H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 1

CANDIDATE NAME	
CLASS	
TUTOR'S NAME	
CENTRE NUMBER	S
INDEX NUMBER	

PHYSICS 8867/02

Paper 2 Structured Questions

16 September 2021

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class, Centre number and index number 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 a HB pencil for any diagrams, graphs or rough working.
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.

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	
Section A	
1	**/ 7**
2	**/ 8**
3	**/ 7**
4	**/ 7**
5	**/ 8**
6	**/ 7**
7	**/ 16**
Section B	
8	**/ 20**
9	**/ 20**
Total	**/ 80**

This document consists of **24** 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
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
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

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

1 When an object moves relative to a fluid, the fluid exerts a drag force F_D on the object due to the viscosity of the fluid. Under non-turbulent conditions, the drag force F_D on a sphere moving in a tube of fluid is given by

$$F_D = 6\pi\eta rv$$

where η is the viscosity of the fluid,
r is the radius of the sphere and,
v is the velocity of the sphere.

(a) Show that the base units of viscosity η are kg m^{-1} s^{-1}.

[1]

(b) A sphere of diameter = (2.0 ± 0.1) cm falls under non-turbulent conditions through a fluid of
viscosity = (0.13 ± 0.02) kg m^{-1} s^{-1}.

A student determines the velocity through the liquid to be 2.7 m s^{-1} and estimates the percentage uncertainty associated with this quantity to be 5 %.

(i) Determine F_D, with its associated uncertainty, acting on the sphere.

F_D = …………………… ± …………………… N [4]

(ii) The true value for F_D is 3.0×10^{-2} N.

State and explain if systematic error is significant in the experimental procedure.

______[2]

[Total: 7]

2 **(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 of motion of this body is

$$s = ut + at^2 .$$

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

____[2]

(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.

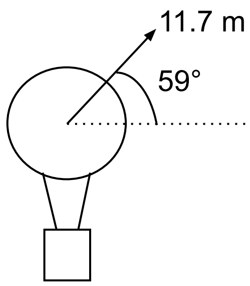

Fig. 2.1

(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.

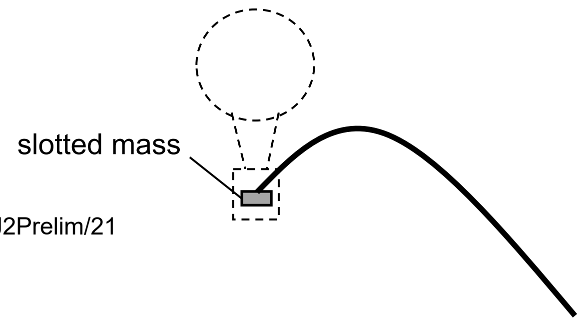

Fig. 2.2

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

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____[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]

3. Describe qualitatively the changes, if any, to the answer in **(b)(ii)2** if a 100 kg cargo was dropped from the balloon instead of the slotted mass. Assume air resistance on the cargo is negligible.

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____[1]

[Total: 8]

3 **(a)** State the conditions required for a body to be in equilibrium.

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____[2]

(b) Fig. 3.1 shows a lamp weighing 5.0 N that is hung from the end of a beam 4.50 m long and weighing 1.0 N, making an angle of 25° below the horizontal.

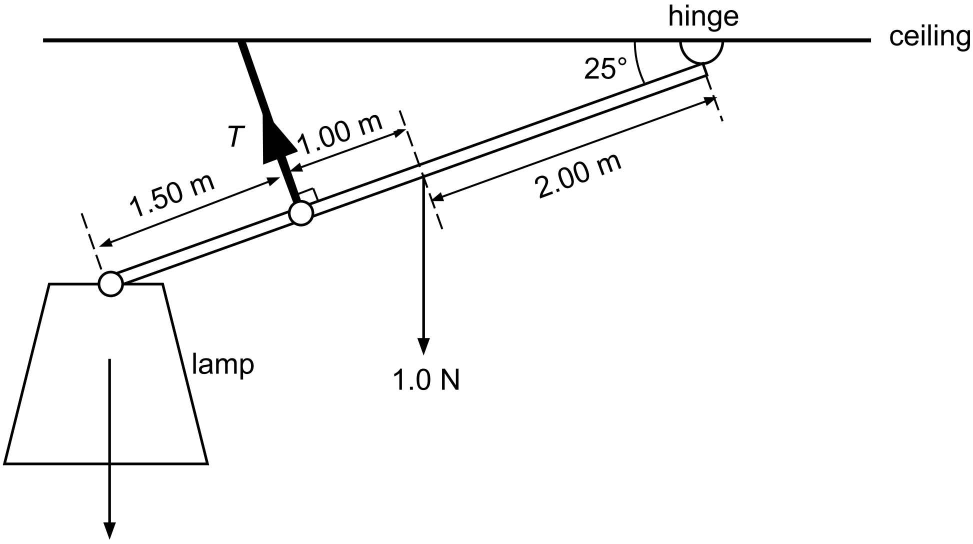

Fig. 3.1

The beam is held in position by a hinge at its upper end and by a cable 3.00 m lower down the beam and perpendicular to it. The centre of gravity of the beam is 2.00 m along the beam from the hinge.

