STRICTLY CONFIDENTIAL

99 Common

General Certificate of Education (Adv. Level) Examination, August 1999

Marking Scheme for Physics II

PART A Structured Essay

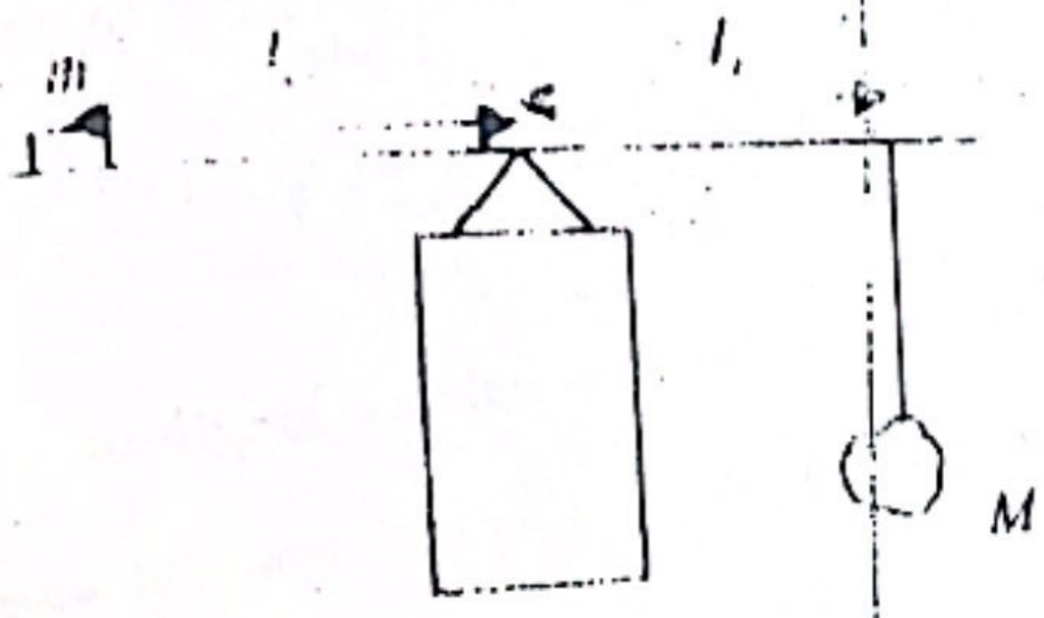
Answer all four questions

(g = 10N kg^{-1})

1. In an experiment to find the density of glass using the principle of moments, you are provided with each of the following;

(1) a piece of glass of irregular shape mass M (~50 g)
(2) four weights of masses one of 10 g, 100 g and 1000 g
(3) a metre ruler
(4) a knife edge fixed to a support
(5) a beaker of water.
(6) a piece of thread

(a) Draw an experimental setup that you would use to find the mass M by balancing the ruler at its centre of gravity. Label the masses and their corresponding distances l_1 and l_2 from the knife edge



01

Award the mark even if the weight is suspended by a piece of thread ,

Disregard the support . l_1 and l_2 labels can be interchanged)

(b) What is the advantage of balancing the meter ruler at its centre of gravity?

Mass of the meter ruler does not appear in calculations (or in equation)

OR Mass of the meter ruler can be disregarded *OR* Only the moments

l_1 and M come into equation 01

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(c) (i) Of the weights given in (2) above, which one is the most suitable for this experiment Give the reason for your choice.

40 g.

To increase the accuracy of length measurements *OR* To obtain large values for lengths *OR* mass of 40 g weight is close to mass M

(ii) Write down an expression for M in terms of m, l_1 and l_2

$$ml_1 = Ml_2 \quad (M = m\frac{l_1}{l_2})$$

OR $ml_1 = Ml_2 \quad (M = m\frac{l_1}{l_2})$ ..... (1)

[When awarding this mark refer to the drawing in (a)]

(d) (i) What are the next experimental steps that you would perform in order to determine density of glass without changing the position of the glass piece?

Immerse the glass piece in water and rebalance the ruler by moving m

(ii) What is the measurement that you would take? (say l_3)

Distance to m from the knife edge *OR* new balance length of m 01

(e) Obtain an expression for the density of glass ρ in terms of density of water ρ_w, l_3 and l_1 (or l_2)

When the ruler is balanced again

$ml_3 = (M - \frac{M}{\rho}\rho_w)l_2$ *OR* $[ml_3 = (M - \frac{M}{\rho}\rho_w)l_1]$ 01

Dividing this equation by the equation given in (c)(ii),

$\rho = \frac{\rho_w}{(1 - \frac{l_3}{l_1})}$ | $\rho = \frac{l_1\rho_w}{l_1 - l_3}$ | *OR*

$\rho = \frac{\rho_w}{(1 - \frac{l_3}{l_2})}$ | $\rho = \frac{l_2\rho_w}{l_2 - l_3}$ |

01

depending on the drawing in (a)

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(i) Mass of another irregular piece of glass made of the same material but with an air cavity inside is 100 g. The density obtained using the above procedure, was found to be 2.0×10^3 kg m^{-3}. If the density of glass is 2.5×10^3 kg m^{-3}, find the volume of the air cavity.

Let V be the volume of glass and V' be the volume of the air cavity, then

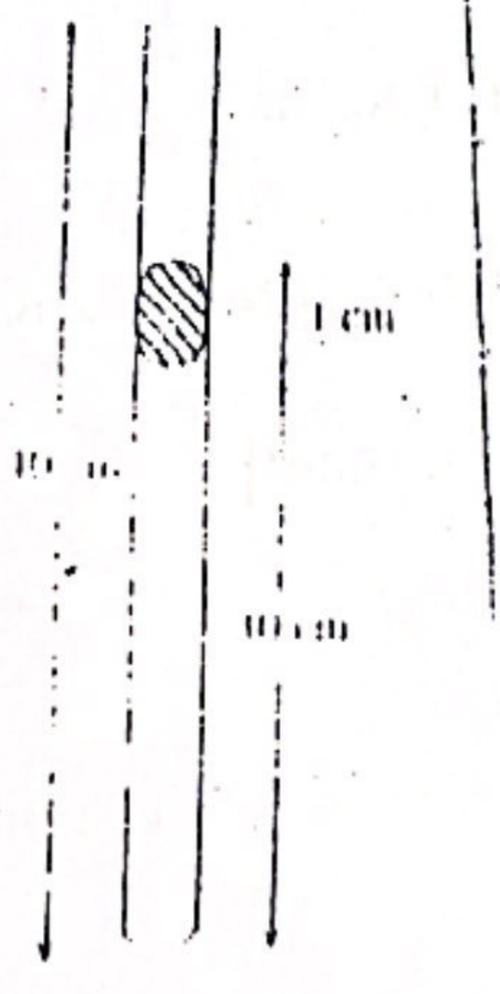
$$V + V' = \frac{100 \times 10^{-3}}{2.0 \times 10^3}$$

$$V = \frac{100 \times 10^{-3}}{2.5 \times 10^3}$$

$$\therefore V' \simeq 100 \times 10^{-3} \left| \frac{1}{2.0 \times 10^3} - \frac{1}{2.5 \times 10^3} \right| \quad \ldots\ldots \quad \ldots\ldots 01$$

