Anglo-Chinese Junior College

Physics Preliminary Examination
Higher 1

A Methodist Institution
(Founded 1886)

CANDIDATE NAME		CLASS	

CENTRE NUMBER	S	3	0	0	4	INDEX NUMBER					

PHYSICS **8866/02**

Paper 2 Structured questions

24 August 2016

2 hours

Candidates answer on the Question Paper
No additional Materials are required

READ THESE INSTRUCTIONS FIRST

Write your Name and Index number in the spaces provided at the boxes above and on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **any two** 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 examiners' use only	
Section A	
1	/ 5
2	/ 6
3	/ 7
4	/ 8
5	/ 8
6	/ 6
Section B	
7	/ 20
8	/ 20
9	/ 20
Total	/ 80

For Examiner's Use

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	=	$\rho g h$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$

For Examiner's Use

Section A

Answer **all** the questions in the spaces provided.

1 **(a)** State the **main** distinction between a systematic error and a random error in the measurement of a physical quantity.

....

....

.... [2]

(b) In a simple pendulum experiment to determine *g* the acceleration due to gravity, the following equation is used,

$$T = 2\pi\sqrt{\frac{l}{g}}$$

The following measurements were obtained with the help of a meter rule and stopwatch respectively.

The length of the pendulum: $l = 98.0$ cm $\pm$ 0.1%
Average time for 10 oscillations: $t = 19.8$ s $\pm$ 1%

g was calculated to be 9.869 m s^{-2}.

Present the value of *g* with its associated uncertainty.

g = ……………. ± .... m s^{-2} [3]

For Examiner's Use

2 (a) State the law of conservation of linear momentum.

....

....

....

....

.... [2]

(b) A bullet of mass 0.02 kg travelling horizontally with a speed of 500 m s^{-1} becomes embedded in a bag of sand of mass 40 kg initially at rest which is suspended vertically via a rope fixed to the ceiling.

Determine the maximum increase in height gained by the sandbag. State your assumptions made.

Maximum increase in height = ……………………… m [4]

For Examiner's Use

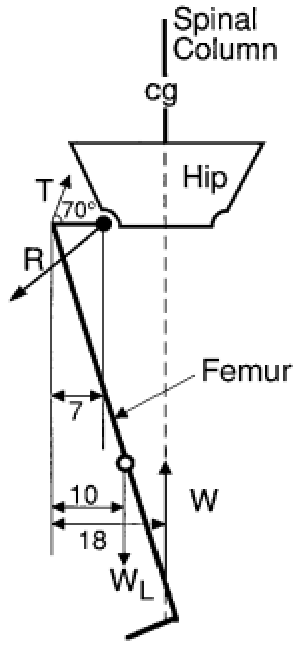
3 (a) State the two conditions required for a body to be in equilibrium.

....

....

.... [2]

(b) When you are walking, there is an instant when only one foot is on the ground and the centre of gravity of your body is directly over that foot. Fig. 3.1 shows the forces acting on that leg.



Source: https://medicalphysics.org/documents/WebPOTB.pdf

Fig. 3.1

The forces are the upward force on the foot equal to the weight of the body *W*; the weight of the leg W_L (which is approximately equal to *W* / 7); the reaction force by the hip on the femur *R* and the tension in the muscle group between the hip and the greater trochanter on the femur *T*.

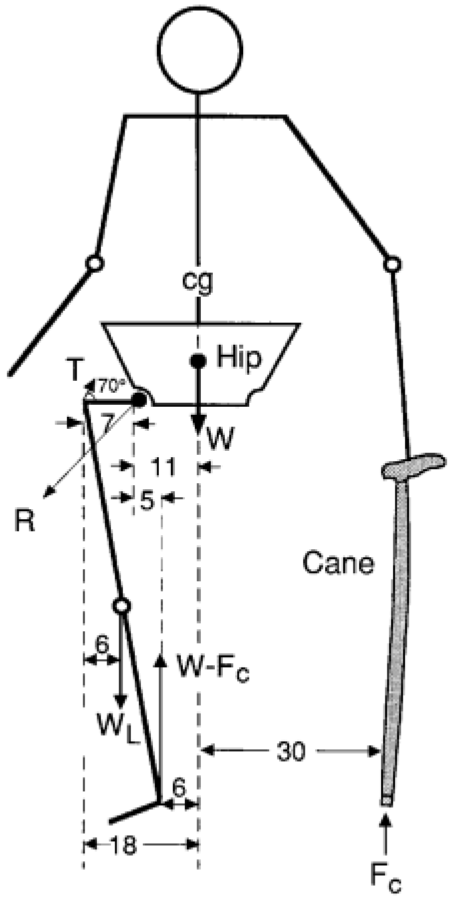
The dimensions provided are in cm.