(i) The position of the centre of gravity of the beam is not at its midpoint. Suggest what this implies about the distribution of the mass in the beam.

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____[1]

(ii) Show that the tension T in the cable is 7.4 N.

[2]

(iii) Determine the magnitude of the force acting on the beam at the hinge.

magnitude = ____________________ N [2]

[Total: 7]

4 A mass-spring system consists of a light spring of unstretched length l suspended vertically from a fixed point, as shown in Fig. 4.1. A mass is attached to the lower end of the spring and is held at rest at length l, as shown in Fig. 4.2.

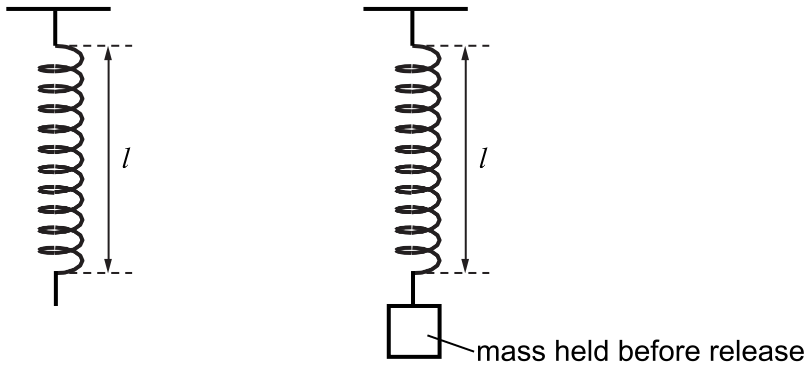

Fig. 4.1 **Fig. 4.2**

The mass is then released. Fig. 4.3 shows how the total energy E_T and kinetic energy K of the mass-spring system vary with extension x of the spring. The total energy is 1.18 J and the maximum kinetic energy is 0.29 J. The gravitational and elastic potential energies are not shown.

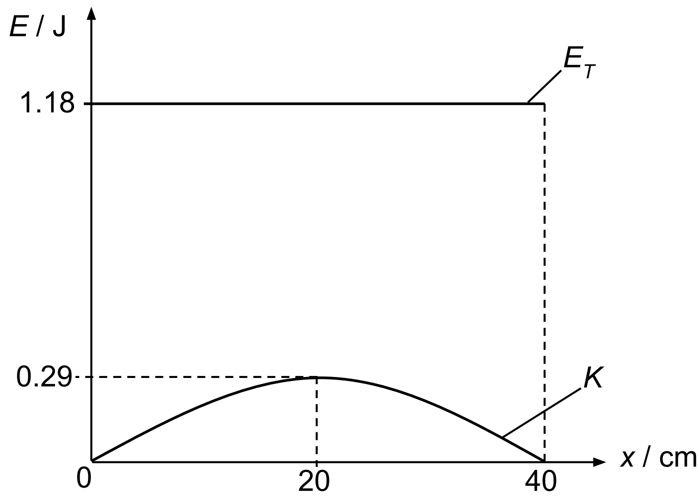

Fig. 4.3 (not to scale)

(a) Distinguish between *gravitational potential energy* and *elastic potential energy*.

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[2]

(b) Taking the gravitational potential energy of the mass at the lowest position to be zero, use information from Fig. 4.3 to

(i) state the gravitational potential energy of the mass at the point of release,

gravitational potential energy = ____________________ J [1]

(ii) determine the elastic potential energy stored in the spring when the kinetic energy of the mass is maximum.

elastic potential energy = ____________________ J [2]

(c) On Fig. 4.3, sketch

(i) the graph of how the gravitational potential energy of the mass varies with extension x. Label this graph G. [1]

(ii) the graph of how the elastic potential energy of the spring varies with extension x. Label this graph E. [1]

[Total: 7]

5 The Earth may be assumed to be a uniform sphere of radius R and mass M. The gravitational force acting on a satellite located at the surface of the Earth is F. The satellite is then sent to orbit around the Earth at a height of 0.30 R above the Earth's surface.

(a) Show that the gravitational force acting on the satellite at this height is 0.59 F.

