2015-DSE
PHY

PAPER 1B

B

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2015

PHYSICS PAPER 1

SECTION B : Question-Answer Book B

This paper must be answered in English

INSTRUCTIONS FOR SECTION B

(1) After the announcement of the start of the examination, you should first write your Candidate Number in the space provided on Page 1 and stick barcode labels in the spaces provided on Pages 1, 3, 5, 7 and 9.

(2) Refer to the general instructions on the cover of the Question Paper for Section A.

(3) Answer **ALL** questions.

(4) Write your answers in the spaces provided in this Question-Answer Book. Do not write in the margins. Answers written in the margins will not be marked.

(5) Graph paper and supplementary answer sheets will be provided on request. Write your Candidate Number, mark the question number box and stick a barcode label on each sheet, and fasten them with string **INSIDE** this Question-Answer Book.

(6) No extra time will be given to candidates for sticking on the barcode labels or filling in the question number boxes after the 'Time is up' announcement.

Please stick the barcode label here.

Candidate Number									

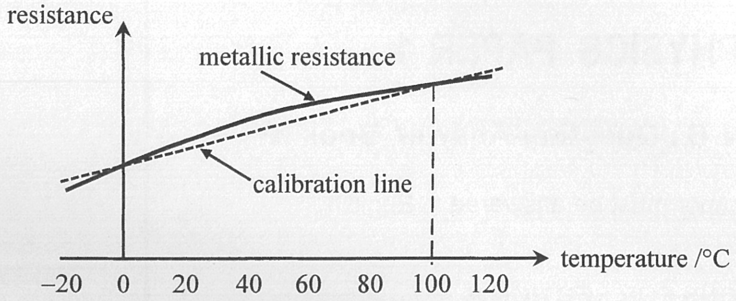
Question No.	Marks
1	**5**
2	**6**
3	**9**
4	**11**
5	**6**
6	**8**
7	**10**
8	**13**
9	**9**
10	**7**

A150E01B

Section B: Answer **ALL** questions. Parts marked with * involve knowledge of the extension component. Write your answers in the spaces provided.

1. The solid curve in Figure 1.1 shows how the resistance of a metallic resistance thermometer varies with temperature. This thermometer is calibrated at standard atmospheric pressure for the melting point of ice and the steam point of boiling water. The dotted calibration line represents how the resistance of the thermometer varies with temperature if a linear resistance-temperature relationship is assumed. The deviation of the curve from linearity has been exaggerated in the figure.

Figure 1.1



(a) (i) Using the resistances at the calibration points tabulated below, calculate the expected resistance at 60 °C if the resistance varies linearly with temperature. (2 marks)

temperature /°C	resistance /Ω
0	102.00
100	140.51

....

(ii) Now if the resistance of the resistance thermometer is the value found in (a)(i), is the actual temperature higher than, lower than or equal to 60 °C ? (1 mark)

....

(b) In an experiment to determine the specific heat capacity of water c_W, Peter used this calibrated resistance thermometer to measure the temperature of water being heated from 0 °C to 60 °C. Heating was stopped when this thermometer's resistance reached the value found in (a)(i). Assuming negligible heat exchange with the surroundings, no error in measuring the energy supplied and the mass of water, explain whether the experimental value of c_W found is higher than, lower than or the same as the actual value. (2 marks)

....

*2. The aqua-lung (a cylinder containing compressed air) for divers has a capacity of 1.0×10^4 cm^3. When the aqua-lung is filled, the air inside has a pressure of 210 atm (atmospheric pressure) at 24 °C. The air in the aqua-lung is allowed to expand through a pressure-reducing valve until its pressure equals that of the surrounding water before it is supplied to divers. Assume that the temperature of the air inside the aqua-lung is always equal to that of the surrounding water.

(a) A diver stays in water of temperature 24 °C and pressure 2.0 atm at a depth of 10 m. Find the total volume of air (in cm^3) available for the diver from the aqua-lung at this water pressure. (2 marks)

....

(b) The supply of air in (a) is sufficient for the diver to remain at such a depth for 1 hour.

(i) If the diver breathed in the same volume V_0 (in cm^3) of air per minute, find V_0. (1 mark)

....

(ii) If the diver dives deeper where the water is of temperature 20 °C and pressure 4.5 atm, estimate how long (in minutes) the air in a fully-filled aqua-lung would last. Assume that the diver breathes in the **same volume of air** per minute as that found in (b)(i). (3 marks)

....

