H

NANYANG JUNIOR COLLEGE
Science Department

JC 2 PRELIMINARY EXAMINATION

Higher 2

Candidate Name						
Class					Tutor Name	

PHYSICS 9646/02

Paper 2 Structured Questions **24 September 2013**

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and tutor 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.

Answer **all** 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 document consists of **20** printed pages

Nanyang Junior College

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} Fm^{-1} $(1 / (36\ \pi)) \times 10^{-9}$ Fm^{-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
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-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	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	Pgh
gravitational potential,	ϕ	=	$-Gm / r$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_o \cos \omega t$
		=	$\pm \omega\sqrt{\left(x_o^{\,2} - x^2\right)}$
mean kinetic energy of a molecule of an ideal gas	E	=	$\frac{3}{2}kT$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$Q / 4\pi\varepsilon_o r$
alternating current/voltage,	x	=	$x_o \sin \omega t$
transmission coefficient,	T	α	exp(-2kd)
	where k	=	$\sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant	λ	=	$\frac{0.693}{t_{\frac{1}{2}}}$

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1 **(a)** State the relation between force and momentum.

……. [1]

(b) A rigid bar of mass 450 g is held horizontally by two supports A and B, as shown in Fig. 1.1.

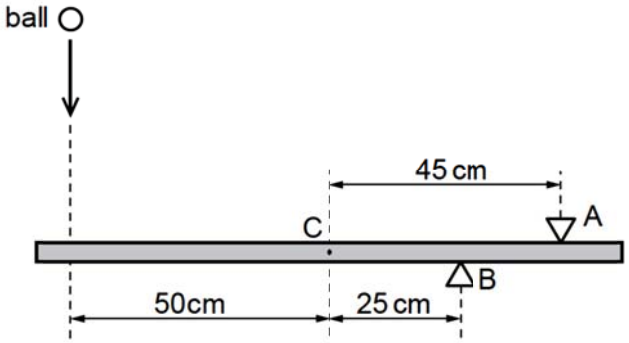

Fig. 1.1

The support A is 45 cm from the centre of gravity C of the bar and the support B is 25 cm from C.

A ball of mass 140 g falls vertically onto the bar such that it hits the bar at a distance of 50 cm from C, as shown in Fig. 1.1. The variation with time of the velocity of the ball before, during and after hitting the bar is shown in Fig. 1.2.

