HWA CHONG INSTITUTION
JC2 Preliminary Examination
Higher 1

CANDIDATE NAME		**CT GROUP**	23S
CENTRE NUMBER		**INDEX NUMBER**	

PHYSICS 8867/02

Paper 2 Structured Questions

10 September 2024

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre Number, index number and name in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

Section A
Answer **all** questions.

Section B
Answer any **one** question.

The number of marks is given in brackets [ ] at the end of each question or part question.
You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use		
Paper 2		
Section A		
1		**6**
2		**7**
3		**12**
4		**8**
5		**12**
6		**15**
Section B		
7		**20**
8		**20**
Deductions		
Total		**80**

Data

speed of light in free space,
$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$

elementary charge,
$e = 1.60 \times 10^{-19}\ \mathrm{C}$

unified atomic mass constant,
$u = 1.66 \times 10^{-27}\ \mathrm{kg}$

rest mass of electron,
$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$

rest mass of proton,
$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$

the Avogadro constant,
$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$

gravitational constant,
$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^2\,kg^{-2}}$

acceleration of free fall,
$g = 9.81\ \mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion
$s = ut + \frac{1}{2}at^2$
$v^2 = u^2 + 2as$

resistors in series
$R = R_1 + R_2 + \ldots$

resistors in parallel
$1/R = 1/R_1 + 1/R_2 + \ldots$

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Section A

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

1 **(a)** A body has an initial velocity u and an acceleration a. After a time t, the body has moved a displacement s and has a final velocity v.

One of the equations to describe the motion of this body is

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

State the condition that must be satisfied for the above equation to be valid.

………..

………[1]

(b) A hot air balloon is moving at a constant velocity of 11.7 m s^{-1}, at an angle of 59° from the horizontal, as shown in Fig. 2.1.

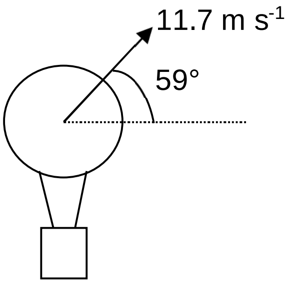

Fig. 2.1

(i) Determine the vertical component of the velocity of the balloon.

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

(ii) A slotted mass is released from the balloon. Fig. 2.2 shows the subsequent path of the slotted mass. The dotted figure shows the position of the hot air balloon at the instant when the slotted mass is released.

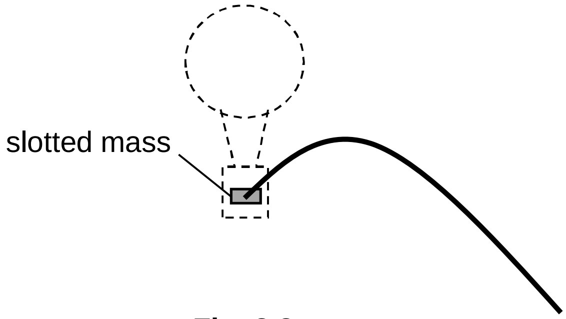

Fig. 2.2

1. Throughout the motion, the slotted mass is observed by a person in the hot air balloon to be directly below the balloon. Explain why this is so.

………………………………………………………………………………………………………

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

2. Determine how far below the balloon would the slotted mass be after 3.0 s. You may assume that the slotted mass has not yet landed on the ground and that air resistance on the slotted mass is negligible.

distance = ... m [3]

[Total: 6]

2 **(a)** State *Newton's third law of motion*.

....

....

....[1]

(b) In a track and field event, a high jumper jumps over a horizontal bar and lands on a thick mattress. Fig. 2.1 shows the instant where she is just clearing the bar at her maximum height. The high jumper is considered as a point mass labelled P.