Go on to the next page

3.

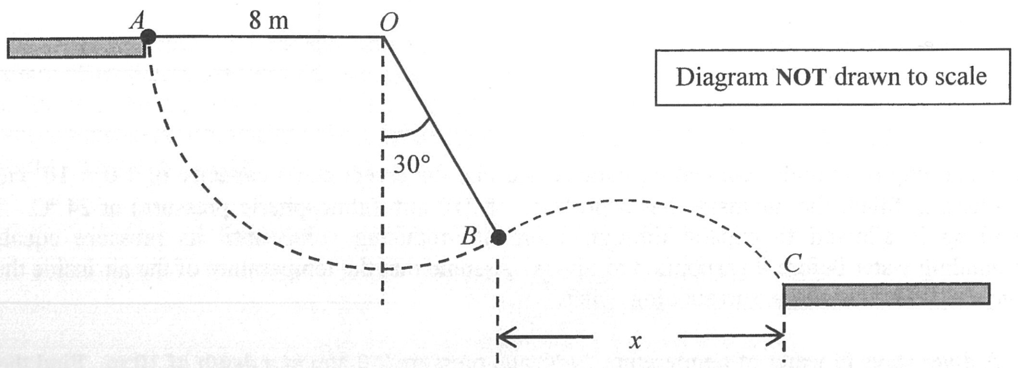


Figure 3.1

Figure 3.1 shows two horizontal platforms with end points A and C. An acrobat tries to swing from A to C by using a light rope of 8 m long and with one end fixed at point O, which is at the same level as A. He leaves A by holding the end of the rope and then releases it when reaching point B at which the angle between the rope and the vertical is 30°. The acrobat can be treated as a point mass and the rope remains taut and not extended throughout the motion. Neglect air resistance. ($g = 9.81\ \text{m s}^{-2}$)

(a) Mark on Figure 3.1 the velocity v_B of the acrobat at B. If the speed of the acrobat when leaving A is zero, find the magnitude of v_B. (3 marks)

*(b) (i) It takes 1.25 s for the acrobat to reach C after releasing the rope at B. By considering his horizontal motion, find the horizontal separation x between B and C. (2 marks)

Answers written in the margins will not be marked.

Please stick the barcode label here.

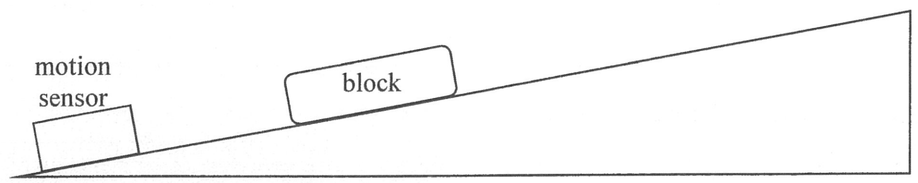
(ii) Calculate the vertical distance of C below B. (3 marks)

(c) Before reaching the lower platform, is there any change to the acrobat's mechanical energy among the points A, B and C? (1 mark)

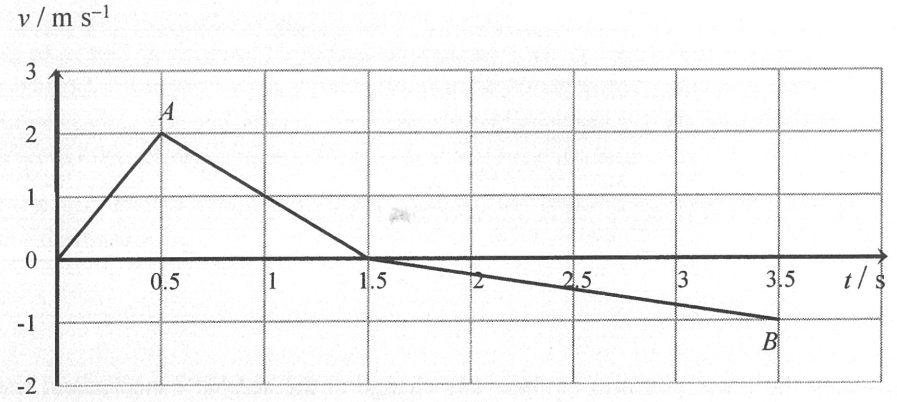
Answers written in the margins will not be marked.

