MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

UNIVERSITY OF MALTA, MSIDA

MATRICULATION CERTIFICATE EXAMINATION
INTERMEDIATE LEVEL
MAY 2012

SUBJECT:	PHYSICS
DATE:	24th May 2012
TIME:	4.00 p.m. to 7.00 p.m.

A list of useful formulae and equations is provided. Take the acceleration due to gravity g = 10 m s^{-2} ***unless otherwise stated.***

SECTION A

Attempt all <u>10 questions</u> in this section. Each question carries 5 marks. This section carries 50% of the total marks for this paper.

1. a) A ball is dropped on a hard surface and makes several bounces before coming to rest. Which of the graphs best represents how the velocity of the ball varies with time? [2 marks]

   b) Explain in detail how you arrived at choosing your answer in (a). [3 marks]

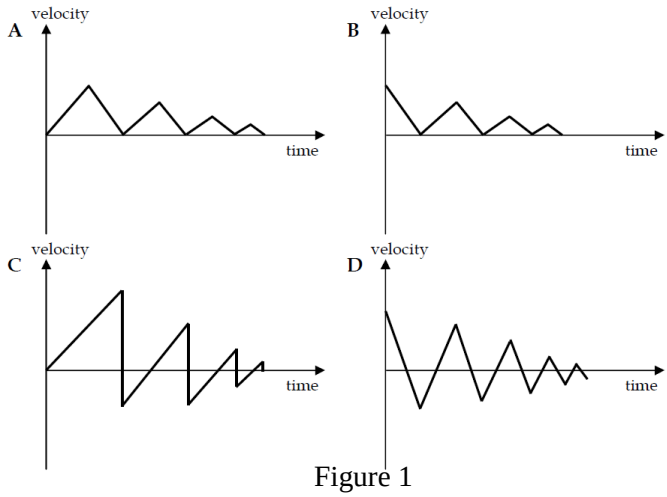

Figure 1

2. A substance is heated at a constant rate of energy transfer. A graph of its temperature against time is shown in Figure 2.

   a) Which part of the graph corresponds to the substance existing as a mixture of **two phases?** [1 mark]

   b) The substance melts at 63 K, and its specific heat capacity when solid is 1.6 x 10^{3} J kg^{-1} K^{-1}, calculate the specific latent heat of fusion of the substance. [4 marks]

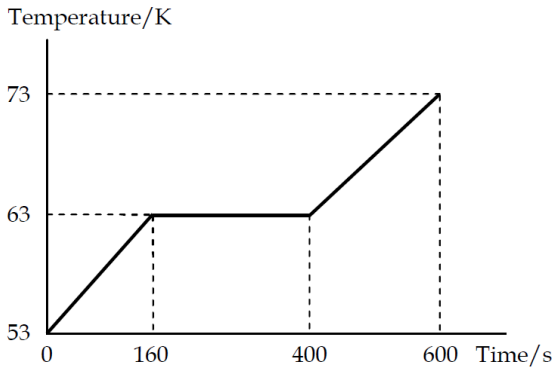

Figure 2

3. a) State in words Newton's Law of Gravitation. [1 mark]

   b) If a satellite of mass 240 kg is put in a circular orbit just above the surface of the Earth, with what speed must the satellite be moving? [2 marks]

   c) How long would it take the satellite in (b), near Earth's surface to orbit Earth? [2 marks]

   [Universal Gravitational constant *G* equals 6.67 x 10^{-11} N m^{2} kg^{-2}, mass of Earth *M* equals 5.98 x 10^{24} kg, radius of Earth *R* equals 6.37 x 10^{6} m]

4. a) On the same scale and axes sketch two graphs to indicate the difference between the rates of decay of two substances with different half-lives. Clearly mark the graph which represents the substance with the longer half-life. [1 mark]

   b) When a tree is cut down, the carbon-14 ($^{14}_{6}C$) present in the wood at that time decays with a half-life of 5800 years.
      i) Carbon-14 decays by beta emission, forming nitrogen-14. Write the equation for this decay. [2 marks]
      ii) For an old wooden bowl from an archaeological site, the average count-rate of beta particles detected per kg of carbon is 13 counts per minute. The corresponding count rate from newly cut wood is 52 counts per kg per minute. How many half lives have passed since the bowl was constructed? Calculate the approximate age of the wooden bowl. [1, 1 mark]

5. A fixed mass of gas undergoes various changes of temperature, pressure and volume such that it is taken round the P – V cycle shown in Figure 3 .