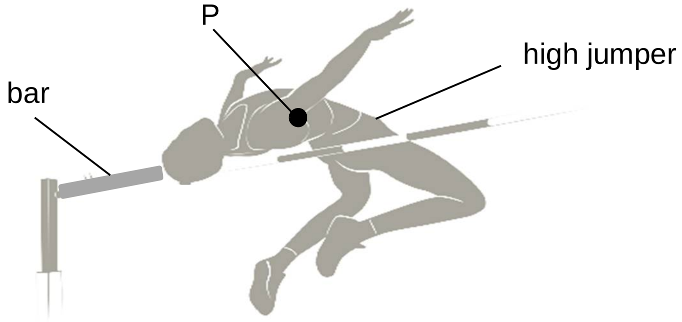

Fig. 2.1

(i) On Fig. 2.1, draw a labelled free body diagram to show the force(s) acting on her. [1]

(ii) Fig. 2.2 shows the instant she lands on the mattress.

Fig. 2.2

1. On Fig. 2.2, draw a labelled free body diagram to show the forces acting on her. [1]

2. On Fig. 2.3, draw a labelled free body diagram to show the forces acting on the mattress. [2]

Fig. 2.3

(c) Fig. 2.4 shows the variation with time t of the net force F_{net} on her upon hitting the mattress. She has a mass of 50.0 kg and she comes to rest without rebounding at t = 1.20 s.

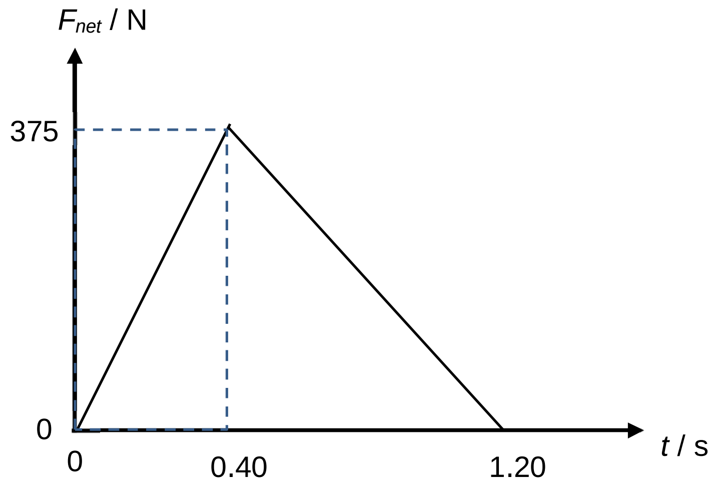

Fig. 2.4

Determine the speed at which she hits the mattress.

speed = ... m s^{-1} [2]

[Total: 7]

3 (a) State the conditions for a rigid body to be in static equilibrium.

....

....

.... [2]

(b) Fig. 3.1 shows a uniform ladder of weight 80 N resting on a smooth wall and a rough floor. The ladder makes an angle of 60° with the floor.

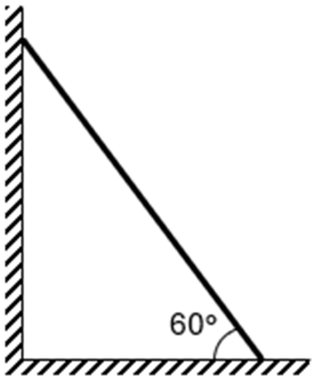

Fig. 3.1

(i) Show that the force exerted by the wall on the ladder is 23 N.

[2]

(ii) Calculate the force exerted by the floor on the ladder.

magnitude of force = ... N

angle force makes with the floor = ... [4]

(iii) A person now stands on the ladder. The ladder remains stationary.

State and explain the effects, if any, on

1. the vertical force exerted by the floor on the ladder,

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………[2]

2. the horizontal force exerted by the wall on the ladder.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………[2]

[Total: 12]

4 (a) A negatively charged particle enters a uniform field. Fig. 4.1 shows the particle travelling along the direction of the field.

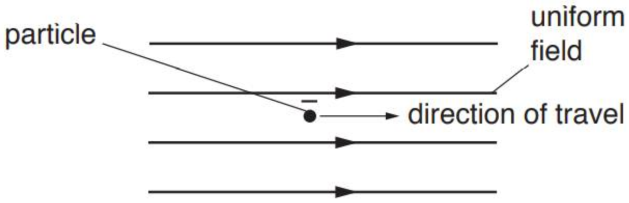

Fig. 4.1

Describe the motion of the particle when the particle is only in

(i) a gravitational field,

……………………………………………………………………………………………

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

(ii) an electric field,

……………………………………………………………………………………………

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

(iii) a magnetic field.

