ratio = ... [2]

(iii) Use the answers in **(c)(ii)** and **(d)(ii)** to calculate the speed of the trolley of mass 800 g.

speed = ... m s^{-1} [3]

(e) In a separate experiment, a trolley of mass 850 g is held between two fixed points by means of two identical springs in **(c)**, as shown in Fig. 6.5.

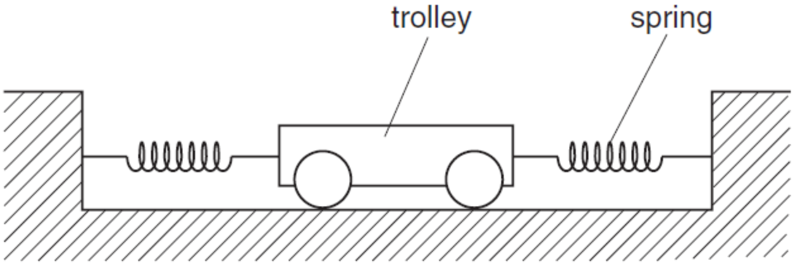

Fig. 6.5

When the trolley is in equilibrium, the springs are each extended by 4.5 cm.

The trolley is moved a distance of 1.5 cm along the direction of the springs. This causes the extension of one spring to be increased and the extension of the other spring to be decreased. The trolley is then released. The trolley accelerates and reaches its maximum speed at the equilibrium position.

Determine the maximum speed of the trolley.

speed = ... $m\,s^{-1}$ [3]

7 **(a)** A progressive sound wave of frequency 660 Hz passes through air. The variation of particle displacement with distance along the wave at one instant of time is shown in Fig. 7.1.

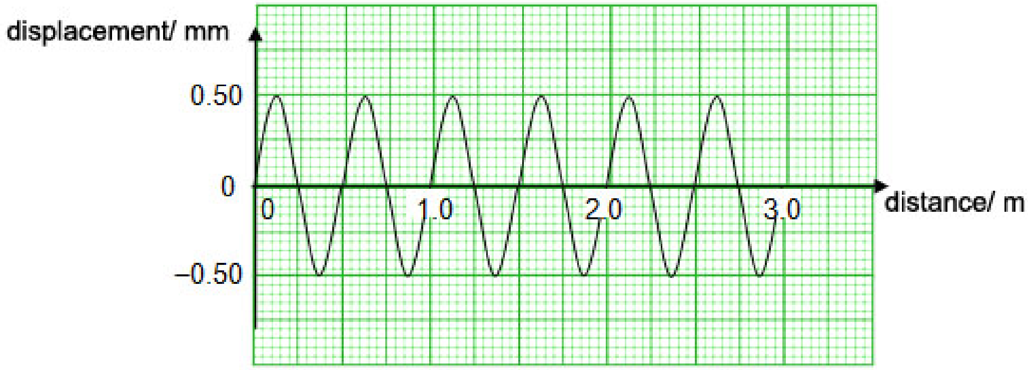

Fig. 7.1

(i) Explain what is meant by a *progressive wave*.

....

....

.... [2]

(ii) State whether this wave is an example of a longitudinal or a transverse wave.

.... [1]

(iii) Using the data from Fig. 7.1, deduce for this wave,

1. the wavelength,

wavelength = ... m [1]

2. the amplitude,

amplitude = ... mm [1]

3. the speed.

speed = ... m s^{-1} [1]

(b) Fig. 7.2 shows a stretched string, fixed at one end and driven by an oscillator at the other end. A stationary wave is produced on the string such that it vibrates in three loops. The distance between the oscillator and the wall is 1.8 m and the speed of the transverse wave on the string is 7.2 m s^{-1}.