10^{-5} m^3 (10 cm^3) 01

A student is given a narrow glass tube closed at one end trapping an air column trapped by a small mercury thread as shown in the figure. The lengths of the air column and mercury thread at room temperature are shown in the figure. Student is asked to measure the variation of the length of the air column (l) with the temperature (θ) when the tube is held vertically.



(i) Suppose three separate water baths of height 10 cm, 30 cm and 50 cm are available in the laboratory. Which bath is most suitable for this experiment?

50 cm height bath 01

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(b) In order to ensure that the measured temperature of the water is the temperature of the mi
what experimental procedure should he follow?

Stir continuously and increase the temperature very slowly.

OR Stir continuously and raise the temperature by a few degrees above the required temperature, and allow to cool to the required temperature *OR* Remove the burner and stir well and allow to cool to the required temperature

(c) As the temperature is increased mercury thread will also expand. Can the student assum
the pressure of the air column remains constant? Explain your answer

Yes, the <u>mass of mercury remains constant</u> and pressure exerted by mercury thread remains constant

OR the <u>density of mercury will decrease</u> and pressure exerted by mercury thread ($h\rho g$) remains unchanged.

[Therefore the total pressure, atmospheric plus pressure due to the mercury thread remains constant]

5.(b)

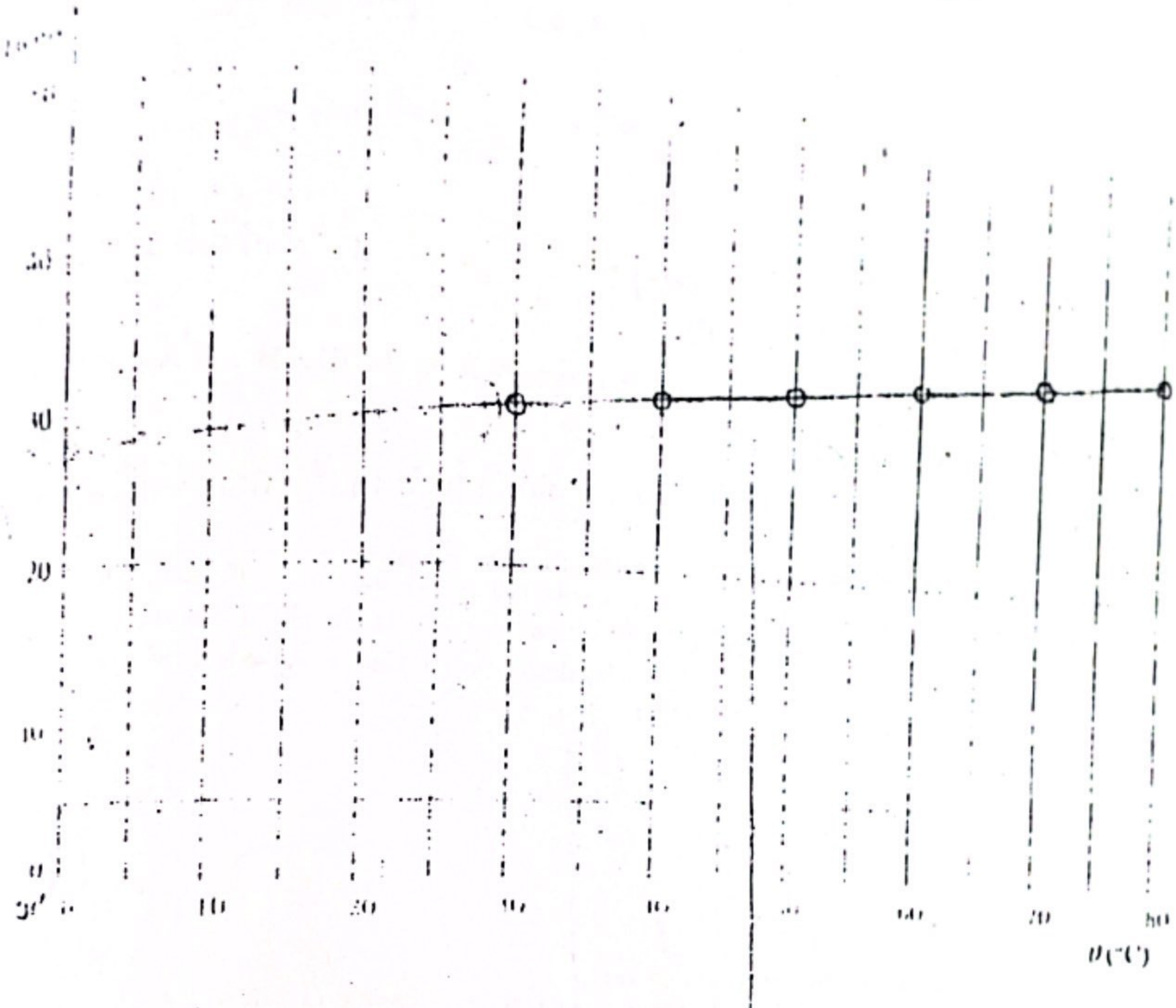
6.(b)

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The following data were obtained by the student for θ and l

θ (°)	10	40	50	60	70	80
l (cm)	10	11	12	11	14	15

(a) Plot the graph l vs. θ selecting 0 °C and 0 cm as the origin



Drawing the graph correctly ..... .01

[Do not award this mark if the student has connected (.30,.30) point to (0,0)]

[To earn this mark the student does not have to extrapolate the line up to the l axis]

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PHY

vdw

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You are to trace the passage of a light ray through a semicircular glass block and find a value for the refractive index, (n_g) of the glass. The block is kept on a sheet of white paper and two pins P_1 and P_2 are placed vertically along the line OA as shown in the figure. Here O is the centre of the straight edge of the block.



(a) Give the experimental steps needed to trace the passage of the light ray AO through the block using two other pins.