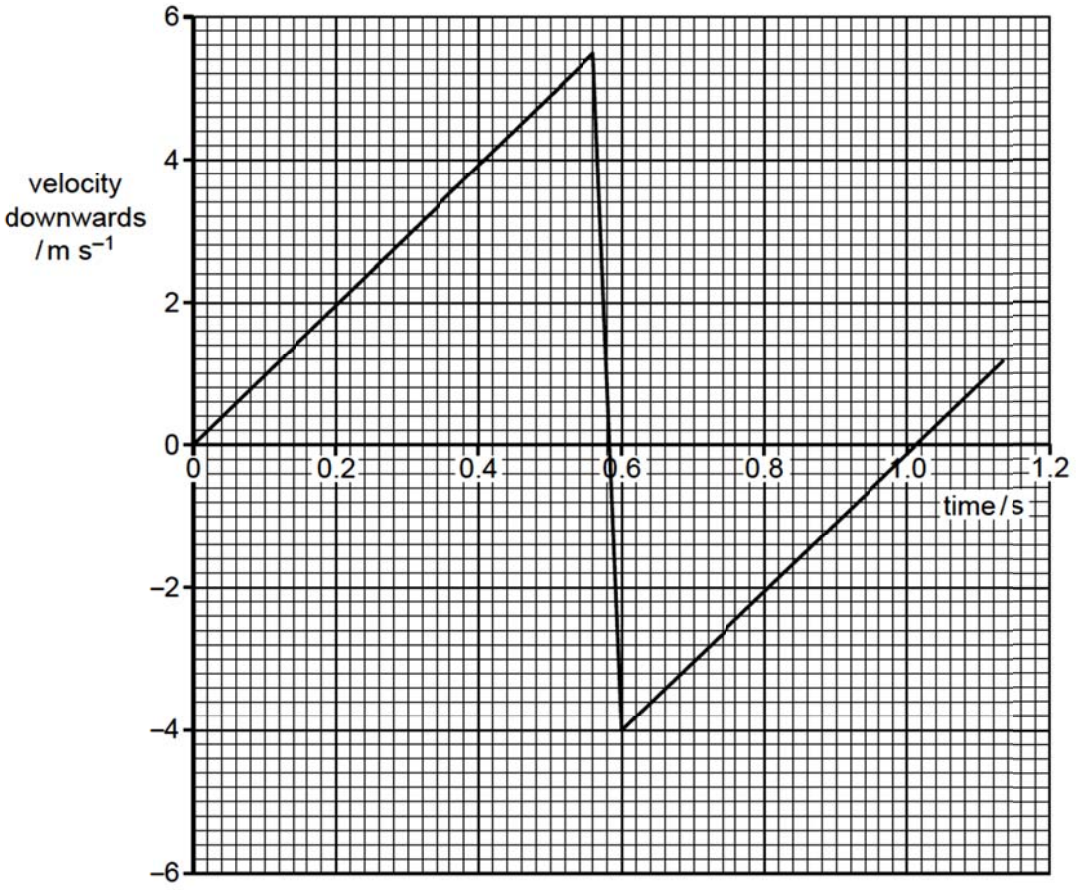

Fig. 1.2

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For the time that the ball is in contact with the bar, use Fig. 1.2 to determine

(i) the magnitude of the change in momentum of the ball,

change in momentum = ... kg m s^{-1} [2]

(ii) the magnitude of the force exerted by the ball on the bar.

force by ball = ... N [2]

(c) Hence, calculate the magnitude of the force exerted on the bar by support A for the time that the ball is in contact with the bar.

force by support A = ... N [2]

For Examiner's Use

2 An unpowered artificial satellite of mass m has been placed in a stable orbit around the Sun in the same direction as that of the Earth. It is at a distance of $0.99R$ from the Sun, where R is the orbital radius of the Earth as shown in Fig. 2.1.

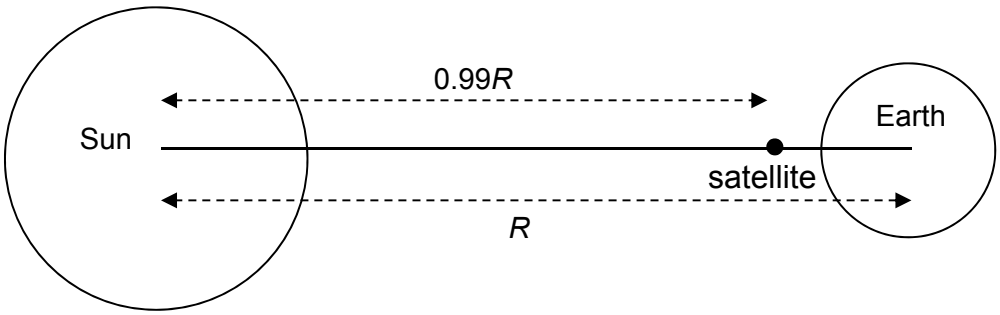

Fig. 2.1

(a) Ignore the very small force the satellite acts on the Earth. Show that the period of the Earth round the Sun T_E is given by

$$T_E = \sqrt{\frac{4\pi^2}{GM_S}} R^{3/2}$$

where M_S is the mass of the Sun.

[2]

(b) Show that the resultant force on the satellite is given by $0.99\frac{GM_S m}{R^2}$, given that the mass of the Sun is 3.33×10^5 times the mass of Earth.

[2]

For Examiner's Use

(c) Hence determine the period of the satellite round the Sun in terms of the period of the Earth T_E.

Period of satellite = ... [2]

(d) 'Since the satellite is going round the Sun in a stable orbit, it is in stable equilibrium.' Comment on the statement.

.....

..... [1]

3 **(a)** State the *principle of superposition*.

.....

.....

..... [1]

(b) Figure 3.1 shows a double slit S_1 and S_2 emitting waves of amplitude A and of wavelength 590 nm. They are placed 0.800 mm apart and at a distance of 2.70 m from a line XY. Point O is in the center of the fringe pattern. Two polarizers P_1 and P_2 are placed in front of S_1 and S_2 respectively. The polarizers are rotated such that a fringe pattern is observed along the line XY.