4. The motion of a block on an inclined plane can be investigated using a motion sensor connected to a computer (not shown in Figure 4.1).

Figure 4.1



A block is given a push up a rough inclined plane and then released. The velocity-time (v-t) graph recorded by the sensor is shown below. Assume that the frictional force acting on the block is constant in magnitude throughout the motion. Neglect air resistance. ($g = 9.81$ m s^{-2})



Point A on the graph corresponds to the instant at which the push is removed.

(a) Describe the block's motion **from *A* to *B***. (2 marks)

....

....

....

....

....

(b) (i) Find the magnitude of the block's acceleration from $t = 1.5$ s to $t = 3.5$ s. (2 marks)

....

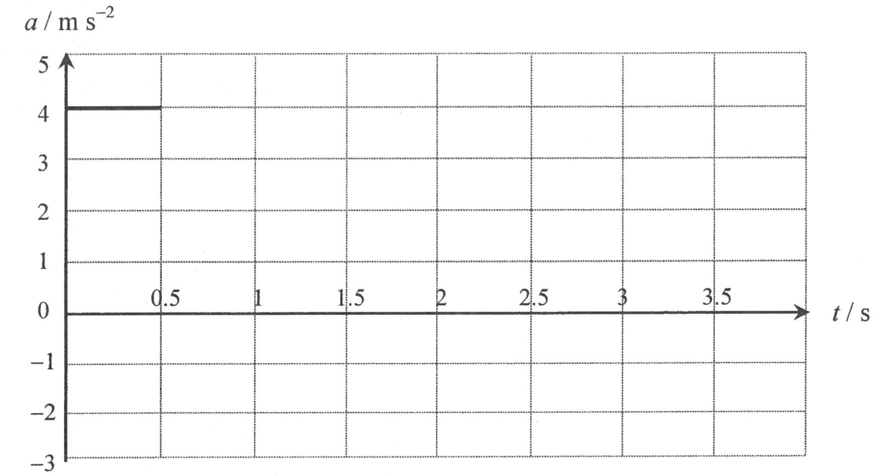
....

....

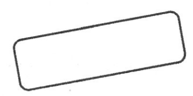
....

....

(ii) Draw the corresponding acceleration-time (a-t) graph of the block. With the direction up the inclined plane taken to be positive, the part during which the block is being pushed has been drawn for you. (2 marks)



(c) Draw a free-body diagram to show the force(s) (with labels) acting on the block as it moves up the inclined plane after the push is removed. (2 marks)



(d) If the mass of the block is 1.0 kg, find the magnitude of the frictional force. (3 marks)

....

....

....

....

....

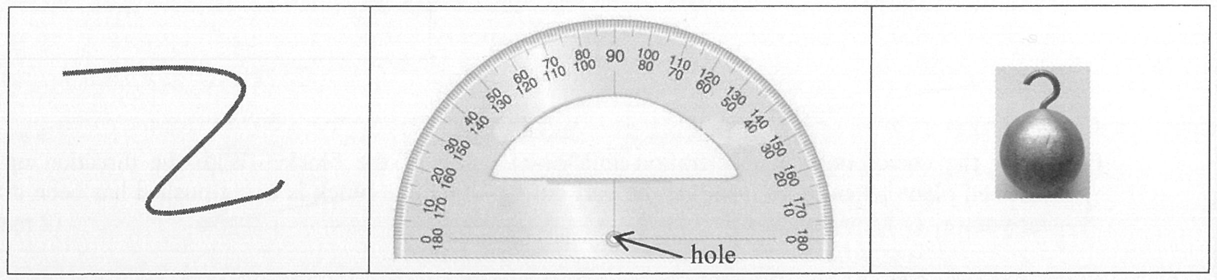
....

....

....

Go on to the next page

5. You are given a long light string, a protractor and a metal ball with a hook.



Suppose you are inside a train which is at rest initially and later it travels along a straight horizontal track with constant acceleration. With the aid of a diagram, describe how to measure the acceleration of the train. Show your working including mathematical derivation. (6 marks)

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

Please stick the barcode label here.

Do not write on this page.

Answers written on this page will not be marked.