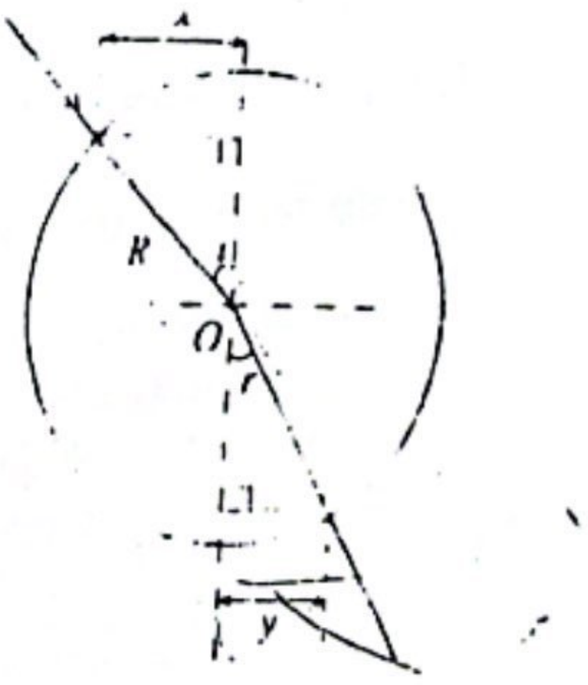
Observe the images of the pins through the curved surface and place the other pins in line [or along the same straight line)] with (the images of) pins P_1 and P_2

01

Remove the block and connect the positions of the two other pins to point O.

(No mark for saying that the other pins are placed in coincidence with the images of P_1 and P_2).

(b) Once the refracted ray is traced-out, a circle of radius R is drawn as shown in the diagram with O as the centre and the distances x and y are measured.



(i) Write down sin i in terms of x and R

$\sin i = \frac{x}{R}$

.....01

(ii) Hence find an expression for n_g in terms of x and y

$n_g = \frac{\sin i}{\sin r}$

$n_g = \frac{x}{y}$

01

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Q4(

(a) What is the purpose of having resistors connected in series with the potentiometer wire AB?

To achieve a small potential drop across the potentiometer wire. *OR*

To increase the sensitivity *OR* To obtain a measurable balance length. 01

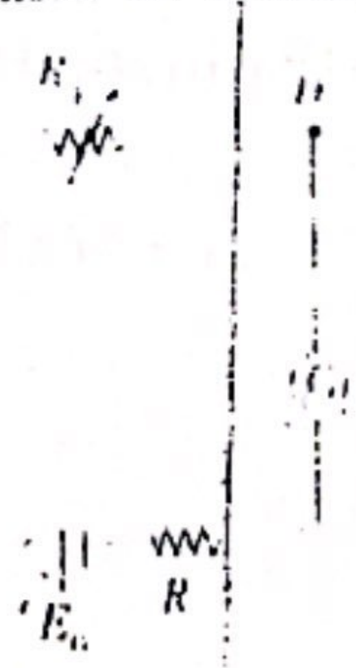
(b) It is desired to have a potential drop of 4 mV across the potentiometer wire AB. If the potentiometer wire has a resistance of 10 Ω what should be the total value of the resistance R_1 and R_2?

Current through the potentiometer wire $\frac{4\times10^{-3}}{10}$ *or* $\frac{4}{10}$ 01

The total resistance of R_1 and R_2 $\frac{12-(4\times10^{-3}/10)}{(4\times10^{-3}/10)} = \frac{1\cdot996}{4\times10^{-4}} = \frac{19960}{4}$

4990 Ω 01

(c) To find the current I in the potentiometer circuit experimentally, a standard cell of emf E_0 a high resistance R and a galvanometer are connected across R_1 as shown in the figure.



(i) What is the purpose of having R other than protecting the galvanometer?

To protect the standard cell *OR* To avoid drawing large currents from the standard cell 01

(ii) What should be the value of R when the appropriate measurement is taken?

Zero (0) 01

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(iii) What procedure should be adopted to obtain I ensuring that the potential drop across AB is maintained at 4 mV? 11

Adjust R_1 while keeping R_1+R_2 constant until a balance point is observed (or until no current flows through the galvanometer) 01

(iv) Write down an expression for the current I in terms of R_1 and ε_0

$I = \frac{\varepsilon_0}{R_1}$ 01

(d) If the total length of the potentiometer wire is 600 cm, write down an expression for the potential drop per unit length k, in terms of I.

$k = \frac{\varepsilon_0}{600} = \frac{I}{60}$ 01

(e) How would you determine the emf of the thermocouple at a given temperature?

Obtain the corresponding balance length (l) and calculate the e m f

using e.m.f $E = kl$ 01

(f) Give a specific advantage of using a thermocouple for measuring temperature

(1) To measure temperatures at different points (e g flame)

(2) To measure temperature of a small quantity (e g small quantity of liquid)

(3) To measure high temperatures

(4) To measure rapidly varying temperatures

(5) To measure temperatures on surfaces

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(6) To measure temperatures at unreachable places where other thermometers are unable to use

(7) It has a low heat capacity

(8) It can be easily constructed in the laboratory.

(9) It responds quickly.

Any one of the above or any other correct advantage

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PART B — Essay

(Section 10N kp h)