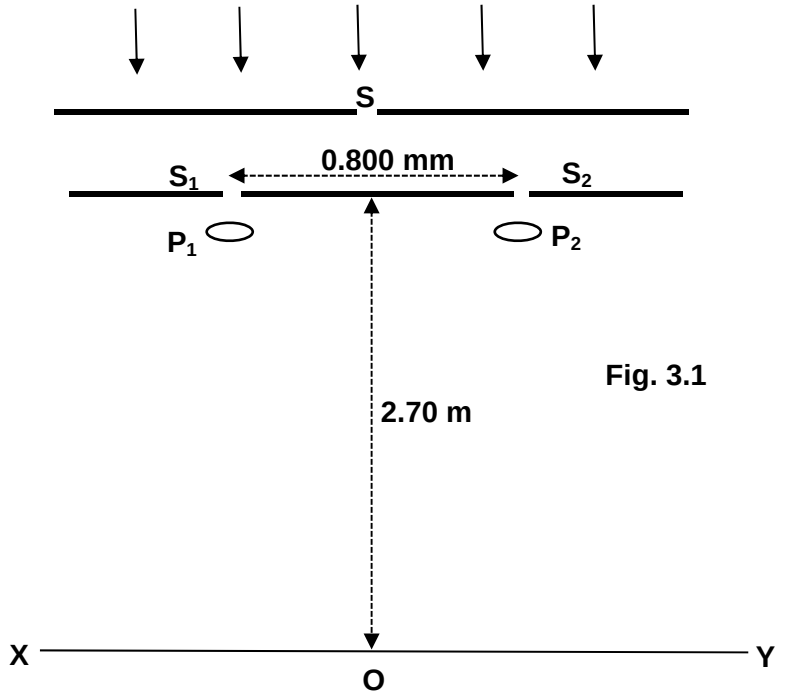

Fig. 3.1

For Examiner's Use

(i) Show that the fringe separation along the line XY is 2.00 mm.

[1]

(ii) On Fig. 3.2, sketch the variation of intensity along the line XY. [2]

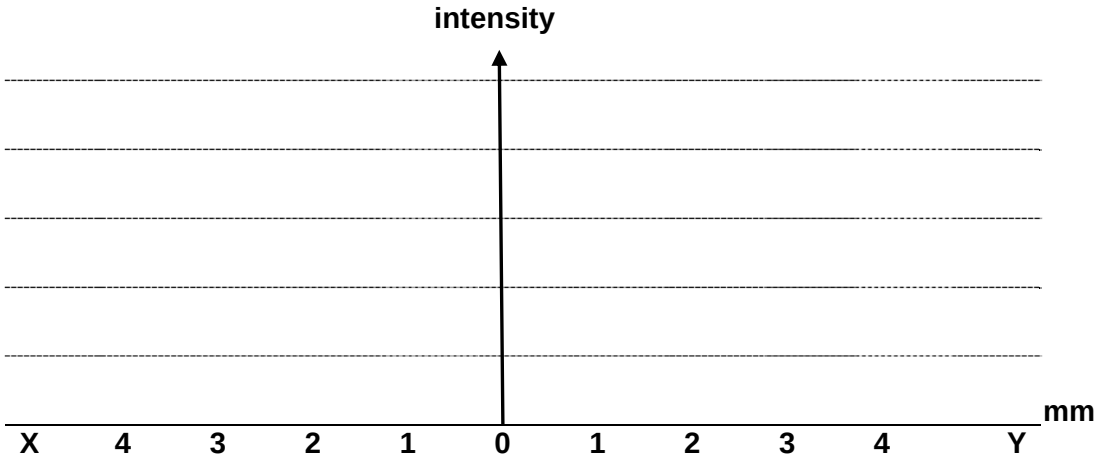

Fig. 3.2

(c) The polarizer P_1 is rotated 90^o along its plane.

(i) Calculate the resultant amplitude at point O on the line XY in terms of *A*.

amplitude = ... [1]

For Examiner's Use

(ii) Calculate the resultant amplitude at a point 1.00 mm from point O along the line XY in terms of *A*.

amplitude = ... [1]

(iii) Describe the appearance of the fringe pattern.

.....

..... [1]

4 An ideal transformer has 5000 turns on its primary coil. It is used to convert a main supply of root mean square value of 230 V to an alternating voltage having a peak value of 12.0 V.

(a) (i) Explain what is meant by *root mean square value of 230 V*.

.....

.....