Go on to the next page

6. Read the following description about a **mirage** and answer the questions that follow.

A mirage is often seen on highways during hot summers. Pools of water seem to cover the roadway far ahead. Distant objects appear to be reflected by the surface of the 'water'. The phenomenon is caused by the difference in refractive index between the hot air near the road surface and the cooler air above it. The refractive index of cool air is greater than that of hot air, but the differences are so small that the subsequent deviations of light rays are tiny. Sufficiently large temperature differences between the hot air near the road surface and the above cooler air over a short height (i.e. high temperature gradient) and light rays travelling along sufficiently long path lengths are required to form a mirage.

Figure 6.1 Mirage seen on a highway. This photo was taken with a telephoto lens which gives the perception that the viewer is very close to the car ahead.

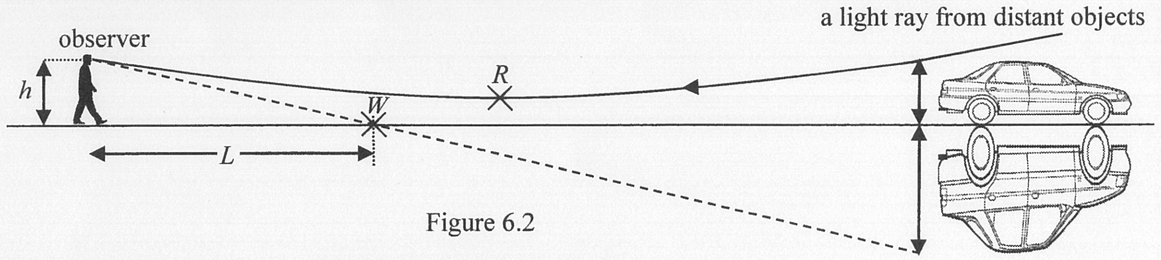


Figure 6.2

Figures 6.2 and 6.3 illustrate the principle of the phenomenon. Air of different temperatures is simplified to several layers and modeled as parallel slabs as shown in Figure 6.3. The bending of the light ray from distant objects is much exaggerated. θ_1, θ_2, θ_3 and θ_4 denote the angles of incidence at various boundaries of air layers.

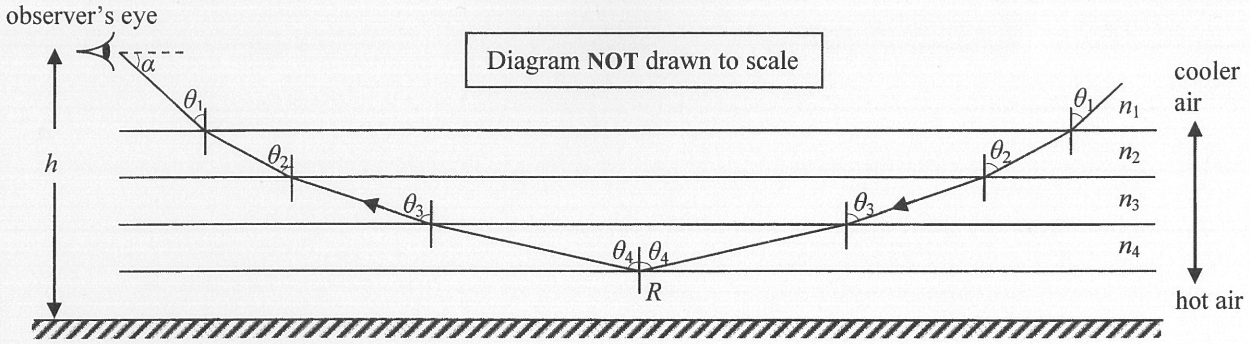


Figure 6.3

(a) State **ONE** essential condition for a mirage to be observed. (1 mark)