[2]

(b) Determine the angular speed of the satellite about the Earth. The radius R of the Earth is 6.4×10^6 m.

angular speed = ____________________ rad s^{-1} [2]

(c) Calculate the time, in hours, for one complete orbit of the satellite.

time = ____________________ h [2]

(d) Explain why the satellite does not fall towards the Earth even though the gravitational force is directed towards the centre of the Earth.

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____[2]

[Total: 8]

6 **(a)** Two cylindrical resistors M and N of the same material are connected in parallel in Fig. 6.1. The mass of M is identical to the mass of N but the radius of M is half the radius of N.

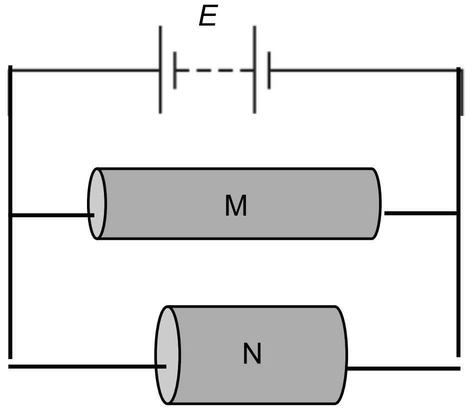

Fig 6.1 (not to scale)

Determine the ratio

(i) $\dfrac{cross\text{−}sectional\ area\ of\ M}{cross\text{−}sectional\ area\ of\ N}$,

ratio = ____________________ [1]

(ii) $\dfrac{resistance\ of\ M}{resistance\ of\ N}$.

ratio = ____________________ [2]

(b) A cell of electromotive force (e.m.f.) 1.5 V and internal resistance 1.0 Ω is connected to a resistor X and a thermistor Y as shown in Fig. 6.2.

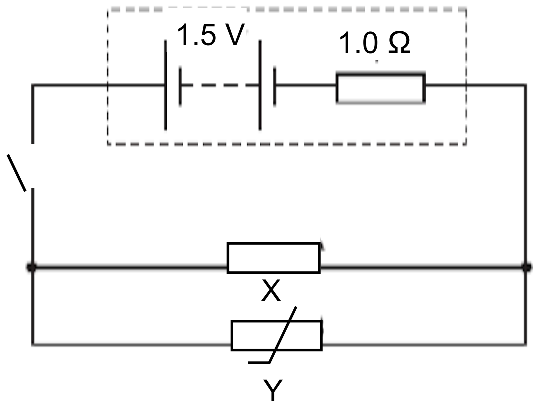

Fig. 6.2

X has resistance of 2.0 Ω while Y has a resistance of 6.0 Ω at room temperature.

(i) Show that the current in the cell is 0.60 A when the switch is closed.

[1]

(ii) Determine the power dissipated in the cell.

power = ____________________ W [1]

(iii) The temperature of Y gradually increases.
State and explain the change, if any, to the power dissipated in the cell.

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____[2]

[Total: 7]

7 Thermal conduction is the transfer of thermal energy (heat) through a material with no overall movement of the material. An apparatus consisting of an aluminium rod surrounded by insulation is placed between two baths of water, as shown in Fig. 7.1.

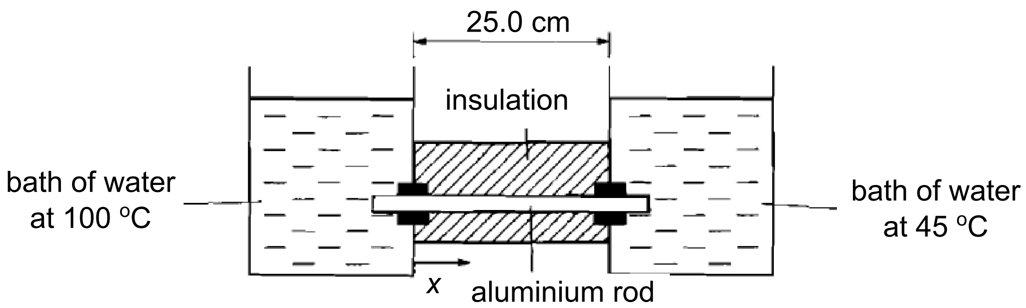

Fig. 7.1

The baths of water are maintained at temperatures of 100 °C and 45 °C. The length of the aluminium rod between the baths of water is 25.0 cm. The apparatus is left until the temperature at any point along the rod does not change.

The rate of thermal conduction $\frac{dQ}{dt}$ through the rod can be expressed as

$$\frac{dQ}{dt} = -kA\frac{dT}{dx},$$

where k is the thermal conductivity of the material of the rod, A is the cross-sectional area perpendicular to the direction of thermal conduction and $\frac{dT}{dx}$ is the temperature gradient.