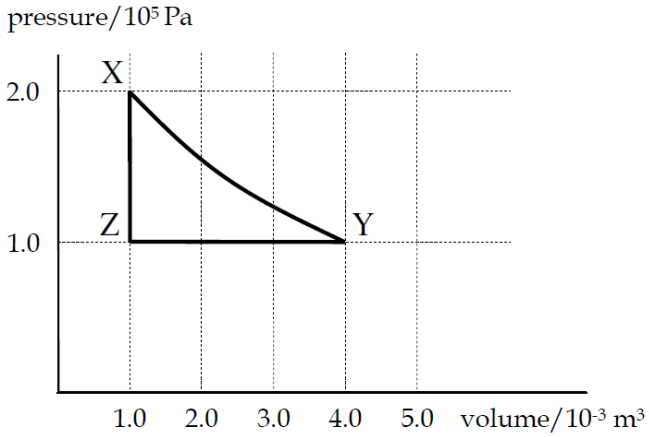

Figure 3

In the part Y to Z, the gas is compressed and 800 J of thermal energy is transferred from the gas to the reservoir.

   a) Use the graph to determine the work done on the gas during the process Y to Z. [2 marks]

   b) What is the change in internal energy of the gas during the process Y to Z? [3 marks]

6. a) State in words Faraday's law of electromagnetic induction. [1 mark]

   b) A loop of wire is rotated in a uniform magnetic field. A cathode ray oscilloscope measures the varying induced potential difference across the loop, as shown in Figure 4. What is the r.m.s. value of the induced p.d.? [1 mark]

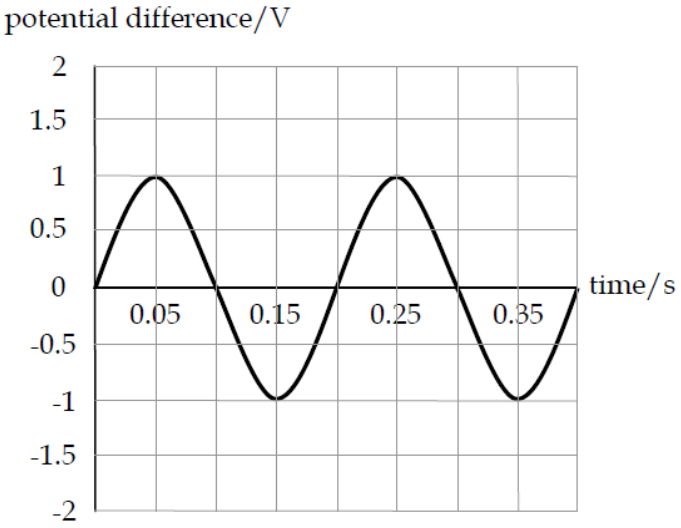

Figure 4

c) If the coil is rotated at twice the speed, sketch the new graph obtained, of potential difference against time. The new values obtained are to be inserted near both axes. [3 marks]

7. a) Sketch a labelled graph of current against voltage for a filament lamp. [2 marks]

b) The filament of a bulb is to emit 60 W of light energy when connected to a 240 V supply. The bulb is 40% efficient at converting electric energy into light energy. Calculate the resistance of the bulb. [3 marks]

8. a) Define simple harmonic motion. [2 marks]

b) A particle moving with SHM has an acceleration of 12 m s^{-2} when it is 3.0 m from its equilibrium position.

i) Find the periodic time of the oscillation. [1 mark]

ii) State the position of the particle during the oscillation, for the acceleration to be at a maximum value. [2 marks]

9. The graph in Figure 5 shows how the extension of a wire changes as it is loaded.

a) Calculate the stress produced by a load of 50 N, given that the wire has a diameter of 5.0×10^{-4} m. [2 marks]

b) Calculate the energy stored in the stretched wire. [2 marks]

c) Estimate the loss in gravitational potential energy of a 5.0 kg mass, when this is used to load the wire. [1 mark]