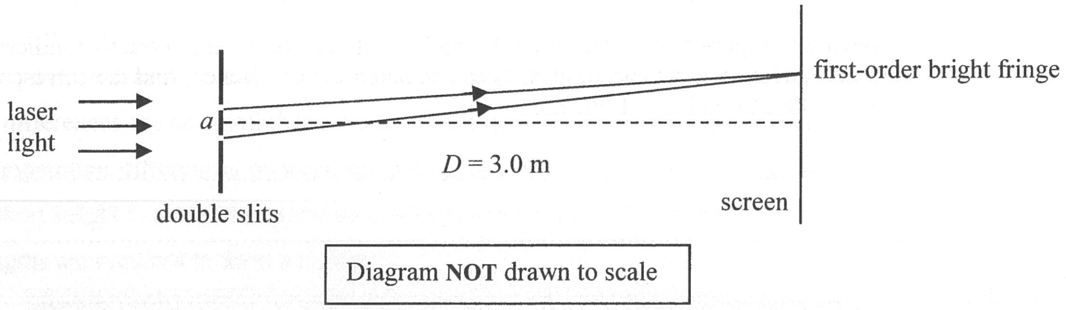
(b) (i) Referring to Figure 6.3, deduce the relationship between θ_1, θ_4 and refractive indices n_1, n_4. For total internal reflection just to occur at R, θ_4 can be taken as 90°. Hence, find the corresponding value of θ_1 if $n_1 = 1.000261$ and $n_4 = 1.000221$. (3 marks)

(ii) Find L in Figure 6.2 if $h = 1.5$ m. (Note: $\alpha + \theta_1 = 90°$ in Figure 6.3.) (2 marks)

(c) A thirsty traveller in a vast desert sees similar mirages such that a 'water source' appears at W which is distance L away like the one in Figure 6.2. If he walks a distance L towards that 'water source', how far would the 'water source' appear to him ? Explain your answer. (2 marks)

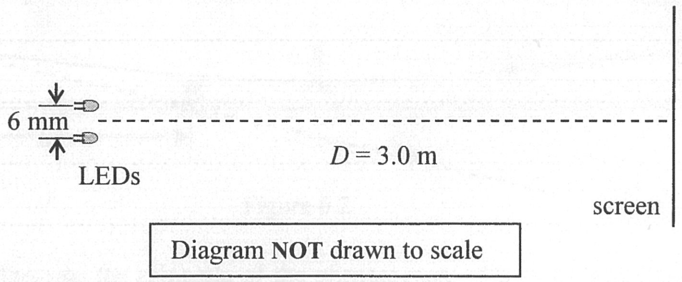
7. *(a) A laser light beam of wavelength 650 nm is incident normally on a pair of slits separated by $a = 0.325$ mm. Interference pattern is observed on a screen at a distance $D = 3.0$ m from the slits as shown in Figure 7.1. What is the separation between adjacent first- and second-order bright fringes ? (2 marks)

Figure 7.1



(b) Figure 7.2 shows a set-up with two small LEDs separated by 6 mm and both LEDs emit light of wavelength 650 nm. State and explain what you would expect to see on the screen. (2 marks)