……………………………………………………………………………………………

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

(b) Fig. 4.2 shows a rigid, straight metal rod **XY** placed perpendicular to a magnetic field. The magnetic field is produced by two magnets that are placed on a U-shaped steel core. The steel core sits on a digital balance.

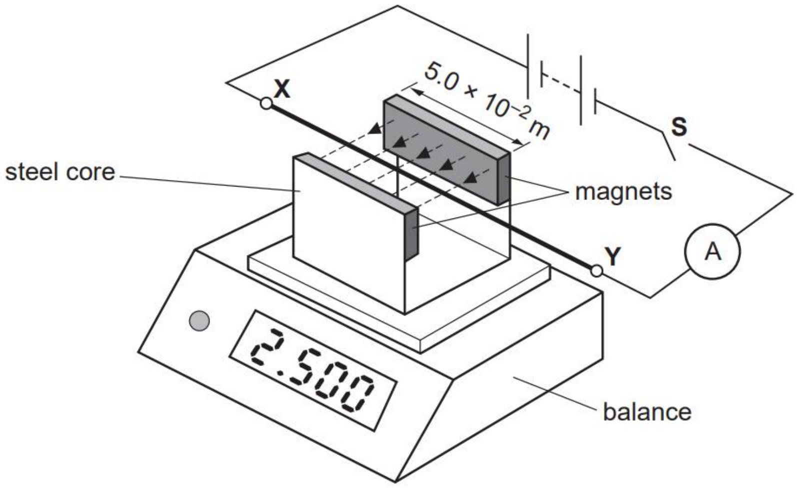

Fig. 4.2

The rod is clamped at points **X** and **Y**. The rod is connected to a battery, switch and ammeter as shown in Fig. 4.2. The weight of the steel core and the magnets is 2.500 N. The direction of the magnetic field is perpendicular to the rod as shown in the figure.

Switch **S** is now closed.

(i) The length of the rod in the magnetic field is 5.0×10^{-2} m and the current in the rod is 4.0 A. Assume that the magnets provide a uniform magnetic field of magnetic flux density 0.080T.

1. Calculate the force acting on the rod due to the magnetic field.

force = ... N [2]

2. State and explain the new reading on the balance.

reading on balance = ... N

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[3]

[Total: 8]

5 Tritium is an isotope of hydrogen and is represented by the symbol $^{3}_{1}H$. It has a binding energy per nucleon of 2.83 MeV.

(a) **(i)** Explain the term *isotope*.

……………………………………………………………………………………………..……………

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

(ii) Explain what is meant by the *binding energy* of a nucleus.

……………………………………………………………………………………………..……………

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

(b) **(i)** Calculate the binding energy of the tritium nucleus.

binding energy = ... MeV [2]

(ii) Given that the mass of a proton is 1.00783 *u* and the mass of a neutron is 1.00867 *u*, calculate, to five decimal places, the mass of a tritium nucleus.

mass = ... u [2]

(c) In a fusion power reactor, two deuterium nuclei fuse together to form a tritium nucleus.

(i) Complete the nuclear equation below for the fusion of deuterium.

$${}^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{1}H + ...$$ [1]

(ii) For the fusion of deuterium shown in **(c)(i)**, 4.03 MeV of energy is released.

1. Using your answer to **(b)(i)**, calculate the binding energy of a deuterium nucleus.

.

binding energy = ... MeV [2]

2. Calculate the mass of deuterium required per unit time to produce 2.86×10^{9} W of power.

mass = ... kg [3]

[Total: 12]

6 For thousands of years, people have studied the night sky and some ancient buildings provided evidence of astronomical observations by people of many different cultures. As instrumentation improved, so did the precision of astronomical observations.

In the early 17th century, Johannes Kepler made interpretations of these observations and deduced three laws, one of which had a great impact on later discoveries. Kepler's third law established the useful relationship between the periods and the radii of orbits of the various planets around the Sun.

As a result of Kepler's work, Newton formulated the law of gravitation.

(a) **(i)** State an equation representing Newton's law of gravitation and explain the symbols used.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(ii) By relating the gravitational force on a planet to the centripetal acceleration it causes, show that for a circular orbit

$$T \propto r^{\frac{3}{2}}$$

where T and r are the orbital period and radius respectively.