..... [2]

(ii) Calculate the number of turns on the secondary coil.

number of turns = ... [2]

(b) The secondary coil is connected in series with a resistor R. The variation with time *t*, in seconds, of the potential difference at the secondary coil is given by the expression

$$V = 12.0 \sin(380t)$$

(i) Determine the frequency of the supply.

frequency = ... Hz [1]

(ii) To prevent overheating, the mean power dissipated in R must not exceed 300W. Calculate the minimum resistance of R.

resistance = ... Ω [2]

5 **(a)** 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. 5.1.

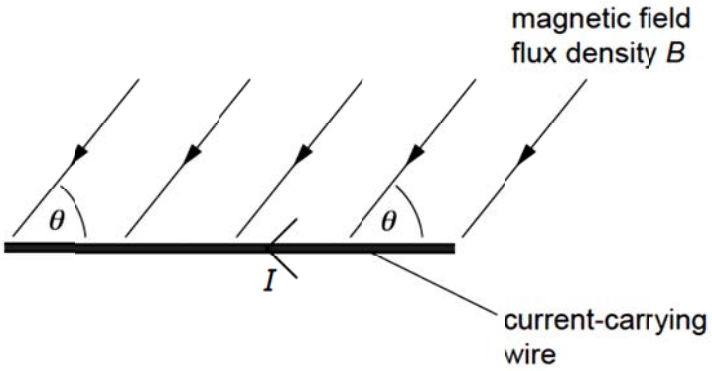

Fig. 5.1

(i) Define the term *magnetic flux density*.

.....

..... [1]

For Examiner's Use

(ii) The current I in the wire is changed, keeping the angle θ constant.

On Fig. 5.2, sketch a graph to show the variation with the current I of the force F on the wire. [1]

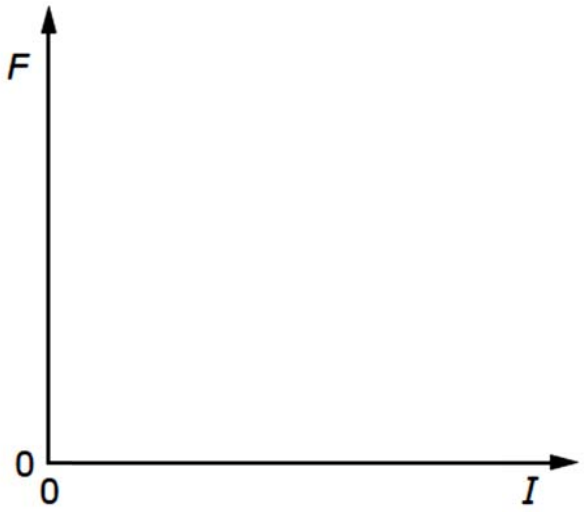

Fig. 5.2

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

On Fig. 5.3, sketch a graph to show the variation with angle θ of the force F on the wire. [1]

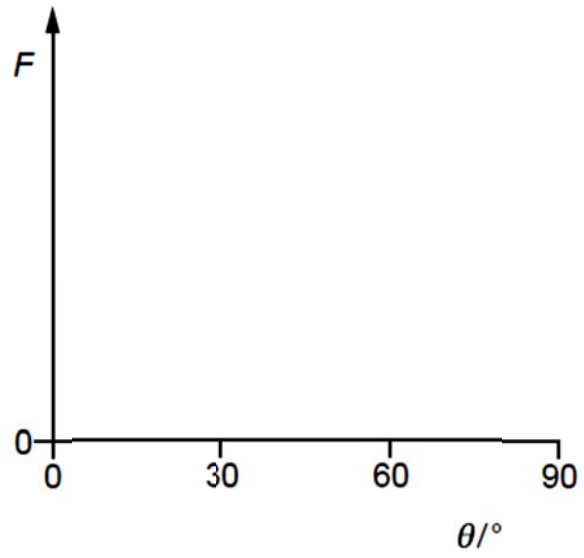

Fig. 5.3

For Examiner's Use

(b) Negative ions are travelling through a vacuum in a narrow beam. The ions enter a region of uniform magnetic field of flux density *B* and are deflected in a semi-circular arc, as shown in Fig. 5.4.