(a) **(i)** The SI unit for thermal conductivity is W m^{-1} K^{-1}.
Use the unit to deduce what is meant by *thermal conductivity* of a material.

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____[1]

(ii) Suggest **one** method that can increase the rate of thermal conduction through a material.

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____[1]

(b) Fig. 7.2 shows the variation of the temperature T of the rod with the distance x from the hotter bath of water.

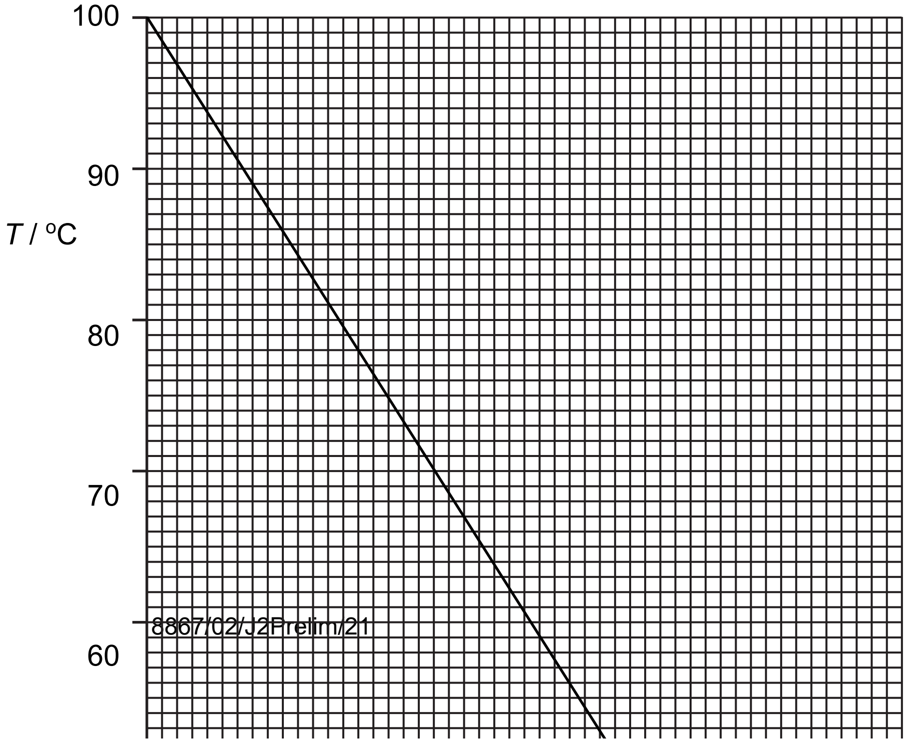

Fig. 7.2

(i) Use Fig. 7.2 to determine the temperature gradient.

temperature gradient = ____________________ $^{o}C\ cm^{-1}$ [1]

(ii) Hence, calculate the rate of thermal conduction through the aluminium rod.

The rod has a diameter of 5.0 cm and the thermal conductivity of aluminium is 205 W m^{-1} K^{-1}.

rate of thermal conduction = ____________________ W [3]

(c) The apparatus in Fig. 7.1 is modified to the one shown in Fig. 7.3.

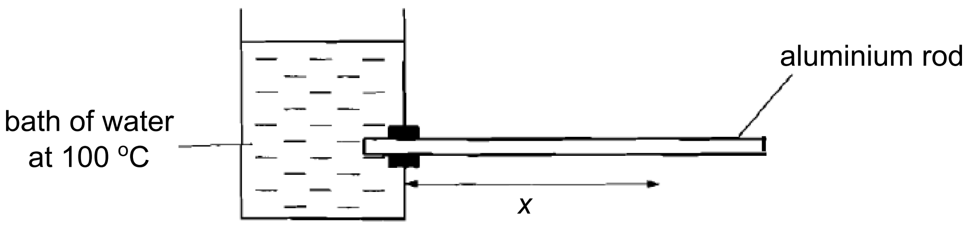

Fig. 7.3

One of the water baths and insulation surrounding the aluminium rod is removed, with one end of the rod still maintained at a temperature of 100 °C using the hotter bath of water. The apparatus is left until the temperature at any point along the rod does not change.

Fig. 7.4 shows the variation of the temperature T of the rod with distance x from the bath of water.

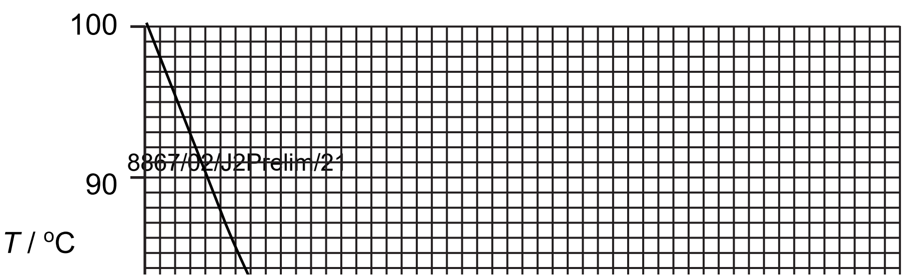

Fig. 7.4

An experiment is conducted in room temperature of 20 °C using the apparatus in Fig. 7.3. Data collected from the experiment are tabulated in Table 7.5.