[3]

(b) The planet Uranus has five major moons which orbit around Uranus at different orbital radii. Data for these moons are given in Fig. 6.1.

Moon	*T* / days	*r* / 10^8 m	lg (*r* / m)	lg (*T* / days)
Miranda	1.41	1.3	8.11	0.149
Ariel	2.52	1.9		
Umbriel	4.14	2.7	8.43	0.617
Titania	8.71	4.4		
Oberon	13.46	5.8	8.76	1.1290

Fig. 6.1

(i) Complete Fig. 6.1 by calculating values for lg (*T* / days) and lg (*r* / m). [2]

(ii) Fig. 6.2 shows a graph of some of the data in Fig. 6.1.

Complete Fig. 6.2 using the data calculated above and draw a line of best fit. [2]

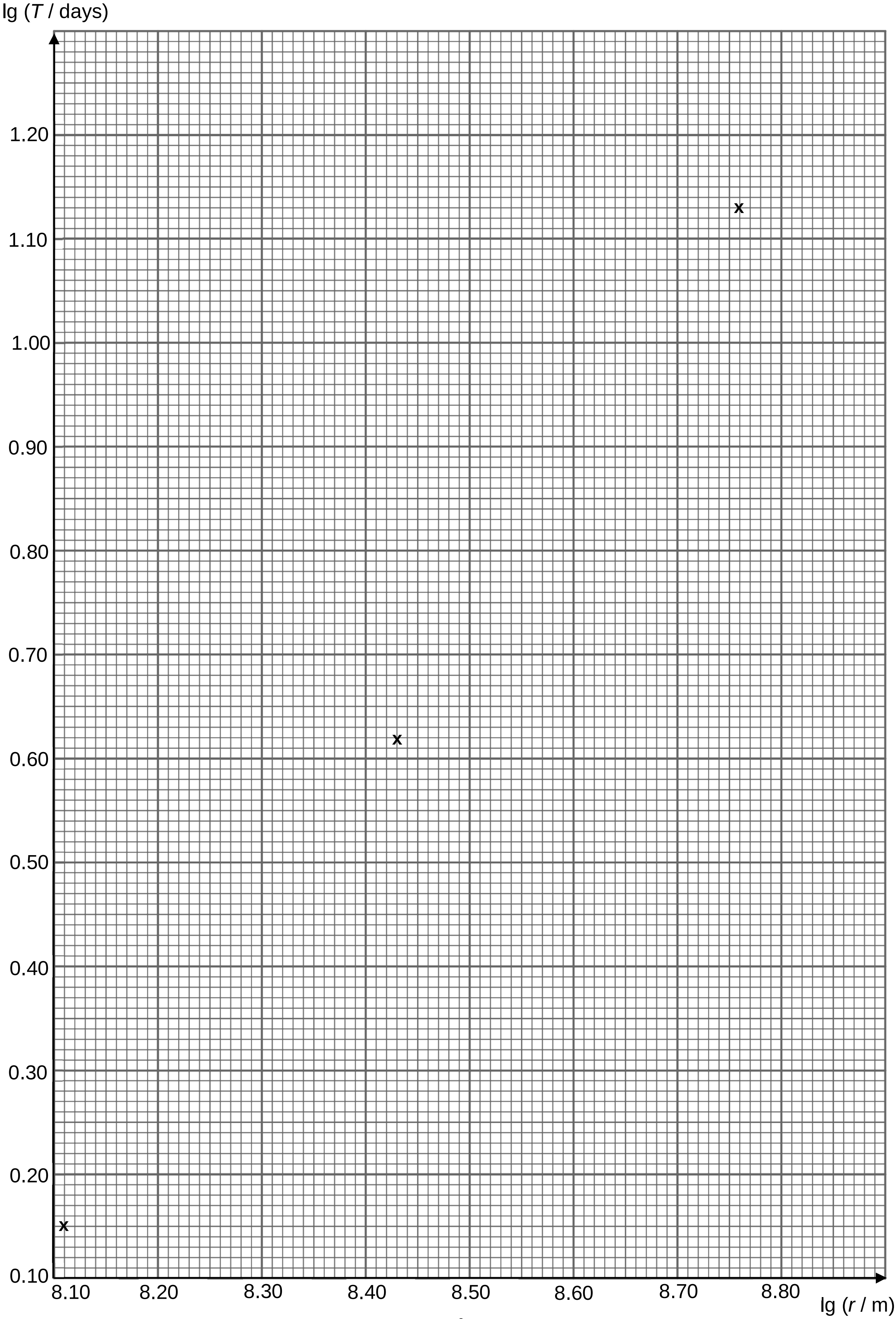
lg (T / days)
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
8.10
8.20
8.30
8.40
8.50
8.60
8.70
8.80
lg (r / m)