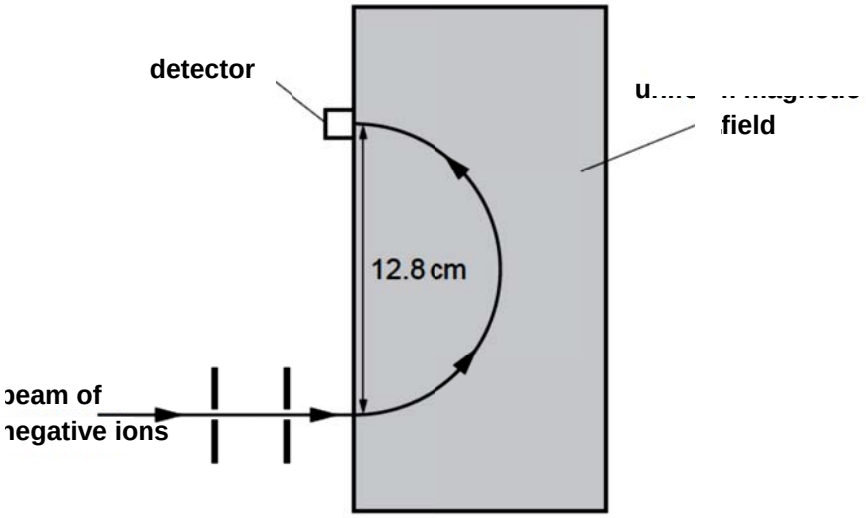

Fig. 5.4

The ions, travelling with speed 1.40×10^5 m s^{-1}, are detected at a fixed detector when the diameter of the arc in the magnetic field is 12.8 cm.

(i) By reference to Fig. 5.4, state the direction of the magnetic field.

..... [1]

(ii) The ions have mass 20*u* and charge -1.6×10^{-19} C. Show that the magnetic flux density is 0.454 T. Explain your working.

[2]

(iii) Ions of a larger mass with the same charge and speed as those in **(b)(ii)** are also present in the beam. On Fig. 5.4, sketch the path of these ions in the magnetic field of magnetic flux density 0.454 T. [1]

For Examiner's Use

6 Fig. 6.1 shows a simple circuit. The resistance of the lamp is 20 Ω and it requires a minimum of 60 V to light up.

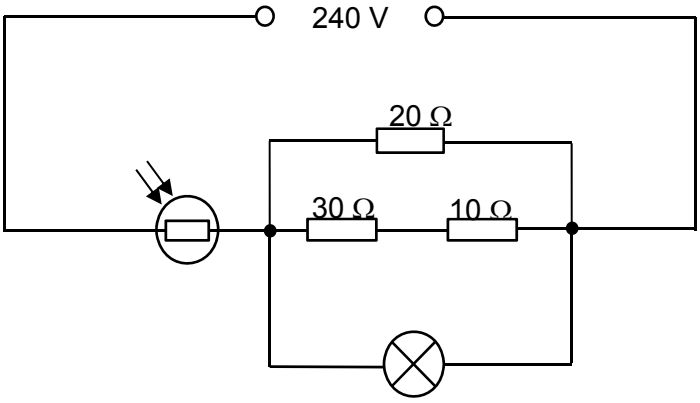

Fig. 6.1

Fig. 6.2 shows how the current I through the light dependent resistor varies with the potential difference V across it when different intensities of light fall onto it.