(i) Show that $T = 1.6\ W$ and $R = 2.4\ W$.

[3]

For Examiner's Use

(ii) The use of crutches or a cane can reduce the force on the hip joint. Fig. 3.2 shows the effect of the use of a cane on the body.



Source: https://medicalphysics.org/documents/WebPOTB.pdf

Fig. 3.2

Note that the cane is in the hand opposite to the injured hip and the force pushing upward on the cane F_C reduces the upward force on the foot.

Explain qualitatively how the cane can reduce the force on the hip joint.

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……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………… [2]

For Examiner's Use

4 Fig. 4 shows two circuit which could be used to act as a dimmer switch for a lamp.

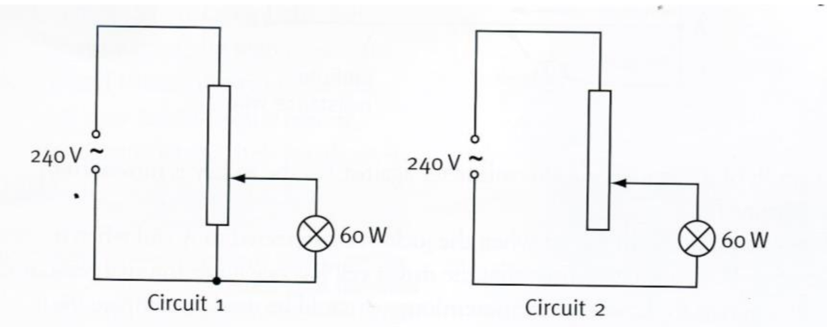

Fig. 4

(a) Explain **one** advantage circuit 1 has over circuit 2.

....

....

....

.... [2]

(b) One problem with circuit 1 is that there is always a current in the resistor. With an aid of a diagram, explain how this problem could be rectified.

....

....

....

.... [2]

For Examiner's Use

(c) **(i)** The lamp is rated at 60 W at 240 V. Calculate the resistance of the lamp filament at its normal operating temperature.

resistance = ... Ω [2]

(ii) State and explain how the resistance of the filament at room temperature would compare with the value calculated in (c)(i).

....

....

....

.... [2]

5 **(a)** By reference to the photoelectric effect, state what is meant by the threshold frequency.

....

....

.... [1]

(b) Electrons are emitted from a metal surface when light of a particular wavelength is incident on the surface.

Explain why the emitted electrons have a range of values of kinetic energy below a maximum value.

....

....

....

....

.... [2]

For Examiner's Use

(c) The wavelength of the incident radiation is λ.

The variation with $1/\lambda$ of the maximum kinetic energy E_{MAX} of electrons emitted from a metal surface is shown in Fig. 6.1.