Fig. 6.2

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(c) **(i)** Determine the gradient of the line you have drawn on Fig. 6.2.

gradient = …………………… [2]

(ii) Hence, discuss whether the data in the table support the relation that you have shown in **(a)(ii)**.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(d) Suggest, with a reason, whether the graph of Fig. 6.2 could be used to check data on the orbital radii and periods of the moons of another planet similar in mass but larger than Uranus.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

[Total: 15]

Section B

Answer **one** question from this section.

7 **(a)** A flat board is placed horizontally on a spring and different weights are placed on it, as shown in Fig. 7.1.

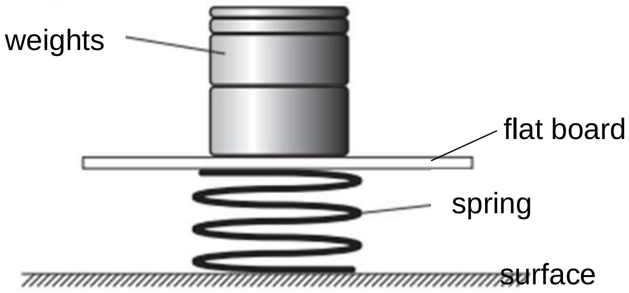

Fig. 7.1

The variation with weight of the compression of the spring is shown in Fig. 7.2.

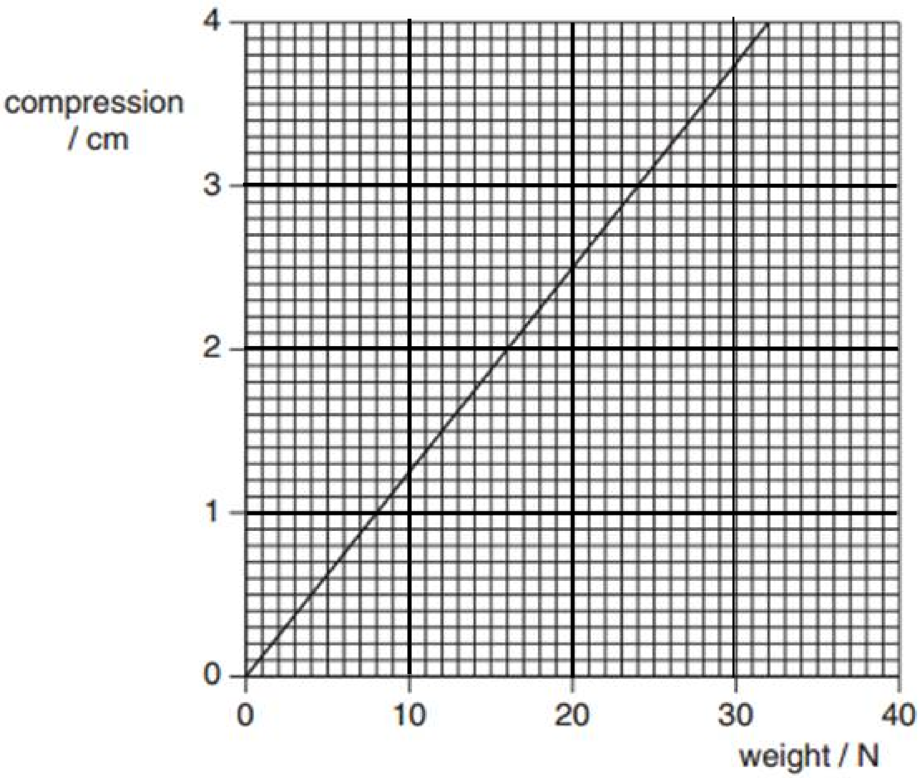

Fig. 7.2

The elastic limit of the spring has not been exceeded.