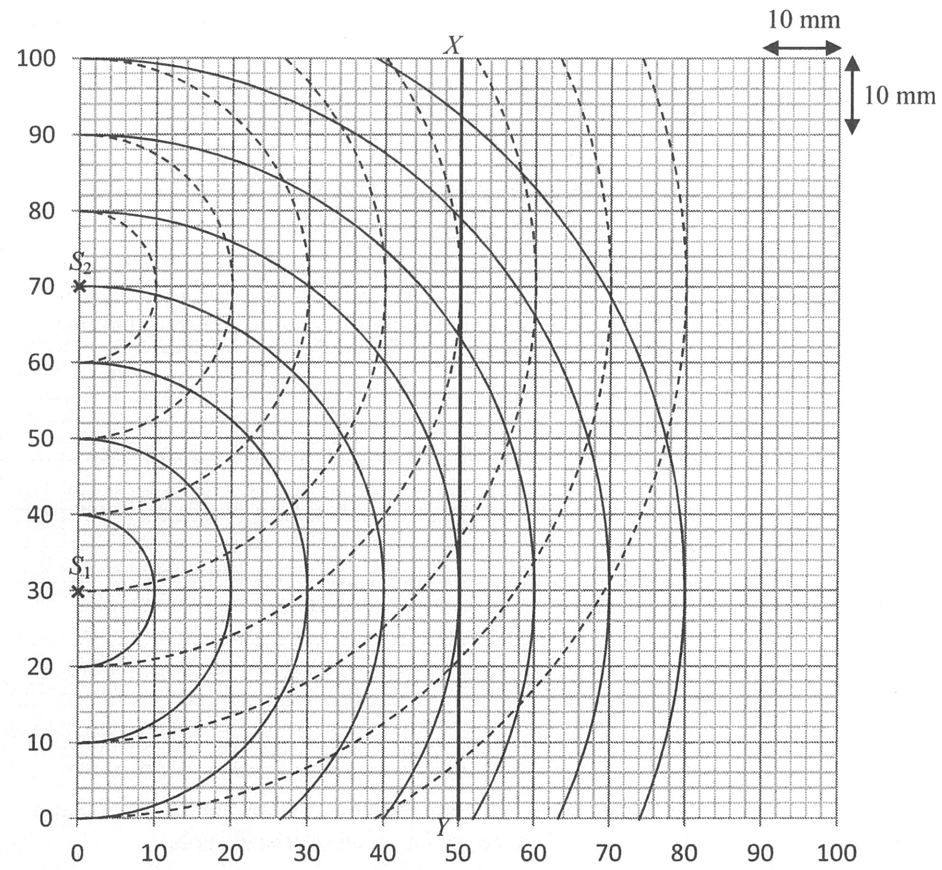
Figure 7.2



Answers written in the margins will not be marked.

Figure 7.3 shows circular water waves in a ripple tank. The two point sources S_1 and S_2, separated by 40 mm, are driven by the same vibrator. The solid lines represent the wave crests from S_1 and the dotted lines represent the wave crests from S_2. The wavelength of the waves is 10 mm.

Figure 7.3



(c) Sketch on Figure 7.3 two lines to indicate all points P with path difference $PS_1 - PS_2$ equals to 10 mm (L_1) and 20 mm (L_2). State the kind of interference that occurs at these points P. (3 marks)

(d) (i) If the interference pattern is observed along line XY at 50 mm from the sources as shown, **measure** the separation between adjacent first- and second-order maxima Δy. (1 mark)

separation Δy = ____________________

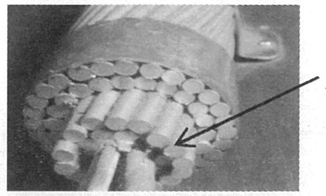
*(ii) However, using the calculation method in (a) would obtain 12.5 mm for this separation. Why does this calculated value differ with the measurement in (d)(i) ? (2 marks)

Answers written in the margins will not be marked.

Go on to the next page

8. Electricity generated from power plants are transmitted at a high voltage through overhead cables in suburban areas.

(a) Each overhead cable consists of 40 strands of identical transmission lines bundled together.



a strand of transmission line of an overhead cable

(i) One single strand of transmission line has a cross-sectional area of 1.3×10^{-5} m^2 and resistivity 2.6×10^{-8} Ω m. Find the resistance per km of a single strand of transmission line. (2 marks)

(ii) Explain why the resistance per km of an overhead cable is much smaller than that of a single strand of transmission line. Estimate the resistance per km of an overhead cable. (2 marks)

(iii) Hence, explain why a bird can stand with both feet on a high-voltage cable without getting an electric shock. (2 marks)

*(b) Electrical power of 180 MW is transmitted at a voltage of 400 kV through an overhead cable.

(i) Calculate the current carried by the overhead cable. (2 marks)

(ii) Show that less than 0.1% of the electrical power is lost after transmitted through a total of 10 km of overhead cable. (2 marks)

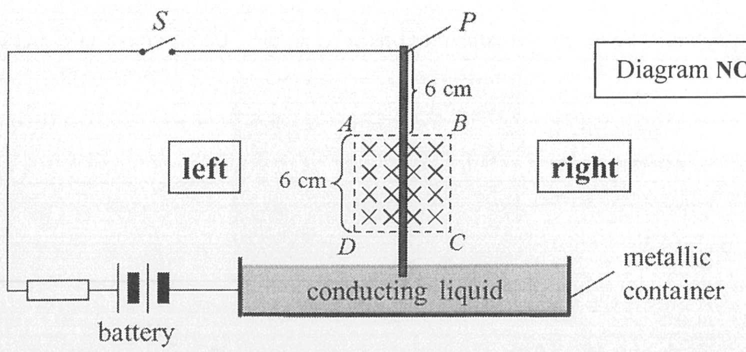
(iii) As the voltage drop across this overhead cable is negligible, a voltage of 400 kV at the cable's end is stepped down by an ideal transformer with turns ratio 12 :1.

(I) Find the secondary voltage from the transformer. (1 mark)

(II) State **ONE** factor leading to energy loss in a practical transformer and suggest the corresponding measure for improvement. (2 marks)

9. Figure 9.1 shows a set-up for demonstrating one of Faraday's discoveries. A light metal rod is free to rotate about point P while its lower end just touches some conducting liquid in a metallic container.