1. Read the following passage carefully, and answer the questions given below.

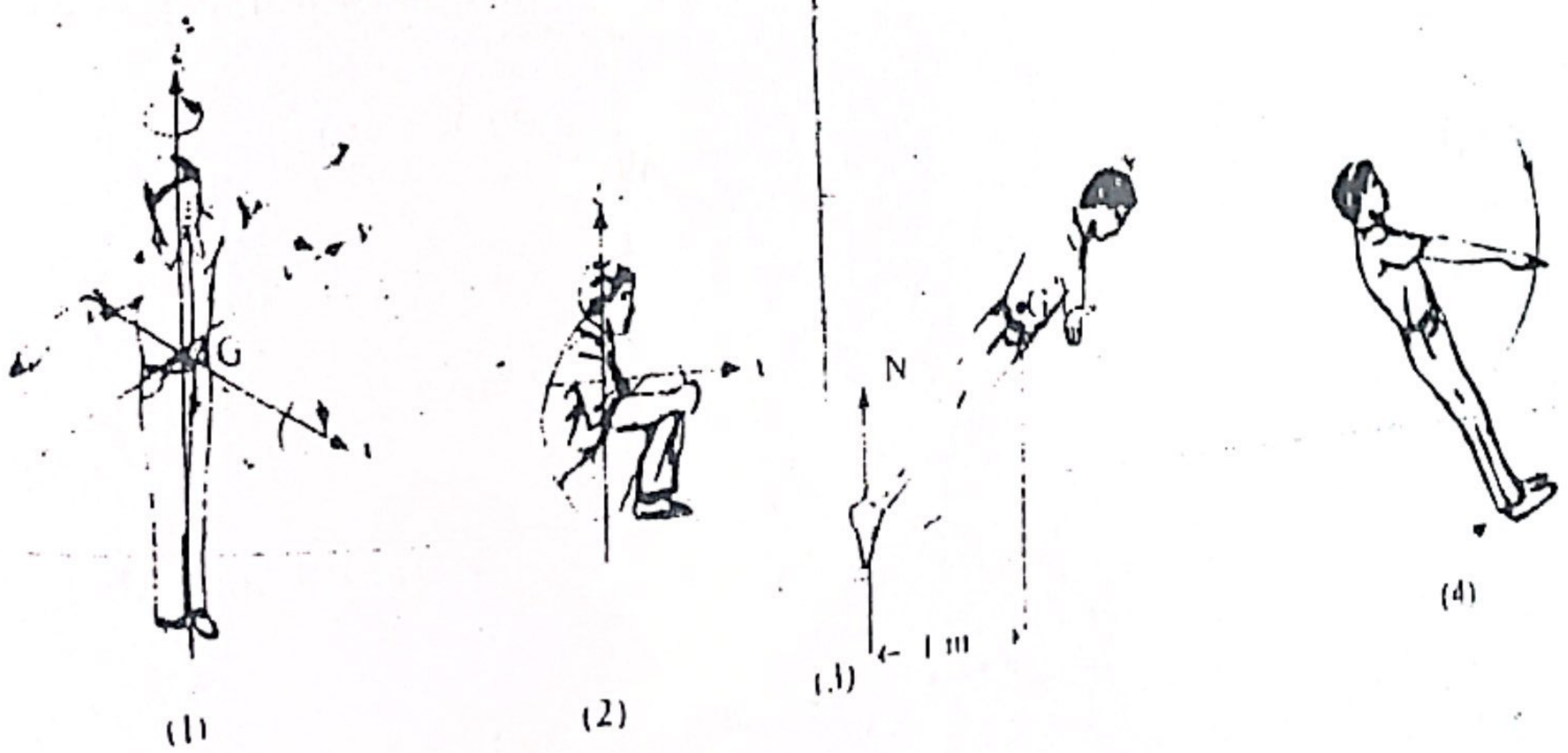
Divers, acrobats, and ballet dancers perform many graceful rotational movements. All these movements can be explained in terms of the physical concepts related to rotational motion.

The rotation of a human body can be related to three mutually perpendicular axes which pass through the centre of gravity (G) as shown in Fig. (1). Rotation about the x axis is called a somersault, about the z axis it is a twist, and about the y axis it is a turntable motion. While performing the twist the body rotates in the plane xy.

The moments of inertia (I) about these axes depend on the positions of the arms and legs. In general I_x is smaller than I_y or I_z. For an average person standing as depicted in Fig. (1), the values are I_x = 1.1 kg m^2, I_y = 10.2 kg m^2 and I_z = 10.0 kg m^2. In the "tuck" position shown in Fig. (2), the values are I_x = 1.0 kg m^2 and $I_y = I_z$ = 4.5 kg m^2.

The most simple way a diver can acquire a somersault motion; or take off is by using a diving board. Fig. (3) shows how the person can acquire angular momentum about the axis y. He merely leans forward as he jumps. The normal reaction R due to the board produces a torque about his centre of gravity.

Now consider how a person acquires a somersault motion while he is in free fall. The body is held rigid and the raised arms are brought rapidly forward in a "arm swing" motion as in Fig. (4). As the arms are brought down, the body will rotate in the opposite sense. The axis of rotation is at the shoulders. The somersault will continue as long as the arms perform the "arm swing" motion. However, the rotation of the body is slow compared to the rotation of arms.



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(ii) Name the plane of rotation of the person in Fig. (1) when he performs a somersault

.... Mass of an object measures the inertia for linear motion. What does the moment of inertia of a [illegible] about a given axis measure?

(iii) How can a person change his moment of inertia about a given axis on his own?

(iv) For the person shown in Fig (1), I_z is smaller than I_x or I_y. What is the reason for this?

(v) The person shown in Fig (1), makes a somersault with angular velocity 2·0 rad s^{-1}. While in rotation he changes to the position shown in Fig (2).

(a) Calculate the new angular velocity of the person

(b) Calculate the change in rotational K.E. of the person

(c) How do you account for this change?

(vi) If the mass of the person is 60 kg determine his initial angular acceleration about his centre of gravity when he takes off the board as in Fig (1)

(vii) When the arms are swinging rapidly as in Fig. (4), what is the reason for the slow rotation of the body

(viii) Is the angular momentum of the person in Fig. (4) conserved about axes going through his shoulders? Give reasons for your answer

(ix) We use the 'arm swing' technique instinctively when we are about to slip on a wet floor. If our feet start to slip forward, a rapid arm swing motion opposite to that in Fig (4) is executed. Briefly explain the [illegible]

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(i) Plane xz *OR* zx 01

(ii) Inertia for rotational motion *OR* rotational inertia *OR* resistance to angular motion *OR* resistance to change angular velocity (or acceleration) 01

(iii) By moving his arms and/or legs *OR* by changing the positions of his arms and/or legs. 01

(iv) Mass distribution (or spread) is closer to z-axis compared to x and y axes *OR* mass distribution (or spread) is away from x and y axes compared to z 01

{No mark for mass} is closer to z-axis or away from x and y axes}

(v) (a) Conservation of angular momentum idea *OR* $I\omega = const$ *OR* $I_1\omega_1 = I_2\omega_2$ *OR*

$10 \cdot ? = 4\omega$

$\omega = 8 rad\ s^{-1}$ 01

(b) Rotational kinetic energy $\frac{1}{2} I\omega^2$ 01

Change in rotational kinetic energy $\frac{1}{2} \times 4 \times 8^2 - \frac{1}{2} \times 10 \times ?^2$ 01

$= 96 J$ 01

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The person has to exert some muscular effort and perform work (or exert energy) *OR* Internal forces within the person do work *OR* Internal work is done *OR* The person must exert a force to counterbalance the centrifugal force and hence perform work (or exert energy) 01

(vi) $N = 60 \times 10 = 600\,\text{N}$ 01

Applying

$$\tau = I\alpha$$

OR

$600 \times 1 = 16\alpha$ 01

$\alpha = 37.5\,(rad\,s^{-2})$ 01

(vii) The moment of inertia of the body about an axis through the shoulders is large compared to that of arms. 01

(viii) No.