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

k = ……………………………. N m^{-1} [2]

(ii) Show that the elastic potential energy stored in the spring is 0.49 J for a compression of 3.5 cm.

[2]

(b) Two trolleys, of masses 800 g and 2400 g, are free to move on a smooth horizontal table. The spring in **(a)** 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. 7.3.

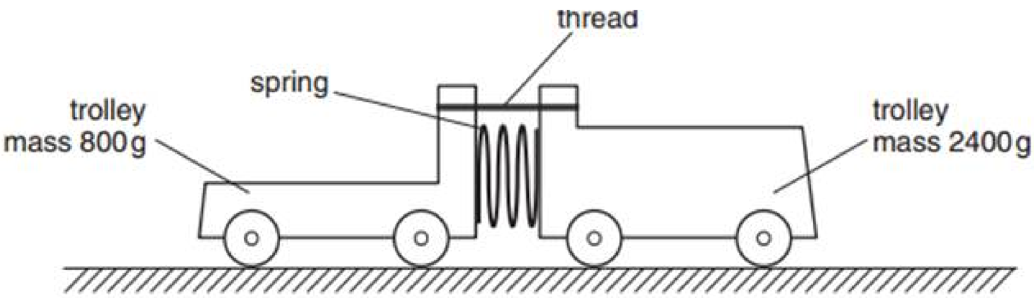

Fig. 7.3

Initially, the trolleys are not moving.

The thread is then cut and the trolleys move apart.

(i) Show that the ratio $\dfrac{\text{speed of lighter trolley}}{\text{speed of heavier trolley}}$ is equal to 3.0.

[2]

(ii) Use the answers in **(a)(ii)** and **(b)(i)** to calculate the final speed of the trolley with a mass 800 g. State any assumption you make.

speed = ……………………m s^{-1} [3]

(c) The spring in **(a)** is now cut in half. For the same applied force on the spring, its compression length is reduced by half.

(i) On Fig. 7.2, sketch the variation with force of the compression of this cut spring. Label it **S**. [1]

(ii) Hence, or otherwise, determine the new spring constant k ' of the cut spring.

k ' = …………………… N m^{-1} [2]

(d) **(i)** A common expression to represent the principle of conservation of energy is

$$\text{initial } E_k + \text{initial } E_p + E_1 = \text{final } E_k + \text{final } E_p + E_2$$

where E_k represents kinetic energy and E_p represents gravitational potential energy.

Describe what E_1 and E_2 each represents.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

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

(ii) At the left end of the smooth horizontal table in **(b)** is a deep pool of water, into which the lighter trolley eventually falls.

As the trolley falls through the water vertically, it reaches terminal velocity. Describe how the following physical quantities vary with time.

1. kinetic energy of the trolley,

……………………………………………………………………………………………………

……………………………………………………………………………………………………

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

2. gravitational potential energy of the trolley,

……………………………………………………………………………………………………

……………………………………………………………………………………………………

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

3. work done against the water resistance on the trolley.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

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

[Total: 20]

8 **(a)** State the equation relating current I, charge Q and time t.

[1]

(b) There is a current of 6.0 A through a component for 200 s.

Calculate

(i) the charge which flows past a point in the component during this time,

charge = ………………………… C [1]

(ii) the number of electrons which passes the point during this time.

number of electrons = ………………………… [2]

(c) Define *resistance* and the *ohm.*

……

……

……

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

(d) The circuit in Fig. 8.1 is used to produce the *I-V* characteristic of the lamp. This characteristic is shown in Fig. 8.2.