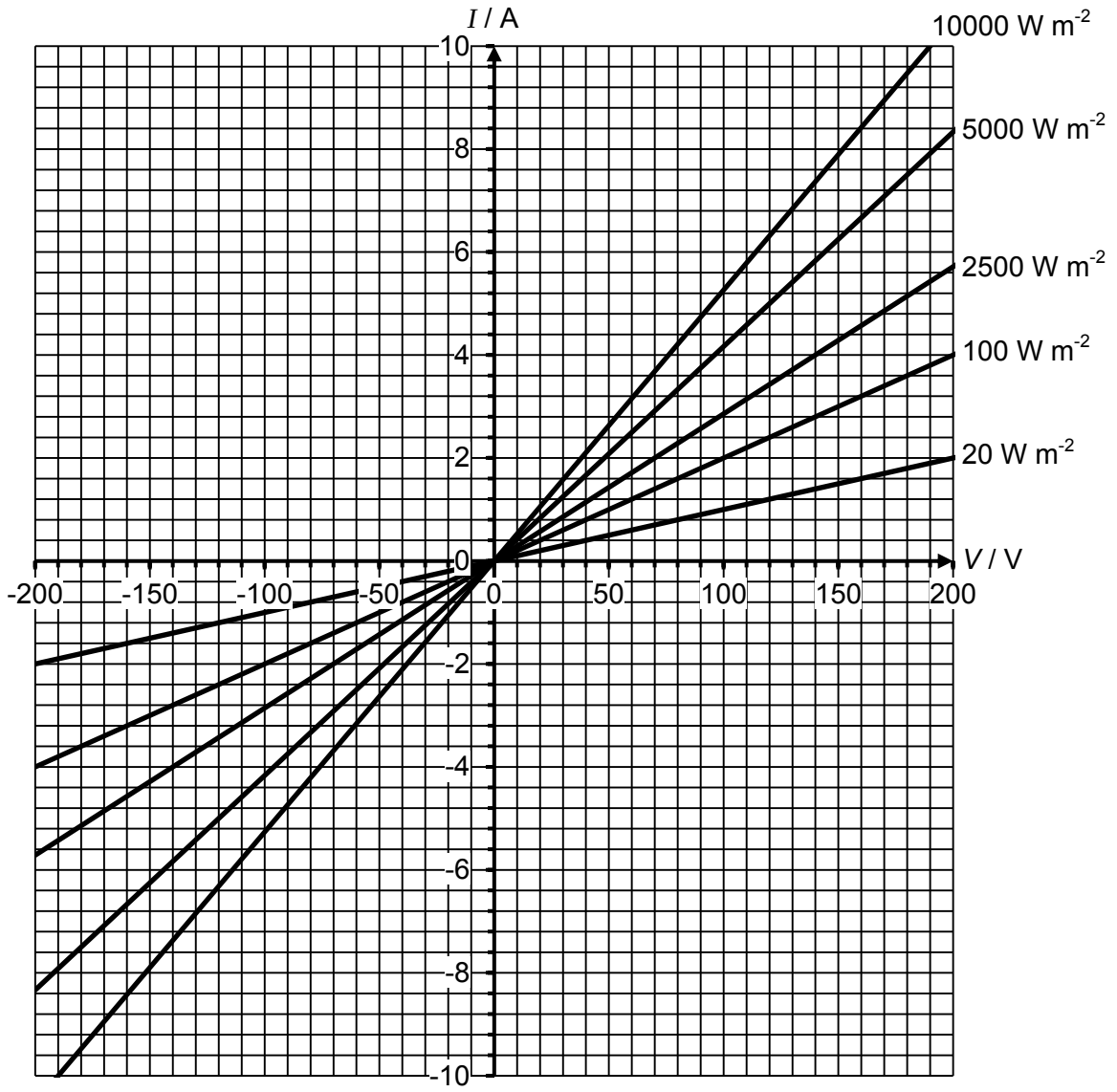

Fig. 6.2

For Examiner's Use

(a) Calculate the current through the 30 Ω resistor when the potential difference across the lamp is 40 V.

current = ... A [2]

(b) Explain how the above circuit can be used as a warning system for an environment which requires low intensity light.

.....

.....

..... [2]

(c) Using Fig. 6.2, determine the intensity of light which will produce a potential difference of 60 V across the lamp.

intensity = ... W m^{-2} [3]

For Examiner's Use

7 Wind power can be used for the generation of electric power. Fig 7.1 and Fig 7.2 illustrate a particular type of wind turbine.