There exists an external torque about the axis of rotation due to the moment of the weight *OR* The weight of the person does not pass through the axis of rotation *OR* The net external torque about the axis of rotation is not zero. 01

(ix) It produces a counter-torque on the body which helps to restore balance *OR* It produces a torque opposite to the direction of slipping and helps to maintain the balance. 01

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2. A resonance tube of variable length closed at one end is made to resonate with a tuning fork of frequency 512 Hz. It was observed that the shortest length of the tube at which resonance occurred was 16.6 cm. As the length of the tube was increased, resonance occurred for the second time at 50.7 cm. The temperature in the laboratory was observed to be 27 °C.

(i) Draw the standing wave patterns in the resonance tube for the two situations above

(ii) Find the end correction of the tube and the velocity of sound under the experimental conditions.

(iii) If the density of air at S.T.P. is 1.2 kg m^{-3}, calculate a value for γ the ratio of principal specific heat capacities of air. Assume that the air behaves as an ideal gas.
(Standard atmospheric pressure $= 1.0 \times 10^5$ N m^{-2})

(iv) For a gas explain why the specific heat capacity at constant pressure (C_p) is greater than that at constant volume (C_v).

(i)



.....01



.....01

(ii) Let V and e be the velocity of sound and the end correction of the tube respectively.

Then at fundamental note,

.....01

$$16.6 + e = \frac{\lambda}{4} \quad \text{.....}$$

At first overtone,

01

$$50.7 + e = \frac{3\lambda}{4} \quad \text{.....}$$

Where λ is the wavelength of the sound waves

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But, $V = n\lambda$ 01

$$\therefore \quad 16.6 + e = \frac{V}{512 \times 4} \text{ ----------(1)}$$

$$50.7 + e = \frac{3V}{512 \times 4} \text{ ----------(2)}$$

01

$V = 349.2$ (*or* 349) m s^{-1} 01

By substituting V in (1) or (2)

$e = 0.45$ (*or* 0.44) cm 01

01

Where T is the absolute temperature of air.

Let V' be the velocity of sound at 273 K, then

V' $\sqrt{273}$

349.2(349) $\sqrt{300}$

$V' = 333.1$ (*or* 332.9) m s^{-1}

01

Now V'(*or* V) $\sqrt{\frac{\gamma P}{\rho}}$ 01

$\gamma = \frac{V'^2 \rho}{P} = \frac{(333.1)^2 \times 1.2}{1.0 \times 10^5}$ 01

(for substitution)

01

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For a gas, when the temperature is increased by one degree under constant pressure some work is done by the gas,

.....

.....01

whereas no work is done in the same process under constant volume.

.....

.....01

OR when heat is added to a gas at constant volume all the heat is used to increase the internal energy of the gas.

Therefore In the first case an additional amount of heat should be supplied to compensate for the work done by the gas.

.....

Hence; c_p becomes greater than c_v. 01

3. Write down an expression for the capacitance C of a parallel plate capacitor filled with a material of dielectric constant k. Identify the symbols used.

A dielectric slab of thickness 3 mm, and of dielectric constant 4 is placed between the plates of a parallel plate capacitor. The plates of the capacitor are square in shape,



each of area $0{\cdot}2 \times 0{\cdot}2$ m^2 and their separation is 3 mm. The slab covers $\frac{3}{4}$ of the plate area of the capacitor as shown in the figure. Find the capacitance of the system.

When a potential difference of 1 kV is established between the plates by connecting a battery across them, it was observed that the slab moved a distance of 1 mm during a short time interval.

(i) What would be the increase in capacitance and increase in energy stored in the capacitor due to the movment of the slab?

(ii) By taking this increase in energy to be equal to the work done on the slab, calculate the force exerted on the slab. Assume that the force on the slab remains constant during the short time interval mentioned above.

(iii) Find the energy supplied by the battery during the same time interval. $\left(\varepsilon_0 = 9 \times 10^{-12}\ \text{F m}^{-1}\right)$

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$\frac{k\varepsilon_0 A}{d}$ 01

permittivity in free space
A plate area
d plate separation
} (for all three) 01

Capacitance (C_1) due to the area covered by the dielectric

$C_1 = \frac{4 \times 9 \times 10^{-12} \times 0.2 \times 0.2 \times 1.4}{1 \times 10^{-3}}$ 01

(for substitution)

$= 3.6 \times 10^{-10}$ F 01

Capacitance (C_2) due to the area without the dielectric

$C_2 = \frac{9 \times 10^{-12} \times 0.2 \times 0.2 \times 1}{1 \times 10^{-3}}$ 01

(for substitution)

$= 0.3 \times 10^{-10}$ F

The total capacitance $C_1 + C_2$ 01

(for the addition)

$(3.9 \times 10^{-10}$ F for $(3.6 + 0.3) \times 10^{-10}$ F) 02 01

(i) Change in the capacitance (ΔC) due to the movement of the slab

$\Delta C = \frac{4 \times 9 \times 10^{-12} \times 0.2 \times 1 \times 10^{-3}}{3 \times 10^{-3}} - \frac{9 \times 10^{-12} \times 0.2 \times 1 \times 10^{-3}}{3 \times 10^{-3}}$ 02

(01 mark for each term ; 01 mark for subtraction)

$= 1.8 \times 10^{-11}$ F .....

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A soap film is formed on a wire frame. A loop made with an elastic string of unstretched length 10 cm is kept on the surface of the film and the film inside the loop is broken. The cross-sectional area of the string is $1{\cdot}25 \times 10^{-9}$ m^2 and the Young's modulus of the material of the string is $7{\cdot}0 \times 10^{6}$ N m^{-2}. Surface tension of the soap solution is $2{\cdot}5 \times 10^{-2}$ N m^{-1}.