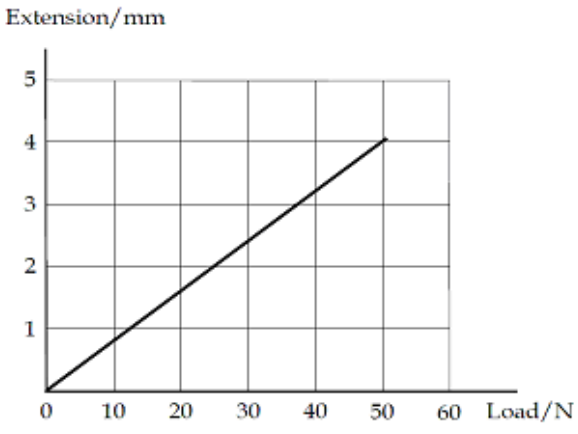

Figure 5

10. A student performs an experiment to measure the focal length of a converging lens. During the experiment a series of object and image distances (u and v) are measured. The student draws a graph as shown in Figure 6.

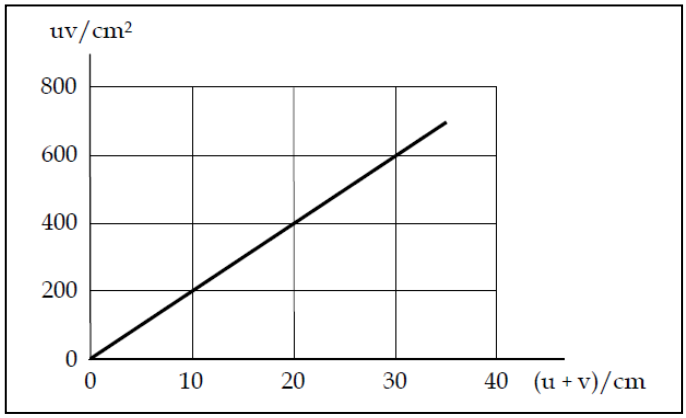

Figure 6

a) If the lens equation used was $\frac{1}{f}=\frac{1}{v}+\frac{1}{u}$ and both u and v were taken as positive, show how the graph can be used to find the value of the focal length. [3 marks]

b) Hence, use the graph to find the focal length of the lens. [2 marks]

SECTION B

This question carries 14% of the total mark for this paper and must be <u>attempted.</u>

11. Figure 7 shows a lagged copper bar heated at end D and cooled by running water at end B. The temperature per unit length along the bar is determined from θ_1 and θ_2 read from thermometers T_1 and T_2 respectively. The rate of flow of heat through the bar is determined by the increase in temperature difference $(\theta_4-\theta_3)$ of the flowing water at end B read from thermometers T_3 and T_4. As the rate of flow of water m/t entering end B is changed, the temperatures $\theta_1, \theta_2, \theta_3$ and θ_4 are recorded in the table below.

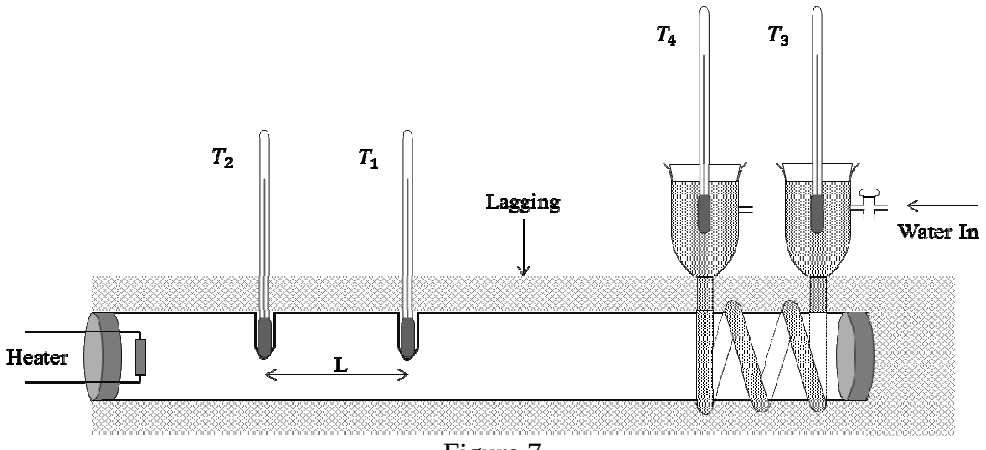

Figure 7

The cross-sectional area of the bar is $A = 0.002\,\text{m}^2$.