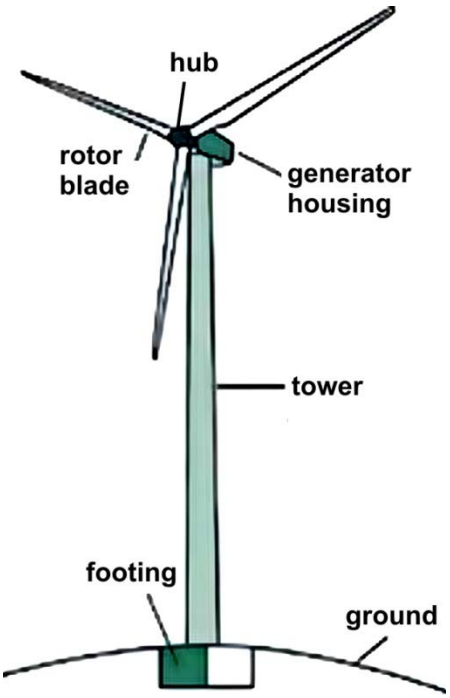

Fig 7.1

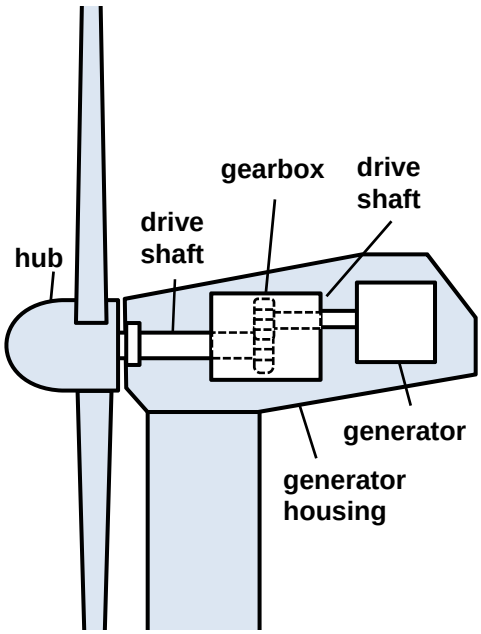

Fig 7.2

Table 7.3 shows some information provided by the manufacturer.

Table 7.3

Height of tower (ground to hub)	80	m
Blade length	45	m
Number of blades	3	
Rated power	3	MW
Voltage	650	V
Frequency	50	Hz

Fig 7.4 shows the wind turbine power curve provided by the manufacturer.

For Examiner's Use

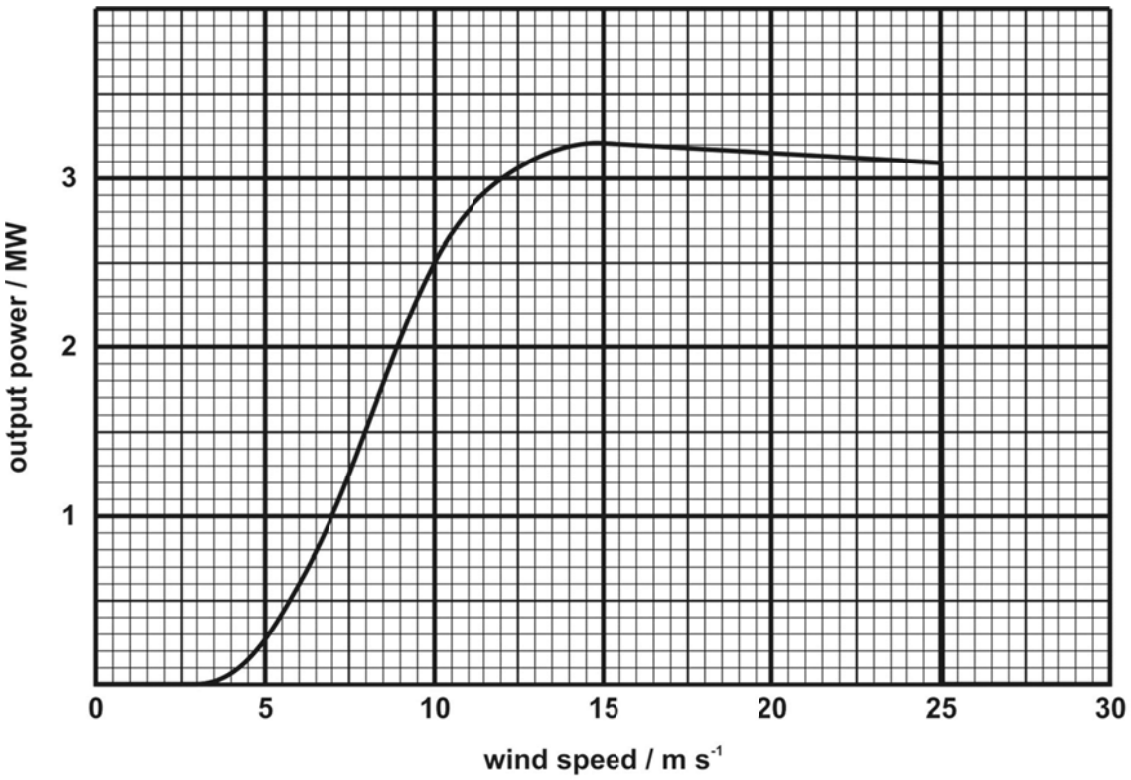

Fig 7.4

(a) Using the information provided in Table 7.3, calculate

(i) the height of the lowest point of the rotor above the ground,

height = ... m [1]

(ii) the area swept by the rotor blades

area = ... m^2 [1]

(iii) the period of revolution of the rotor when the wind speed is 10 m s^{-1}, given that the ratio of the speed of the blade tip to the wind speed is 7.

period = ... s [2]

For Examiner's Use

(b) (i) Discuss, with reasons, if the rated power of 3 MW is a fair value.