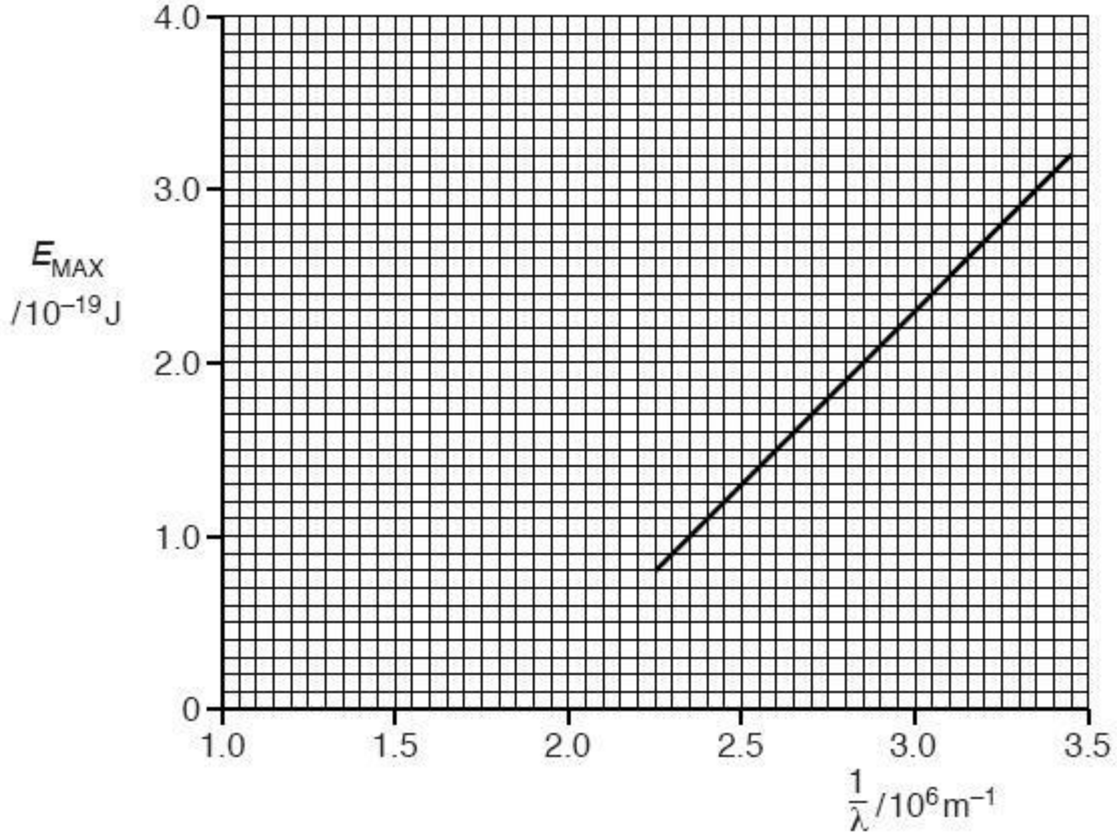

Fig. 6.1

Using the data from Fig. 6.1,

(i) determine the work function energy Φ.

Φ = ... J [2]

(ii) the associated *de broglie's wavelength* of the electron that was emitted with the maximum kinetic energy when a frequency of 7.5 x 10^{14} Hz falls on the metal.

De Broglie's wavelength = ... m [3]

For Examiner's Use

6 The 2 second rule is a rule of thumb by which a driver may maintain a safe following distance at any speed. The idea is that a driver should stay at least two seconds behind any vehicle that is directly in front of the driver's vehicle.

To estimate the time, a driver can wait until the rear end of the vehicle in front passes any distinct and fixed point on the roadway like a road sign, mailbox, line / crack / patch in the road. After the car ahead passes a given fixed point, the front of one's car should pass the same point no less than two seconds later. If the elapsed time is less than this, one should increase the distance, then repeat the method again until the time is at least two seconds.

Fig. 6.1 below shows the recommended minimum stopping distances, thinking distances and braking distances under normal road conditions for different speeds.

Speed ($km\ h^{-1}$)	Stopping distance (m)	Thinking distance (m)	Braking distance (m)
30	12.0	5.6	
40	18.0	7.5	10.5
50	25.0	9.5	
60	33.0	11.3	21.7
80	52.0	15.0	37.0
100	70.0	18.8	
120	102.0	22.5	

Fig. 6.1

The stopping distance depends on thinking distance and braking distance.

- It takes time for a driver to react to a situation. During this reaction time, the car carries on moving. The thinking distance is the distance travelled in between the driver realising he needs to brake and actually braking.
- The braking distance is the distance taken to stop once the brakes are applied.

(a) Complete Fig. 6.1. [1]

(b) From Fig. 6.1.,

(i) calculate the reaction time of the driver.