Table 7.5

x / cm	T / °C	ΔT / °C	ln(ΔT / °C)
0	100	80	4.38
2.0	90	70	4.25
5.0			
8.0	67	47	3.85
12.0	56	36	3.58
15.0	49	29	3.37
17.5	45	25	3.22
20.0	41	21	3.04

25.0	35	15	2.70

(i) Use Fig. 7.4 to complete Table 7.5 for the distance x = 5.0 cm. [2]

Fig. 7.6 is a graph of some of the data from Table 7.5.

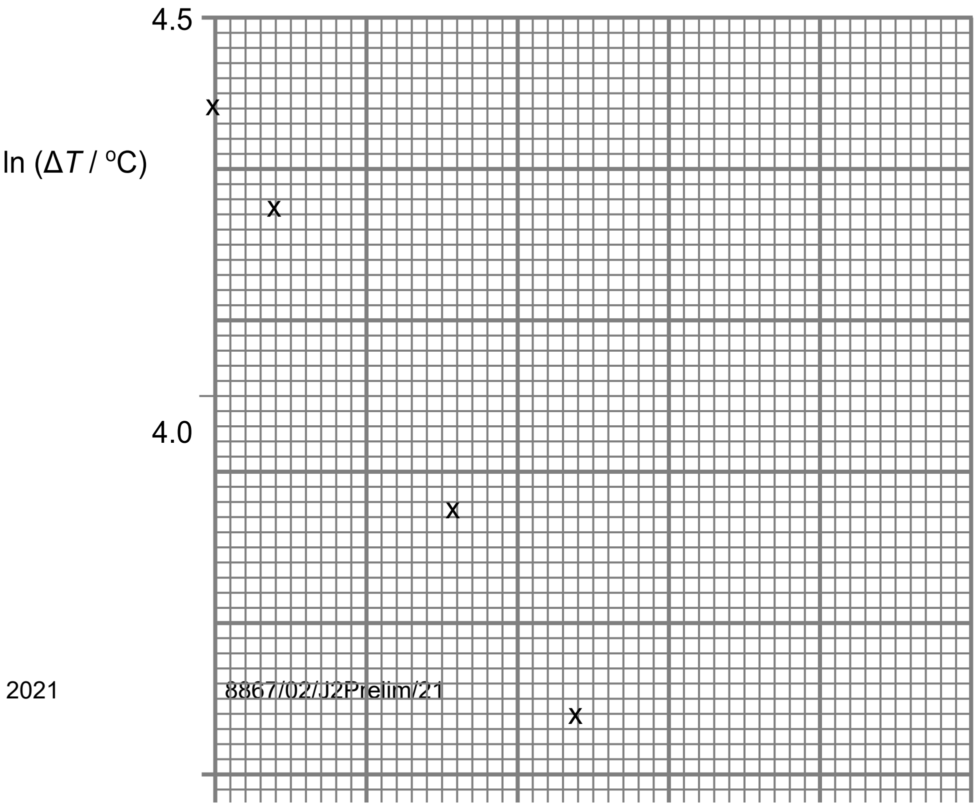

Fig. 7.6

(iii) Plot the point for x = 5.0 cm on Fig. 7.6. [1]

(iv) Complete Fig. 7.6 by drawing the best-fit line. [1]

(v) A student claims that ΔT changes with distance x according to an expression

$$\Delta T = \left(\Delta T_0\right) e^{-\mu x}$$

where ΔT_0 and μ are constants.

1. Use Fig. 7.6 to determine the constants ΔT_0 and μ.

ΔT_0 = ____________________ °C

μ = ___________________ cm^{-1}

[3]

2. Explain whether the graph of Fig. 7.6 supports the student's claim.

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____[2]

(d) The aluminium rod is replaced with a similar rod made of wood, under the same conditions.

On Fig. 7.4, sketch a graph to show a possible variation with distance x of the temperature
T of this wooden rod.

[1]

[Total: 16]

Section B

Answer any **one** question from this Section in the spaces provided.

8 **(a)** **(i)** Define *linear momentum*.

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____[1]

(ii) State the relationship between the change in linear momentum of an object, the constant force acting on the object, and the time for which the force acts.