Figure 9.1



A uniform magnetic field pointing into the paper is applied over the region $ABCD$ containing part of the rod. When switch S is closed, the rod 'kicks' out and leaves the liquid surface.

(a) State the direction (to the left / to the right / into the paper / out of the paper) that the rod 'kicks' and describe the subsequent motion of the rod. (3 marks)

(b) When switch S is closed, the initial moment about point P that makes the rod 'kick' out is 7.2×10^{-4} N m. Assume that the magnetic force acts at the midpoint of the part of the rod within the magnetic field.

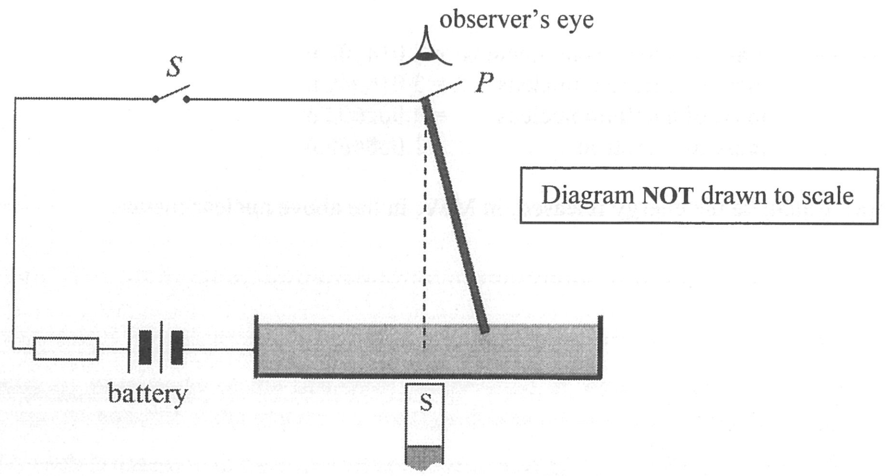
(i) Calculate the magnetic force acting on the rod at that instant. (2 marks)

(ii) Hence, find the strength B of the magnetic field if the current flowing through the rod is 3.2 A when the circuit is closed. (2 marks)

Answers written in the margins will not be marked.

(c) Now the uniform magnetic field is removed and a bar magnet is placed underneath the container as shown in Figure 9.2. The rod is held tilted at an angle to the vertical but with its lower end still in the conducting liquid.

Figure 9.2



(i) Sketch on Figure 9.2 the field lines around the rod due to the bar magnet. (1 mark)

(ii) After closing switch S and the rod is released from rest, describe its subsequent motion viewed from above. (1 mark)

Answers written in the margins will not be marked.

10. Scientists had been experimenting controlled fusion in a nuclear reactor in which deuterium ($^{2}_{1}H$) and tritium ($^{3}_{1}H$) undergo the following nuclear fusion:

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n + \text{energy released}$$

Given: mass of a deuterium nucleus = 2.014102 u
mass of a tritium nucleus = 3.016049 u
mass of a helium nucleus = 4.002602 u
mass of a neutron = 1.008665 u

*(a) Calculate the energy released, in MeV, in the above nuclear fusion. (2 marks)

(b) A deuterium nucleus and a tritium nucleus have to be within 10^{-15} m for nuclear fusion to occur and that a large amount of work done (about 0.4 MeV) is needed to bring two well separated nuclei to such a close distance.

(i) Explain why a large amount of work done is needed and state the kind of energy this work done has become. (2 marks)

Answers written in the margins will not be marked.

In the nuclear reactor, deuterium and tritium exist as plasma, which is a mixture of ions at a very high temperature.

(ii) Explain why a very high temperature is needed for nuclear fusion to occur. (1 mark)

*(iii) Estimate the order of magnitude of the minimum temperature at which fusion of deuterium and tritium nuclei would be possible if the plasma can be regarded as an ideal gas. (Hint: For an ideal gas, the gas molecules each is assumed to have an average kinetic energy $E_K = \frac{3RT}{2N_A}$) (2 marks)

END OF PAPER

Sources of materials used in this paper will be acknowledged in the *Examination Report and Question Papers* published by the Hong Kong Examinations and Assessment Authority at a later stage.

Answers written in the margins will not be marked.