Reaction time = ... s [1]

(ii) Determine the acceleration of the car when the speed of the car is 80 $km\ h^{-1}$.

Acceleration = ... $m\ s^{-2}$ [2]

For Examiner's Use

(c) Using data from the table, justify whether the 2 second rule is a safe method of ensuring the safety of a driver that is behind another vehicle.

....

....

....

.... [2]

For Examiner's Use

Section B

Answer **two** the questions for this section.

7 (a) (i) Using the definition of work done and equations of motion, show that the kinetic energy E_K of an object travelling with speed v is given by

$$E_K = \frac{1}{2}mv^2$$

[2]

(ii) Explain what is meant by kinetic energy.

....

....

....

.... [1]

(b) Explain what is meant by elastic potential energy.

....

....

.... [2]

(c) A light helical spring is fixed at its bottom end, as shown in Fig. 6.1. The natural length of the spring L_o is 40.0 cm.

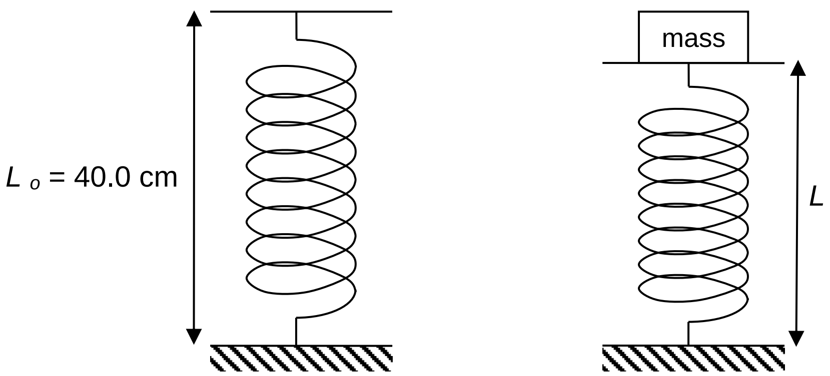

Fig. 7.1

Different masses are placed on top of the spring. The weight *W* of the mass and the length *L* of the spring are noted. The spring undergoes elastic change throughout the experiment and it obeys Hooke's Law.

For Examiner's Use

The variation of the weight *W* with length *L* is shown in Fig. 7.2.

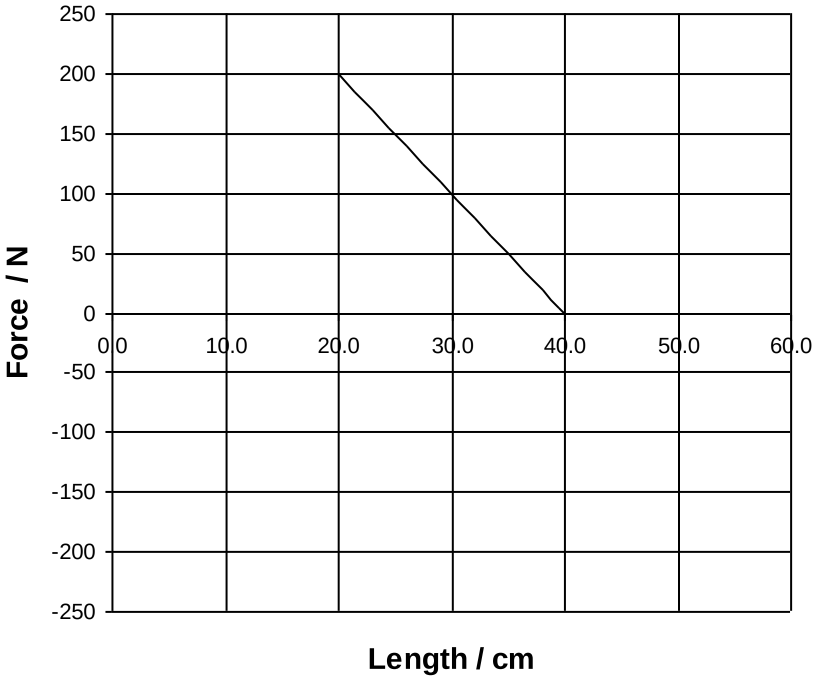

Fig. 7.2

(i) On Fig. 7.2, sketch a graph of spring force F_s against length L. [1]

(ii) Determine the work done by the spring when the spring is compressed from its natural length to a length of 30.0 cm.

work done by spring = __________ J [2]

(iii) Hence, state and explain the elastic potential energy in the spring when it is compressed from its natural length to a length of 30.0 cm.

elastic potential energy = __________ J [1]

For Examiner's Use

(d) The weight is removed and a sphere of mass 5.00 kg is dropped from a height of *h* vertically above the top of the spring.