$(\theta_2 - \theta_1)/\text{K}$	θ_4/K	θ_3/K	$\frac{m}{t}/\text{kg s}^{-1}$	$\frac{m}{t}\times(\theta_4-\theta_3)/kg\ K\ \text{s}^{-1}$
14.9	297.50	293.16	0.007	
18.8	295.36	292.16	0.011	
23.9	294.76	293.16	0.028	
26.4	294.10	293.16	0.055	
29.6	291.66	291.16	0.111	

It is known that the temperatures are related by:

$$(\theta_2 - \theta_1) = \frac{c_w L}{kA}\left[\frac{m}{t}(\theta_4 - \theta_3)\right],$$

where k is the thermal conductivity of the bar, L is 0.10 m and c_W is the specific heat capacity of water equivalent to $4187\ \text{J kg}^{-1}\ K^{-1}$.

a) Copy the table and fill in the missing values.

b) Plot a graph of $(\theta_2 - \theta_1)/\text{K}$ on the y-axis against $\frac{m}{t}\times(\theta_4-\theta_3)/kg\ K\ \text{s}^{-1}$ on the x-axis.

c) Use the graph to determine the conductivity k of copper and state its units.

d) Explain the physical significance of the lagging on the outside of the copper bar.

[4, 5, 3, 2 marks]

SECTION C

Answer any <u>two</u> questions from this section. Each question carries 18 marks. This section carries 36% of the total mark for this paper.

12. a) A student sets up a steel sphere of mass *m* on a smooth bench, to investigate circular motion. The sphere was tied to a string which is passed through a frictionless hole in the bench. Slotted masses *M* were suspended from the other end of the string, as seen in Figure 8.

i) Briefly explain why the weight of the ball does not have an effect on the tension in the string. [2 marks]

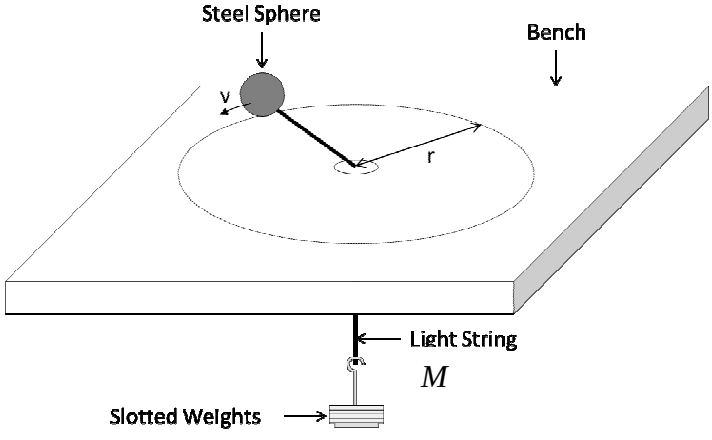

Figure 8

ii) Show that the radius r of the circular path taken by the ball is given by $r = \left(\frac{m}{M}\right)\frac{v^2}{g}$, where v is the tangential speed of the ball and M is the mass of the slotted weights. [3 marks]

iii) State what would happen to the slotted masses if the student reduces the tangential speed of the ball. Explain your reasoning. [1, 2 marks]

b) In a loop-the-loop ride, a coaster of mass 800 kg falls from a point A, a height of 20 m and performs the loop as shown in Figure 9. Assuming the track is frictionless, calculate:

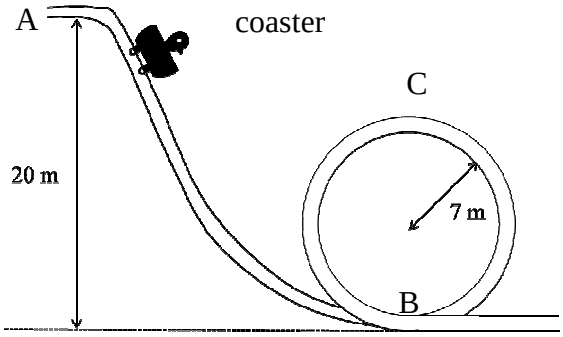

Figure 9

i) the velocity with which the coaster reaches point B; [3 marks]

ii) the force the track exerts on the coaster at point B, noting that it has started circular motion; [4 marks]

iii) the tangential velocity the coaster needs to just reach point C. [3 marks]