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____[1]

(b) Fig. 8.1 shows body A of mass m_A with speed u_A and a body B of mass m_B with speed u_B approaching each other.

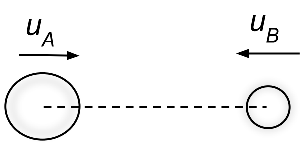

Fig. 8.1

During a head-on elastic collision between A and B, the force that A exerts on B varies with time in the way shown in Fig. 8.2.

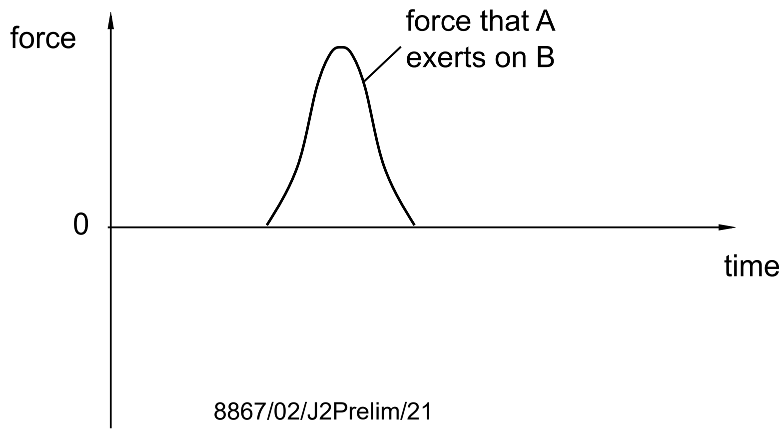

Fig. 8.2

(i) State the *principle of conservation of momentum.*

____[1]

(ii) On Fig. 8.2, sketch a graph of the force that B exerts on A. [1]

(iii) Explain how your answer to **(b)(ii)** is consistent with the principle of conservation of momentum.

____[3]

(iv) Given that m_A = 3.0 kg, m_B = 1.0 kg, u_A = 2.0 m s^{-1} and u_B = 2.0 m s^{-1},

1. complete the table below,

[4]

	before collision		after collision	
	A	B	A	B
kinetic energy / J	6.0	2.0	0	

momentum / N s	6.0			

2. sketch the variation with time of the velocities of A and B, before, during and after the collision on Fig. 8.4. Label the graphs clearly. Include appropriate values of the initial and final velocities of A and B on the vertical axis.

[3]

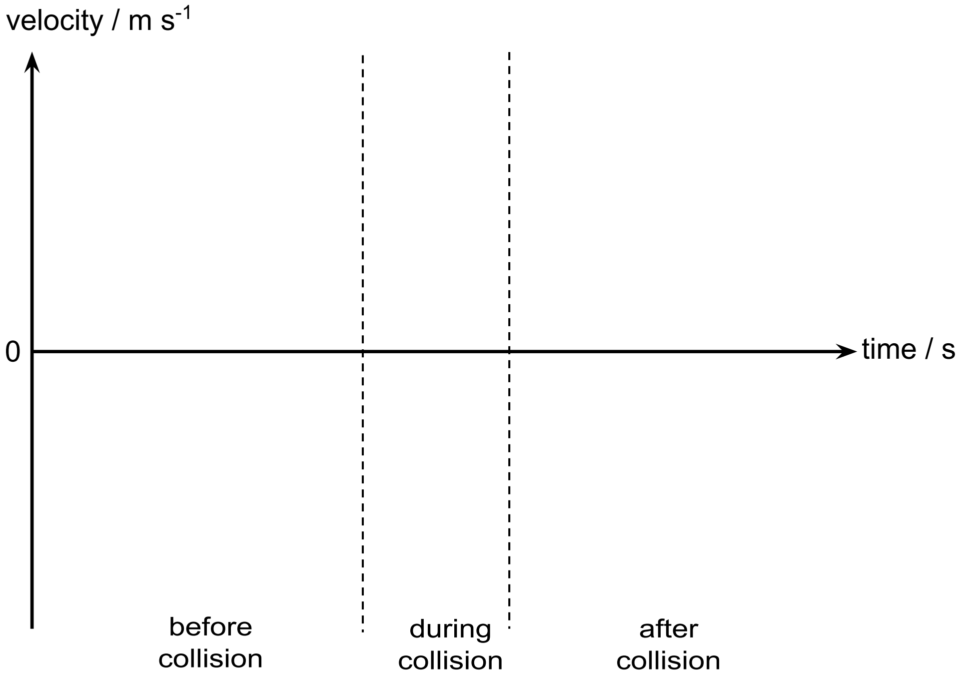

Fig. 8.4

(c) In a traffic accident, a truck of mass 1.2×10^4 kg collides into the back of a car of mass 1.2×10^3 kg. A constant force of 7.2×10^4 N acts for 0.25 s during the collision.