When the sphere is in contact with the spring, the kinetic energy of the sphere is determined and plotted in the graph of energy against length *L*, as shown in Fig. 7.3.

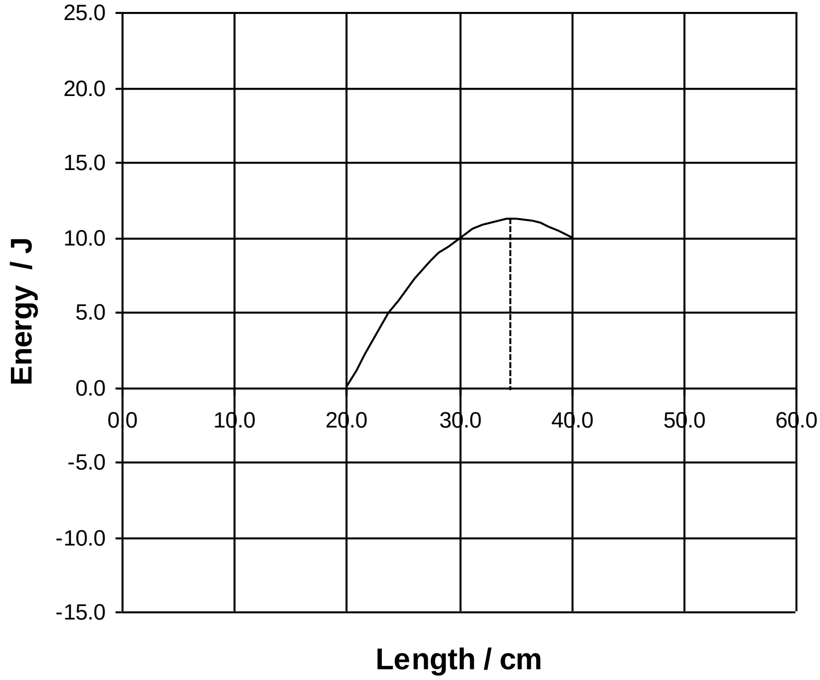

Fig. 7.3

(i) Assume that the gravitational potential energy is 0 J when length L = 40.0 cm. Take g = 9.81 m s^{-2}. When the sphere is instantaneously at rest, determine

1. the gravitational potential energy of the sphere,

gravitational potential energy = ________ J [2]

2. the elastic potential energy in the spring.

elastic potential energy = ________ J [3]

For Examiner's Use

(ii) On Fig. 7.3, draw two lines to represent the variation of the gravitational potential energy of the sphere and the elastic potential energy in the spring with length *L*, respectively. Label your graphs as **GPE** and **EPE**.

[3]

(iii) State and explain the energy transformations that occur from the instant the sphere comes into contact with the spring to the instant the spring is compressed to a length of 35.0 cm and then to the instant when the sphere is instantaneously at rest.

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....

.... [3]

For Examiner's Use

8(a) State the meaning of

(i) diffraction,

………………………………………………………………………………

………………………………………………………………………….[1]

(ii) phase difference,

………………………………………………………………………………

………………………………………………………………………….[1]

(iii) coherence.

………………………………………………………………………………

………………………………………………………………………….[1]

(b) The Fig 8.1 shows two microwave emitters M_1 and M_2. A microwave detector is moved along the line AB.