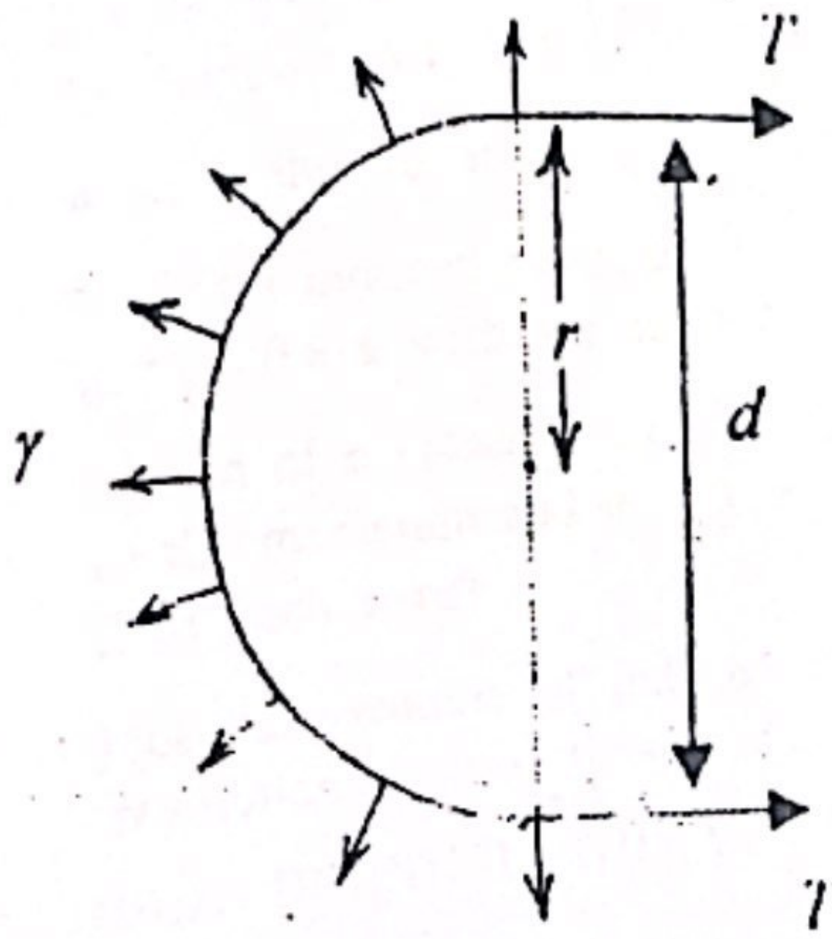
(i) Calculate the diameter of the loop.

(ii) What is the change in surface energy of the film?

(iii) Calculate the energy stored in the string.

(iv) If one half of the length of the string was made with an inextensible string, draw the shape of the loop when the film inside is broken.

(i)



Consider one half of the loop as shown above. Let T be the tension in the string, then

$2T = \gamma 2r$ 2

OR

$T = 2\gamma r$ (or $= 2 \cdot 2.5 \times 10^{-2} r$) 02

OR $T = \gamma d$ (or $= 2.5 \times 10^{-2} d$)

where γ is the surface tension of the soap solution. 01

Applying $Y = \frac{F}{A}\frac{L}{e}$ .....

$7 \times 10^{6} = \frac{T}{1.25 \times 10^{-9} \times (\pi \cdot 0.05)}$ [or $1.25 \times 10^{-9} \cdot (\pi \frac{d}{2} \cdot 0.05)$] 02

OR

$7 \times 10^{6} = \frac{T}{1.25 \cdot 10^{-9} \cdot (2\pi \cdot 0.1)}$ [or $1.25 \times 10^{-9} \cdot (\pi \cdot 0.1)$]

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Substituting for I

$$7\times10^{6} = \frac{2\times2.5\times10^{-2}\times r}{1.25\times10^{-9}\times(\pi r^{2}-0.05)}$$

$$8.75(\pi r^{2}-0.05) = 2r$$

$$r(8.75\pi r - 2.5) = 8.75\times0.05$$

$$25r = 8.75\times0.05$$

$$r = 0.0175 \text{ m}$$

$\therefore$ the diameter of the loop = 3.5 cm (or 0.035 m) 02

(ii) Change in the surface area of the film $= 2\pi r^{2}$ 01

$\therefore$ Change in surface energy of the film $= \gamma \times 2\pi r^{2}$

$$= 2.5\times10^{-2}\times2\times\frac{22}{7}\times(0.0175)^{2} \quad \text{..... 01}$$

$$= 4.8\times10^{-4} \text{ J} \quad \text{..... 01}$$

$$[(4.7 - 4.9)\times10^{-4} J]$$

(iii) Energy stored in the string $= \frac{1}{2}Le$ 01

The circumference of the loop $= 2\pi r = 2\times\frac{22}{7}\times1.75 = 11$ cm

$\therefore$ increase in length $= (11-10) = 1$ cm (or 0.01 m) 01

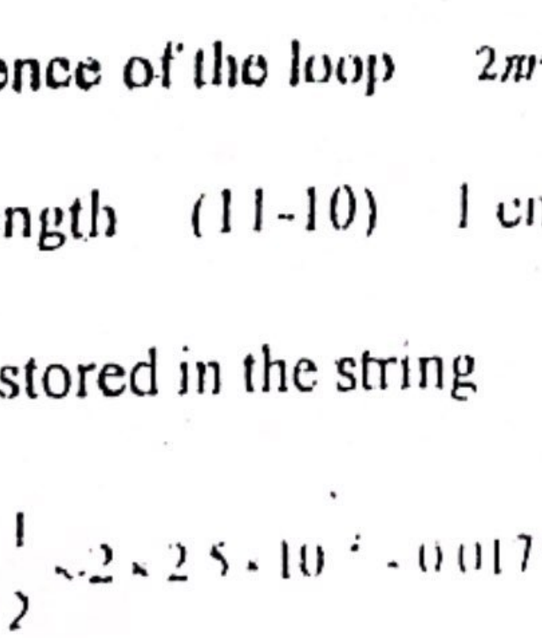
Hence, energy stored in the string

$$= \frac{1}{2}\times2.5\times10^{-2}\times0.0175\times0.01 \quad \text{..... 01}$$

$$= 4.4\times10^{-6} \text{ J} \quad \text{..... 01}$$

$$[(4.3 - 4.5)\times10^{-6} J]$$

iv)

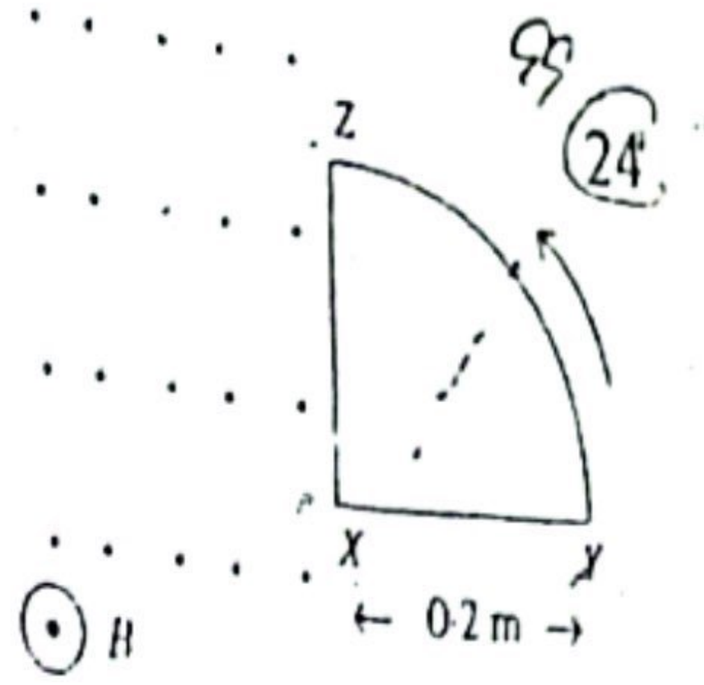


01

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Answer either part (a) or part (b).