13. a) N free electrons travel along a uniform conducting wire of length l and cross-sectional area A, in an average time t.

i) What is the average velocity v of the electrons? [1 mark]

ii) Calculate the number of electrons n per unit volume of the wire. [1 mark]

iii) If e is the charge on an electron, show that the current I, flowing through the wire, is $I = nAve$. [3 marks]

b) A student uses a thermistor in the circuit shown in Figure 10, to switch off the heater when the water in the beaker boils. The e.m.f of the battery is 10.5 V and its internal resistance is r. Points X and Y are connected to another circuit that turns off the heater if the potential difference between them becomes less than 0.5 V.

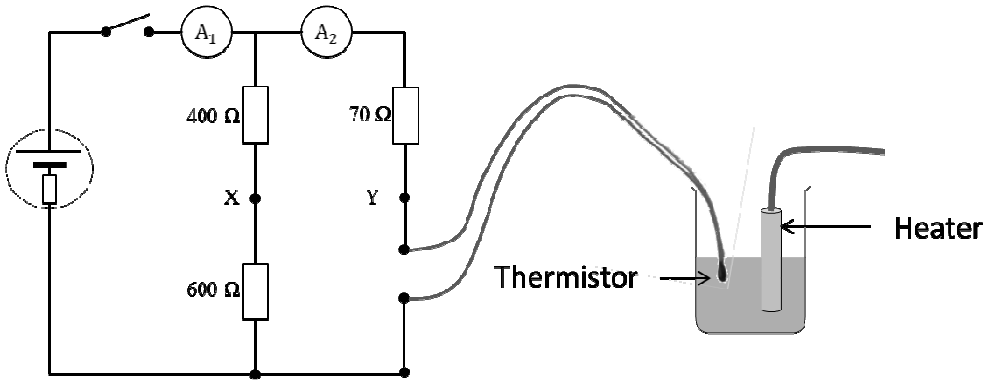

Figure 10

With the water just starting to boil in the beaker, ammeter A_1 reads 0.05 A and ammeter A_2 reads 0.04 A. Determine:

i) the current flowing through point X; [1 mark]
ii) the terminal potential difference of the battery; [3 marks]
iii) the internal resistance *r* of the battery; [3 marks]
iv) the resistance of the thermistor in the boiling water; [3 marks]
v) the potential difference between X and Y, deducing whether the heater has been turned off or is still turned on. [3 marks]

14. a) i) Distinguish between *longitudinal* and *transverse progressive* waves and give an example of each type of wave. [4 marks]
ii) How are *stationary* waves formed? [3 marks]
iii) Contrast two different properties of *progressive* and *stationary* waves. [2 marks]
iv) Explain, using diagrams where necessary, the meaning of the terms *displacement*, *amplitude* and *period* of a transverse wave. [3 marks]

b) The two graphs shown in Figure 11, refer to the same wave.