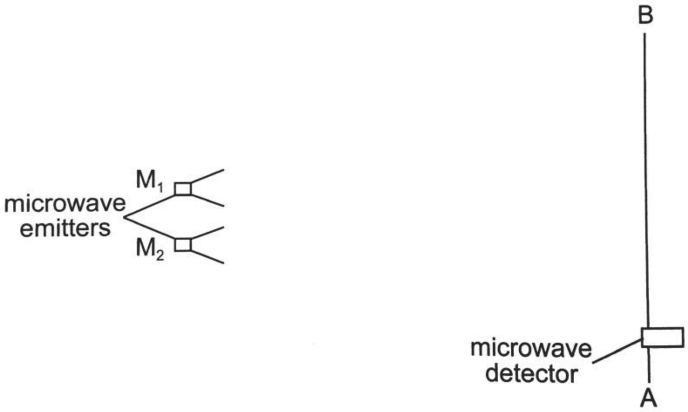

Fig 8.1

(i) Explain how interference fringes are formed along the line AB.

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

……………………………………………………………………………… [3]

(ii) The following changes are made independently. Describe, in each case, the effect on the position and intensity of the fringes.

1. The intensity of the microwaves emitted from M_1 is increased.

………………………………………………………………………………

………………………………………………………………………………

……………………………………………………………………………… [2]

2. The phase difference between the microwaves emitted from M_1 and M_2 is changed by π radian.

………………………………………………………………………………

………………………………………………………………………………

……………………………………………………………………………… [2]

For Examiner's Use

(c) A microwave oven, shown in Fig 8.2 consists of a reflective casing on the opposite wall of the microwave source and a turntable at the bottom that rotates. It produces microwave of frequency 2.45 GHz within the oven.

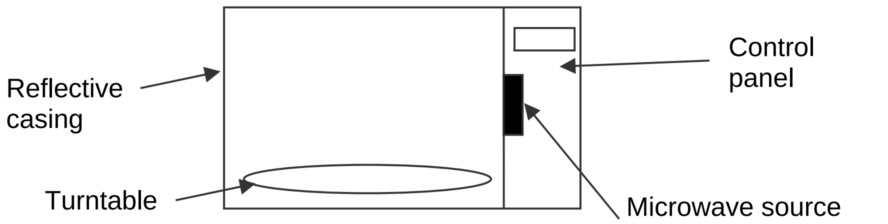

Fig 8.2

Water molecules are electric dipoles (that is, they have one positive end and one negative end). In the oscillating field of the microwave oven, the water molecules in trying to align with the changing field, oscillate rapidly. Thus the water molecules in the food get heated up and hence the food gets heated up.

(i) Explain how standing waves are formed inside the microwave oven.

....

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.... [3]

(ii) **<u>The turntable of the oven is removed from the oven</u>** so that oven's content will not rotate during heating. A wet piece of cardboard is placed flat in a microwave oven. The cardboard is then micro-waved for a short while. Stripes of dry regions regularly spaced apart are seen on the cardboard.

1. Explain the formation of these dry stripes and hence deduce their distances apart.

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....

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....

....

.... [3]

2. The interior of the microwave oven is 30.5 cm wide.

In the space below, **draw the amplitude-position graph** of the standing wave pattern in the oven. Mark the positions on the graph with "D" that would produce dry patches on the wet cardboard as mentioned.

[2]

For Examiner's Use

(iii) **The turntable of the oven is now placed back in the oven**. After five minutes of cooking a dish in a microwave wave, and upon removing it, it is noticed that several ants are inside the oven apparently unharmed by the intense microwave radiation. Deduce why some of the ants did not die.

....

....

....

.... [1]

(iv) Explain the purpose of the turntable of the microwave oven.

....

....

....

.... [1]

For Examiner's Use

9 **(a)** **(i)** Explain what is meant by a *magnetic field*.

....

.... [2]

(ii) Define the *Tesla*.

....

....

....

.... [3]

(b) **(i)** Conventionally, arrows on field lines define the direction of a force acting on an object.

State the property of the object that experiences a force **in a direction opposite** to the direction of a magnetic field.

.... [1]

(ii) **Fig. 9.1** shows the cross-section of two long vertical wires perpendicular to the page. The electric current in the left hand wire is downwards into the page whereas the current in the right hand wire is outwards from the page. The current in the left hand wire is greater than the current in the right hand wire.