(i) Calculate the change in velocity of the car and the truck.

change in velocity of car = ____________________ m s^{-1}

change in velocity of truck = ____________________ m s^{-1}

[4]

(ii) With reference to Newton's second law, explain how an airbag in a car reduces injury to the driver in the event of a collision.

[2]

[Total: 20]

9 **(a)** Define *magnetic flux density*.

[2]

(b) Fig. 9.1 is a <u>full scale diagram</u> showing two long straight parallel copper wires X and Y clamped vertically, viewed from the top.

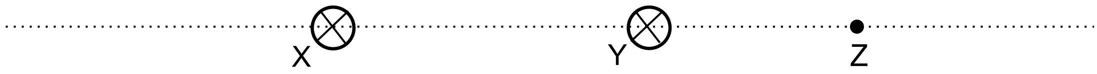

Fig. 9.1 (top view, full scale)

(i) Draw four field lines to represent the pattern of the resultant magnetic field due to the wire X and Y. [3]

(ii) The magnetic flux density *B* at a distance *r* from a long straight wire due to a current I in the wire is given by the expression

$$B = 2.0\times10^{-7}\left(\frac{I}{r}\right)$$

The current in wire X is 5.0 A and that in wire Y is 10.0 A.

Calculate the magnitude of the resultant magnetic flux density at point Z as shown in Fig. 9.1.

resultant magnetic flux density = ____________________ T [2]

(iii) A probe is used to measure the magnetic flux density at point Z.
Suggest **two** possible reasons why the answer in **(b)(ii)** may be significantly different from the one measured by the probe.

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____[2]

(c) A metal rod of mass 6.5 g and diameter 2.0 mm is placed on top of two smooth parallel rails which are inclined at an angle of 30° with the horizontal, as shown in Fig. 9.2 and Fig. 9.3. The metal rod is connected across a battery of e.m.f. 6.0 V. The whole set up is placed in a region with a non-uniform magnetic field acting vertically downwards.

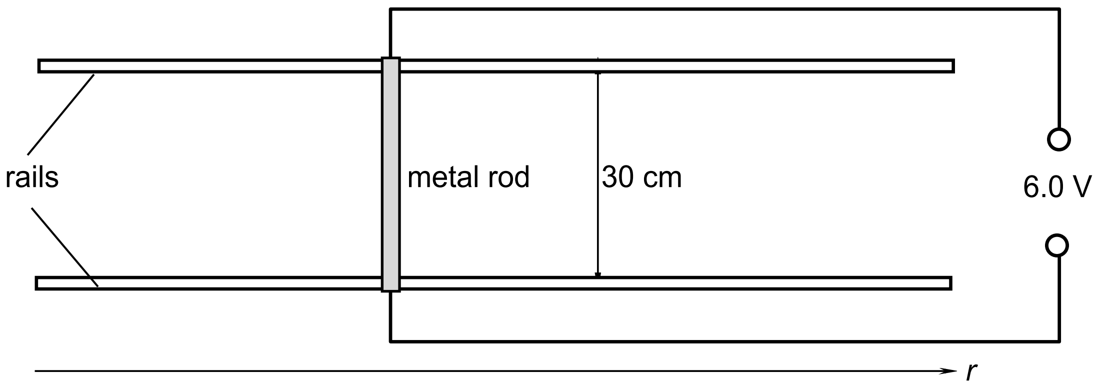

Fig. 9.2 (top view)

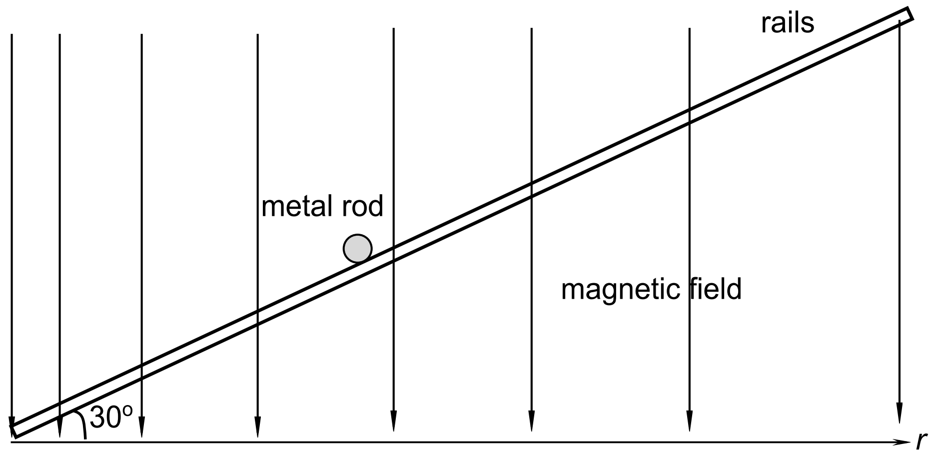

Fig. 9.3 (front view)

(i) Indicate with an arrow on Fig. 9.2 the direction of current in the metal rod to keep it stationary on the rail. [1]

(ii) If the electrical resistivity of the material of the rod is 9.7×10^{-8} Ω m, show that the current in the metal rod is 650 A.