.....

.....

.....

..... [2]

(ii) The average monthly electrical energy consumption per household in Singapore is 470 kW h. Calculate the number of homes one wind turbine can serve when operating at the rated power.

number of homes = ... [2]

(c) (i) Using the information provided in Fig 7.4, obtain values for

1. the maximum power output,

maximum power = ... MW [1]

2. the wind speed for this power.

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

(ii) The incident wind power E, which is the kinetic energy of the air incident on the rotor to turn the blades per unit time, is given by

$$E = k L^2 v^3$$

where L is the blade length of the turbine,
v is the incident wind speed, and
k is a constant of value 1.96 kg m^{-3}

Calculate, for the turbine operating at maximum output power, the incident wind power.

incident wind power = ... W [1]

For Examiner's Use

(iii) According to Betz' Law, which is derived from the principles of conservation of mass and momentum, the maximum amount of the incident wind kinetic energy that can be captured by a wind turbine is 59.3%.

Suggest one evidence that not all of the incident wind energy can be captured.

……

…… [1]

(iv) Calculate the efficiency of the wind turbine in converting the accessible kinetic energy to electrical energy when operating under the conditions stated in **(i)**.

efficiency = …… % [2]

(d) The wind turbine, like most others, has a cut-out speed. This means that at high wind speeds, the gearbox disengages the generator from the rotor and the generator is no longer turned by the rotor.

(i) Use Fig 7.4 to determine the cut-out speed.

cut-out speed = …… m s^{-1} [1]

(ii) Suggest one reason why it is necessary to have a cut-out speed.

……

…… [1]

(e) Wind turbines are usually erected in wide open spaces. As such, they are vulnerable to (i) strong winds which may cause the rotor to rotate too fast and be damaged, and (ii) lightning which may strike the rotor, causing damage.

For each of the hazards mentioned, suggest how the risk of damage to the rotor may be minimized.

(i) Strong winds

……

…… [1]

(ii) Lightning

……

…… [1]

For Examiner's Use

8. Fig. 8.1 shows a coil (coil X).

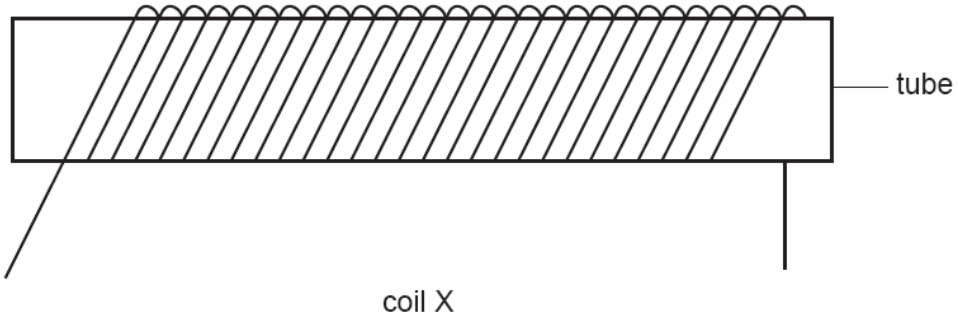

Fig. 8.1

A student winds another coil (coil Y) tightly around coil X.

A changing e.m.f. in coil X induces an e.m.f. in coil Y.

The student wishes to investigate how the e.m.f. V in coil Y depends on the frequency f of the current in coil X.

It is suggested that V is directly proportional to f.

Design a laboratory experiment to investigate the suggested relationship. You should draw a diagram, in the space provided below, showing the arrangement of your equipment. In your account you should pay particular attention to:

(a) the procedure to be followed,
(b) the measurements to be taken,
(c) the control of variables,
(d) the analysis of the data,
(e) the safety precautions to be taken.

Diagram

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[12]