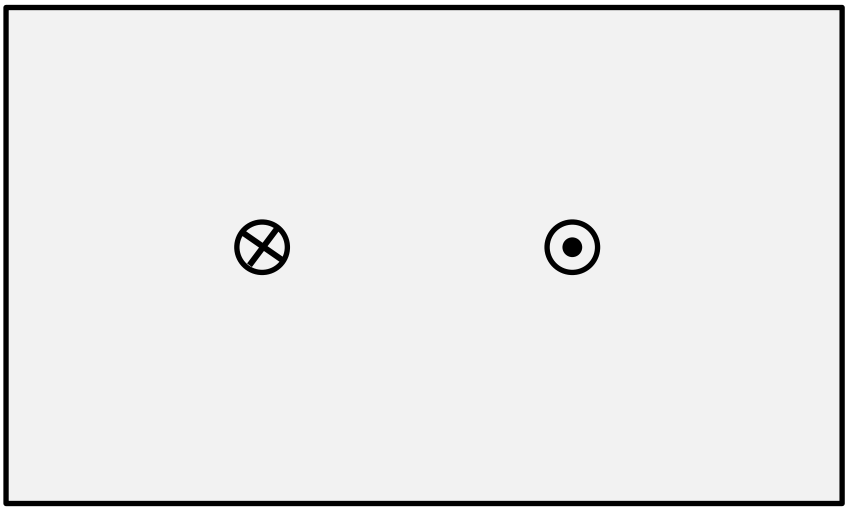

Fig. 9.1

Sketch the resultant magnetic field pattern around the wires within the shaded area. Indicate direction arrows on the field lines. [3]

For Examiner's Use

(c) A uniform magnetic field has constant flux density *B*. A straight wire of fixed length carries a current I at an angle θ to the magnetic field, as shown in Fig. 9.2.

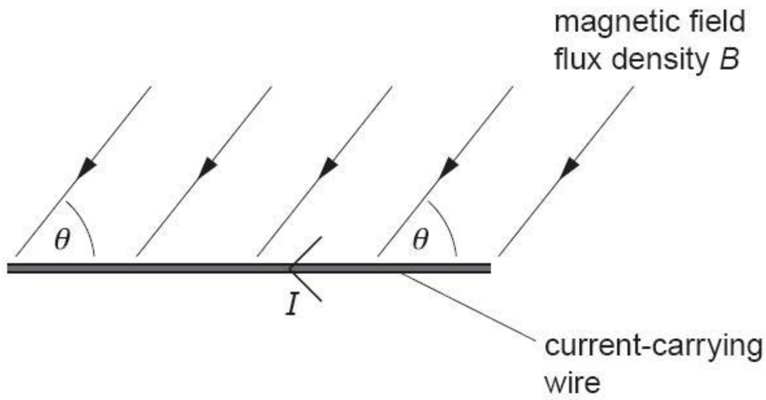

Fig . 9.2

The angle θ between the wire and the magnetic field is now varied. The current I is kept constant.

On Fig. 9.3, sketch a graph to show the variation with angle θ of the force *F* on the wire.

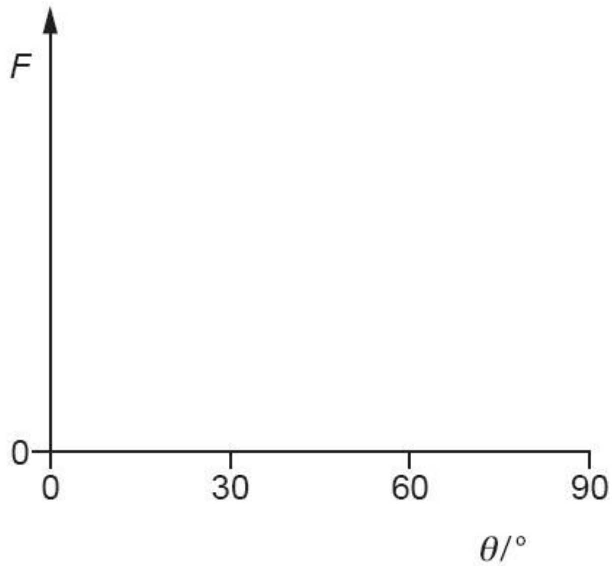

Fig. 9.3

[3]

For Examiner's Use

(d) Fig. 9.4 shows a side view of a U-shaped permanent magnet of mass 82.0 g resting on an electronic top-pan balance.