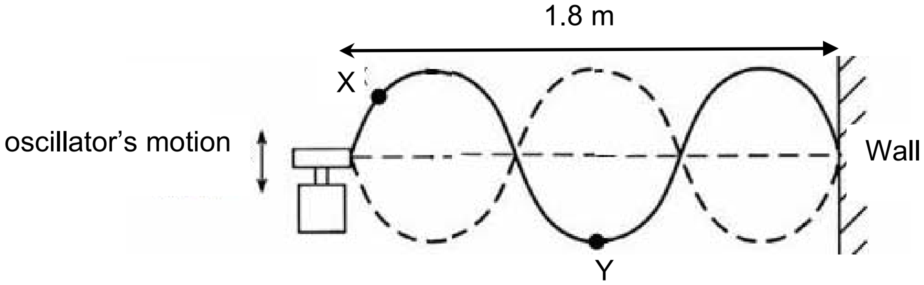

Fig. 7.2

(i) Explain the formation of a stationary wave in the string.

....

....

.... [2]

(i) State the difference in phase, if any, between points X and Y.

.... [1]

(ii) Determine the frequency of the oscillator as shown in Fig. 7.2.

frequency = ... Hz [3]

(iii) Determine the lowest frequency of the oscillator that will produce a well-defined stationary wave in the string.

frequency = ... Hz [2]

(c) Fig. 7.3 shows the arrangement for viewing a visible interference pattern on a screen.

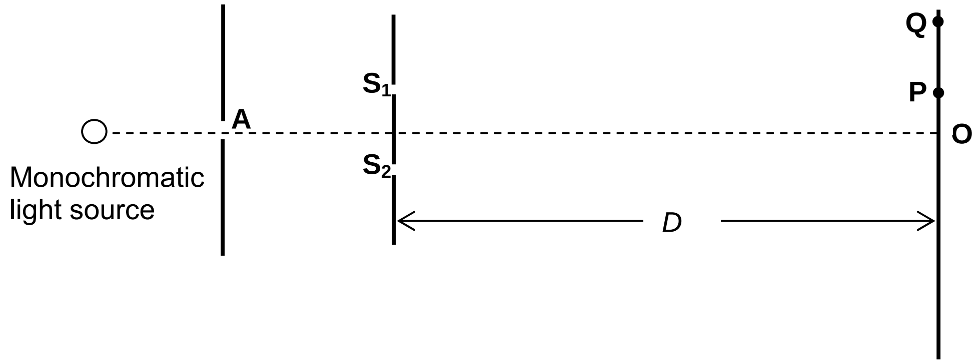

Fig. 7.3

In a darkened room, a double slit (**S_1** and **S_2**) is placed in front of a narrow single slit **A** situated in front of a monochromatic light source. Slit **A** is equidistant from slits **S_1** and **S_2**.

(i) In order to produce a clear interference pattern on the screen, the wave sources must be *coherent*. State what is meant by *coherent* sources.

....

.... [1]

(ii) Explain how the arrangement shown ensures that the slits **S_1** and **S_2** act as coherent light sources.

....

.... [1]

(iii) Points **P** and **Q** are the first and second positions of **minimum** intensity from the central point **O**. State, in terms of the wavelength λ, the magnitude of the path difference between **S_1Q** and **S_2Q**.

path difference = ... [1]

(iv) When D = 1.5 m and light of frequency 4.7 x 10^{14} Hz is incident on the double slit, the distance between **Q** and **O** is 12 mm. Calculate the slit separation a.

a = ... m [3]

8 Albert Einstein and Niels Bohr made many contributions to the early development of quantum theory. Einstein's explanation of the photoelectric effect in terms of photon theory and Bohr's explanation of atomic spectra in terms of quantised energy levels are just two important examples of their contributions.

(a) Explain what is meant by the following terms:

(i) photon,

....

.... [1]

(ii) quantised.

....

.... [1]

(b) Explain how Einstein's photon model of light differs from the classical description of light as an electromagnetic wave in the way it explains

(i) light intensity,

....

....

....

....

....

.... [2]

(ii) the absorption of light energy by a metal surface.

....

....

....

....

....

.... [2]

(c) In an experiment to investigate photoelectric effect, a beam of ultraviolet light is incident on a clean metal surface.

The graph of Fig. 8.1 shows how the maximum kinetic energy KE_{max} of the electrons ejected from the surface varies with the frequency f of the incident light.