[2]

Fig. 9.4 shows the variation of magnetic flux density B with horizontal displacement r from bottom of the rail.

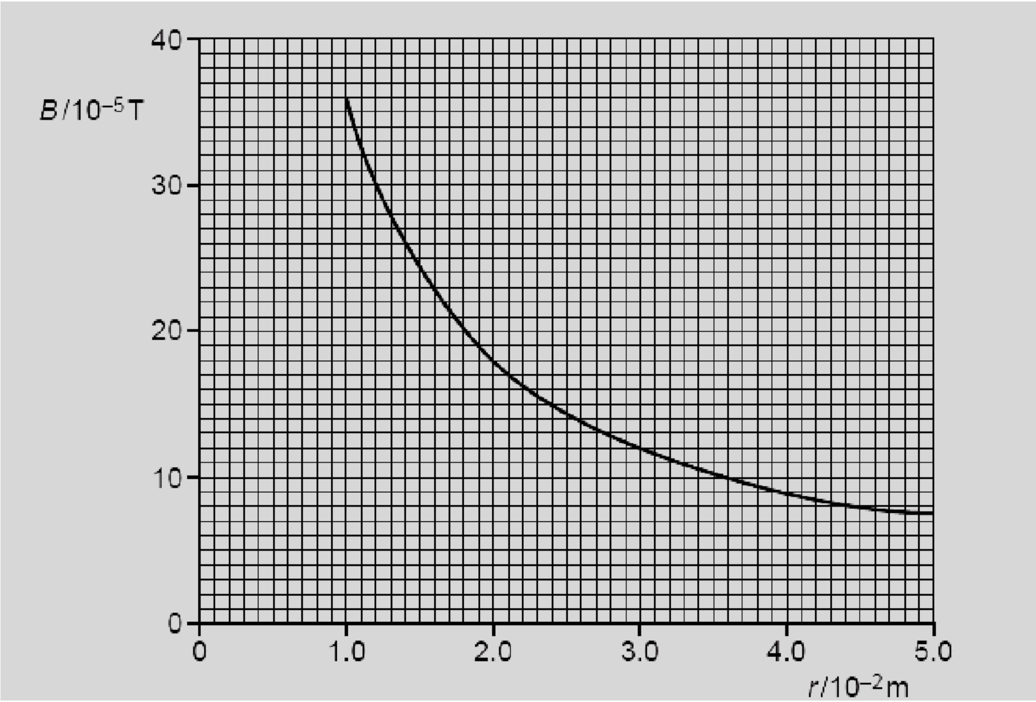

Fig. 9.4

(iii) The metal rod is placed at a position P on the rail such that it will remain stationary. Use Fig. 9.4 to determine the value of r at P.

r = ____________________ m [3]

(iv) If the rails are not perfectly smooth, explain the following observations.

1. The rod can be placed a certain distance above point P and still remain stationary.

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____ [2]

2. The rod can be placed a certain distance below point P and still remain stationary.

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____ [1]

(d) The metal rod in **(c)** is then placed in a region of uniform magnetic field and made to move at constant speed. Fig. 9.5 shows the microscopic view of an electron in the metal rod.

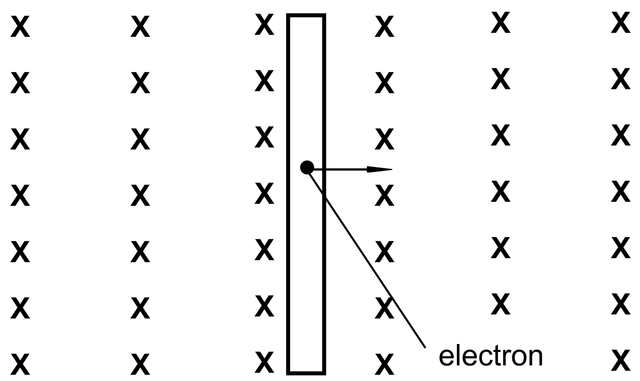

Fig. 9.5

(i) Draw an arrow on Fig. 9.5 to show the direction of the magnetic force acting on the electron. Label it F. [1]

(ii) Suggest why there is potential difference across the rod when it is moving at constant speed.

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____ [1]

[Total: 20]

End of Paper