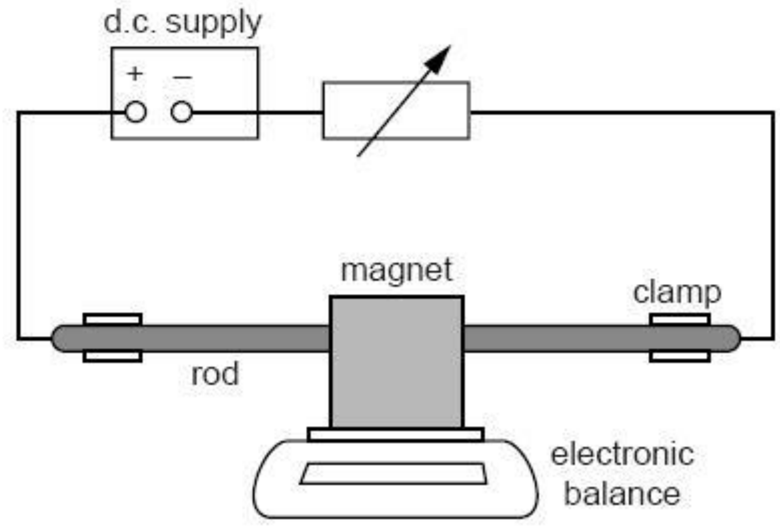

Fig. 9.4

An aluminium rod is clamped between the poles of the magnet so that the rod cannot move. The rod is connected in the circuit shown.

The d.c. supply is switched on. The reading on the balance increases to 82.4 g.

(i) Calculate the additional force exerted on the magnet when there is a current in the circuit.

Additional force = …………………….. N [1]

(ii) Explain how this additional force originates.

....

....

....

....

....

....

.... [3]

For Examiner's Use

(iii) Fig. 9.5 shows a plan view, from above, of part of the apparatus shown in Fig. 9.4. The plan shows the aluminium rod fixed between the poles of the U-shaped magnet.

The direction of current in the aluminium rod is from left to right.

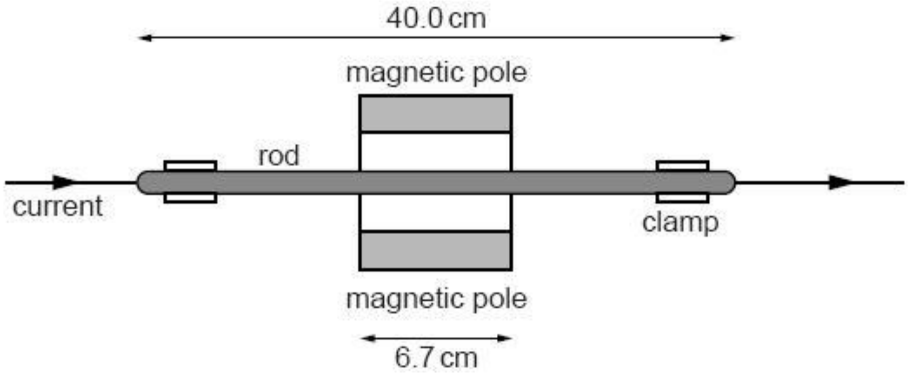

Fig. 9.5

1. On Fig. 9.5, draw an arrow to show the direction of the magnetic field between the poles that would produce the additional force on the magnet. [1]

2. The aluminium rod is 40.0 cm long and the length of each magnetic pole is 6.7 cm. The magnetic flux density between the poles of the magnet is 28.6 mT.

Calculate the current in the aluminium rod.

Current = ……………………. A [2]

3. The connections to the d.c. supply are switched over so that the current is reversed. The reading on the electronic balance changes.

Determine the new reading on the electronic balance.

New reading = …………………g [1]

---------------------------------- End of Paper -----------------------------