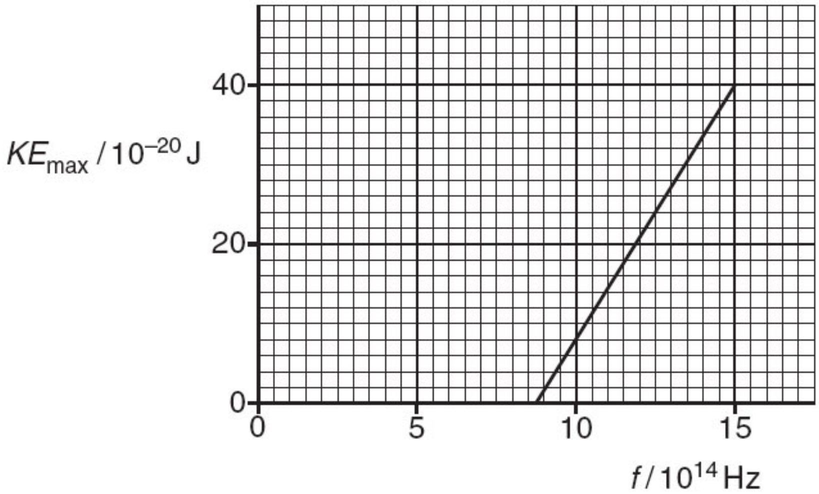

Fig. 8.1

Use the data in Fig. 8.1 to find a value of

(i) the Planck constant,

Planck constant = ... J s [2]

(ii) the work function of the metal.

work function = ... J [2]

(d) In another experiment to observe atomic spectra of gases, some mercury vapour is placed in a discharged tube as shown in Fig. 8.2.

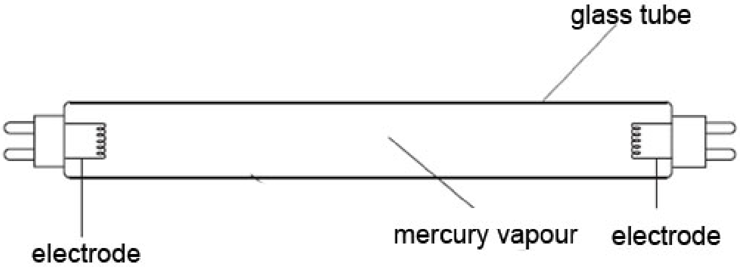

Fig. 8.2

When the tube is connected to a high voltage supply, the mercury atoms become excited and emit electromagnetic radiation.

(i) Explain how the mercury atoms are excited in the discharge tube.

....

....

.... [1]

(ii) Use Bohr's quantised energy levels and Einstein's photon theory to explain why excited atoms emit characteristic frequencies of electromagnetic radiation.

....

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....

....

....

....

....

....

.... [3]

(iii) Two bright lines of wavelengths 436 nm and 546 nm are observed in the atomic spectrum of mercury. The two lines are the result of electronic transitions between energy level A and two lower energy levels B and C as shown in Fig. 8.3.

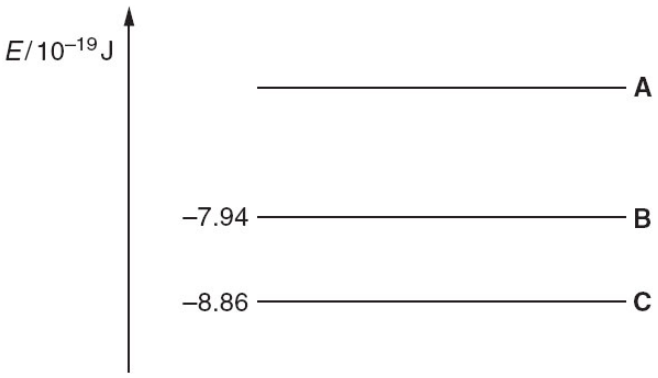

Fig. 8.3

1. State the region of the electromagnetic spectrum in which the two bright lines lies.

.... [1]

2. Draw two arrows on Fig 8.3. to represent the transitions which give rise to these wavelengths. Label each arrow its emitted wavelength. [2]

3. Calculate the value of the energy level A.

energy = ... J [3]