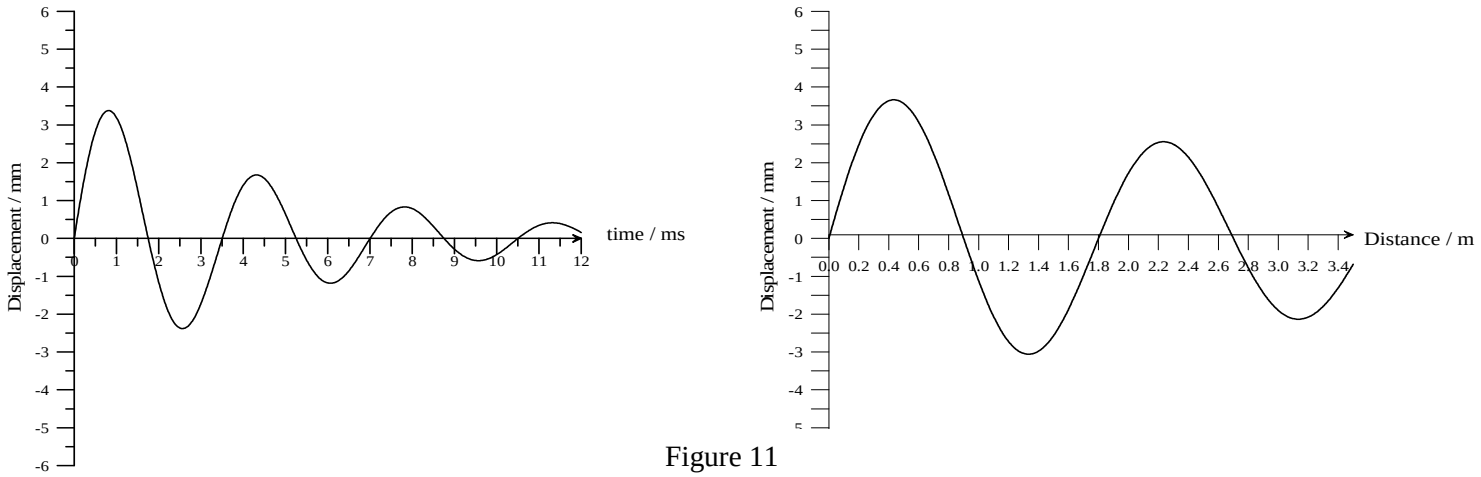

Figure 11

i) Write down the periodic time of the wave and hence calculate the speed of the wave. [2 marks]
ii) Describe briefly what is happening to the energy transmitted by the wave. [1 mark]

c) Two electrical oscillating signals are shown on a CRO screen as in Figure 12 below. Determine:
i) the frequency of the signals; [1 mark]
ii) the phase difference between the two signals, in terms of the periodic time. [2 marks]

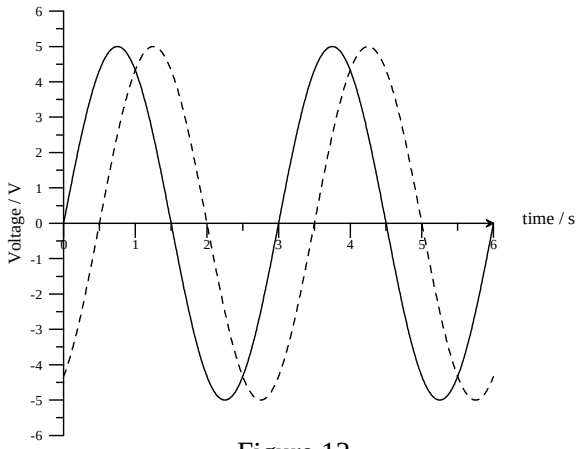

Figure 12

15. a) i) Define the *magnetic flux density B*. [3 marks]

ii) The force on a conductor of length L carrying a current I perpendicular to a magnetic field of flux density B, is given by $F = BIL$. Show that the force on a single electron passing through the conductor is given by $F = Bev$, where e is the electronic charge and v is the drift velocity of the electron. [4 marks]

b) A horizontal rod PQ of mass 0.01 kg and length 0.1 m is placed on a frictionless plane inclined at a angle of 60 deg to the horizontal. A uniform vertical magnetic field B of flux density equal to 1 T, acts downwards as shown in Figure 13. A current I flows through the rod, into the paper.

The only forces acting on the rod are the reaction R, its weight mg and the force F due to the magnetic field.

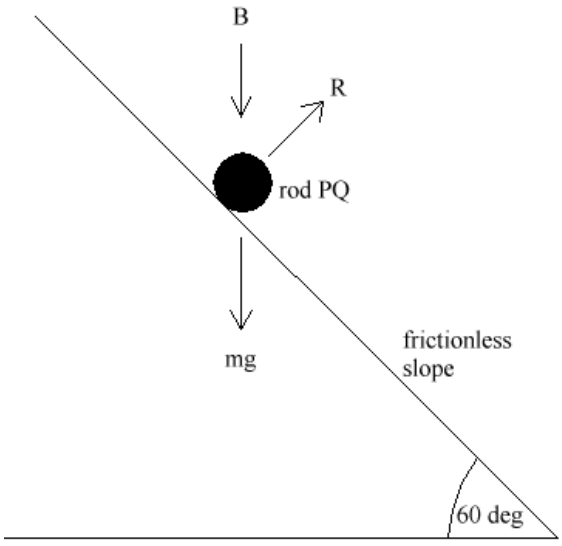

Figure 13

i) Copy the diagram and draw the force F acting on the rod due to the magnetic field. [2 marks]

ii) Calculate the value of the current if the rod remains stationary. [5 marks]

iii) Find the value of the reaction R. [4 marks]