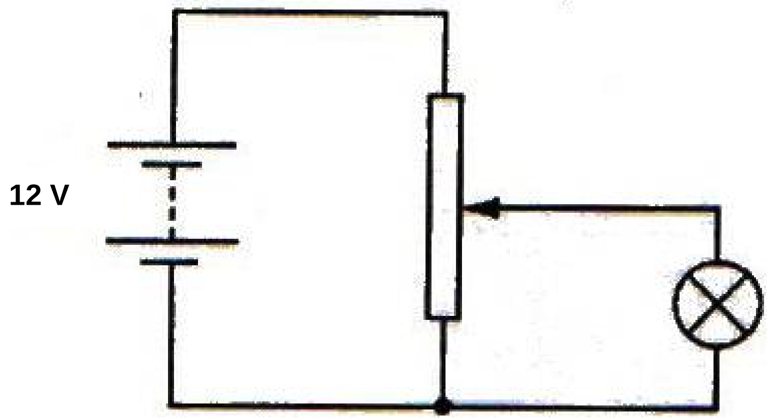

Fig. 8.1

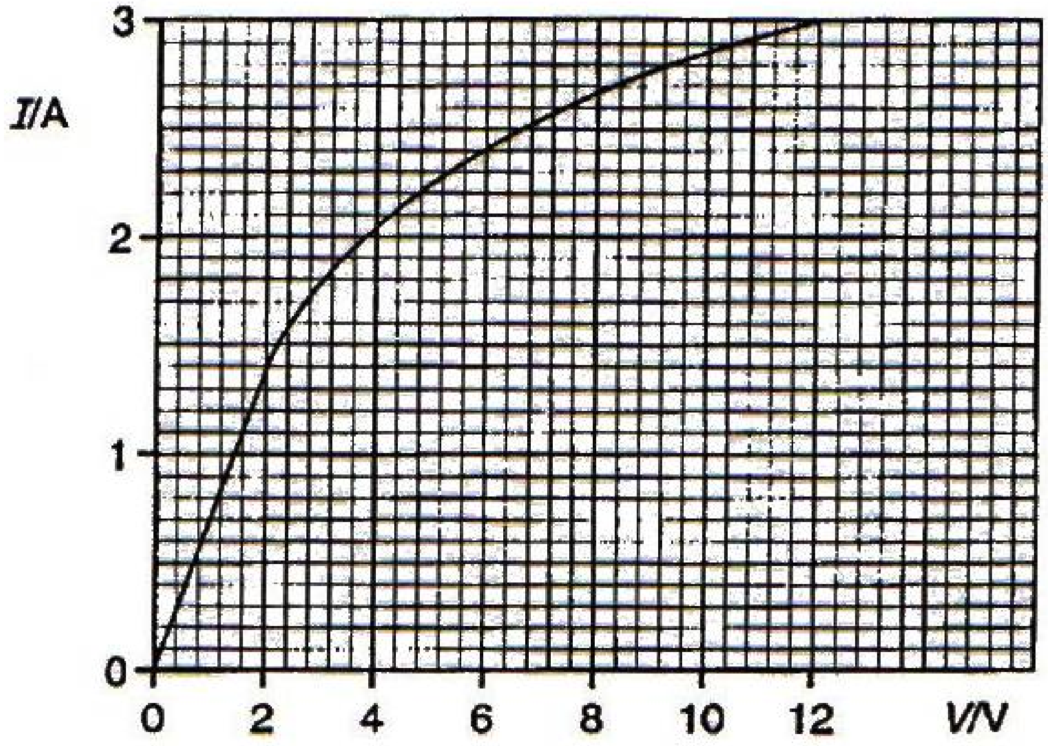

Fig. 8.2

(i) A voltmeter and an ammeter are required to obtain the necessary readings.

Copy Fig. 8.2 and include in the circuit the voltmeter and ammeter at their appropriate positions.

[2]

(ii) For the lamp operating under normal conditions with a potential difference of 12.0 V across it, calculate

1. the resistance of the lamp, and

resistance = ………………………… Ω [2]

2. the power supplied to the lamp.

power = ………………………… W [2]

(iii) Calculate the resistance of the lamp when the potential difference across it is 6.0 V.

resistance = ………………………… Ω [1]

(iv) Explain in microscopic terms why the resistance in **(iii)** is less than the resistance in **(ii)**.

....

....

....

....[3]

(v) Sketch a graph showing how the resistance of the lamp varies with the potential difference across it. Justify the shape of your graph.

....

....

....

....

....[4]

[Total: 20]

End of paper