(a) A flat loop of wire XYZ in the form of a quarter of a circle of radius 0·2 m rotates uniformly about the point X in the plane of the paper. The sense of rotation is given by the arrow. The loop passes in and out of a region of uniform magnetic field of flux density (B) 0·5 T as shown, making one complete revolution in 0·8 seconds.



(i) What is the maximum magnetic flux through the loop during its rotation?

(ii) Plot with relevant values, the variation of magnetic flux through the loop with time t during one complete revolution, assuming that the loop is at the position indicated in the diagram at t = 0.

(iii) What is the maximum magnitude of the induced e.m.f. generated in the loop?

(iv) Draw the induced e.m.f. in the loop, with relevant values, as a function of time on a time scale of 0 – 0·8 s with the same assumption for t = 0 as in (ii).

(v) Instead of a closed loop, if only the two conducting wires XY and XZ are present, what will be the maximum and minimum values of the induced e.m.f. across the ends X and Y or, X and Z of each wire?

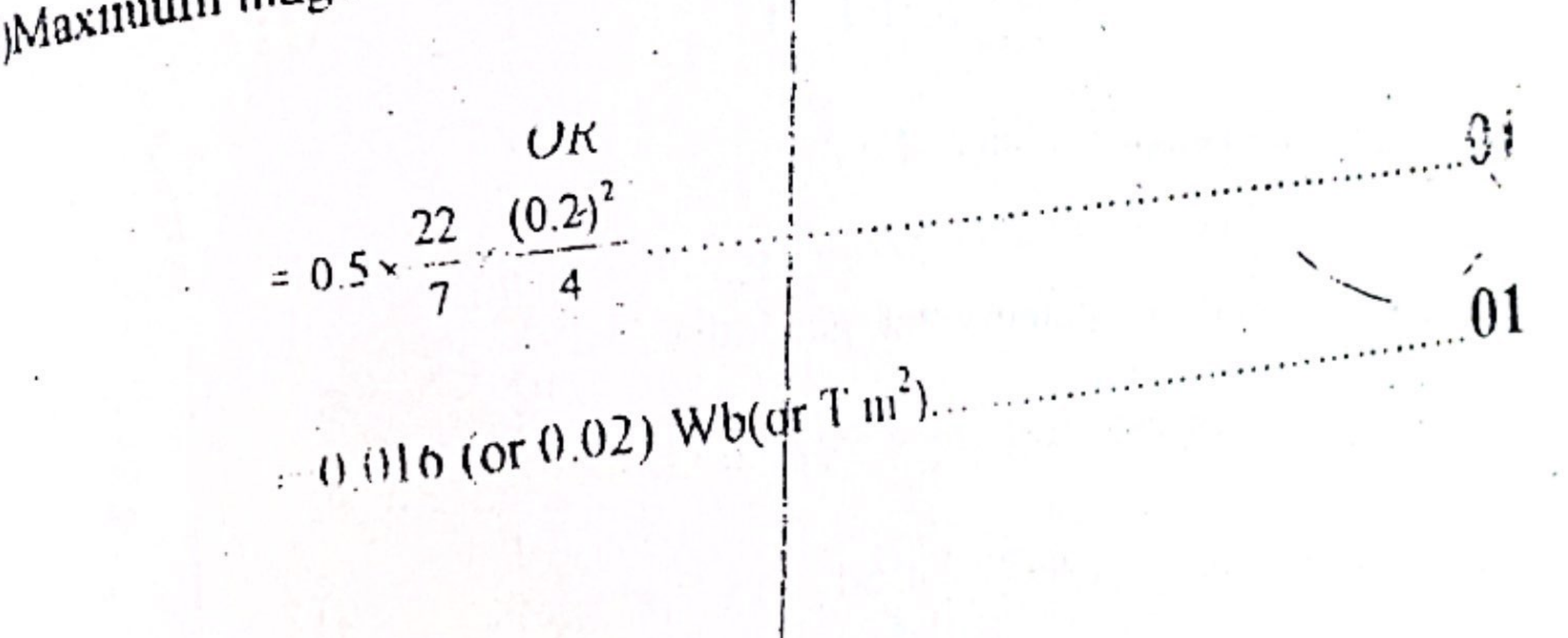
(vi) Plot the variation of induced e.m.f. across one wire as a function of time for one complete revolution.

(i) Maximum magnetic flux through the coil $= B\dfrac{\pi R^2}{4}$

$= 0.5 \times \dfrac{22}{7} \times \dfrac{(0.2)^2}{4}$ 01

$= 0.016$ (or 0.02) Wb (or T m^2) 01

(ii)



Correct time scale 01

Whole graph correct 02

(Any two parts correct ..... 01)

(Disregard the Φ value in the Y-axis)

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Q9 (25)

(iii)e.m.f. generated $\frac{d\Phi}{dt}$

Magnitude of the maximum e.m.f. generated = gradient of the straight line drawn from t = 0 to t = 0.2 s of the above graph

$= \frac{0.016}{0.2}$ or $\frac{0.02}{0.2}$ **01**

$= 0.08\ V$ or $0.1\ V$ **01**

Alternative Method 1

Magnitude of the maximum e.m.f. generated $= \frac{1}{2}BR^2\omega$

OR

$= \frac{1}{2} \times 0.5 \times (0.2)^2 \times 2 \times \frac{22}{7} \times \frac{1}{0.8}$ **01**

$= 0.08\ V$ (or $0.1\ V$) **01**

Alternative Method 2:

Magnitude of the maximum e.m.f. generated $= \frac{B\pi R^2}{0.8}$

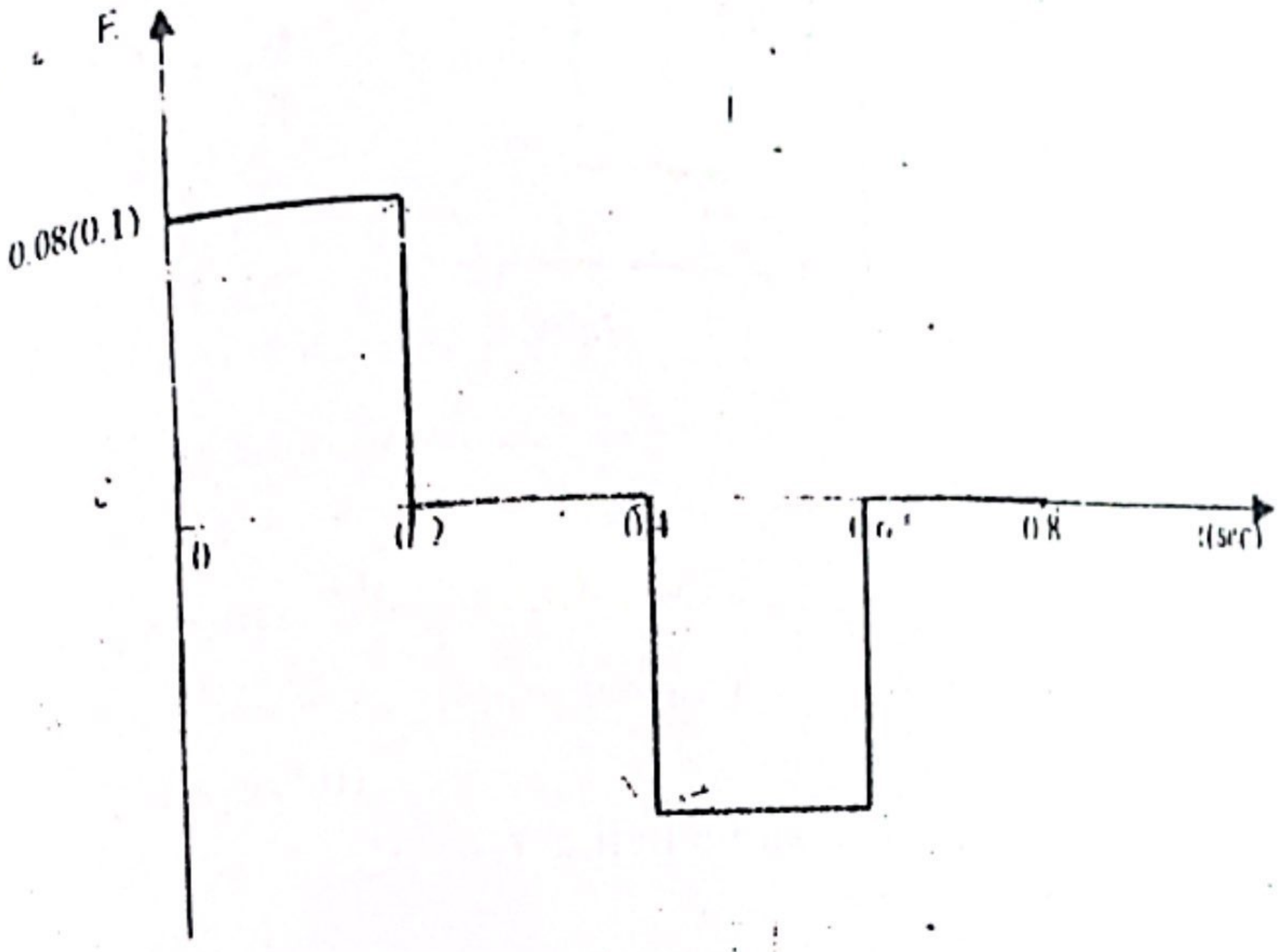
OR

$= 0.5 \times \frac{22 \times (0.2)^2}{7 \times 0.8}$ **01**

$0.08\ V$ (or $0.1\ V$) **01**

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(iv)



Correct time scale 01

Correct full cycle 02

(Correct half cycle ..... 01)

(Disregard the F value in the Y axis)

{Do not look for the vertical lines in the above graph when awarding marks}

The signs of the induced e.m.f. s can be interchanged}

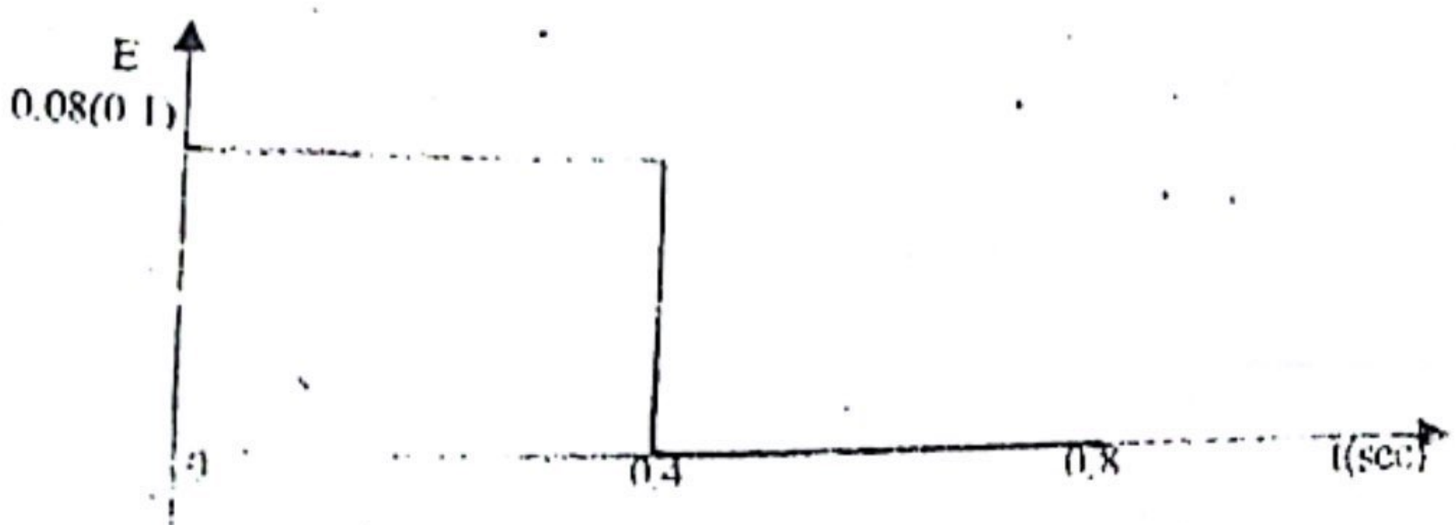
(v)Induced e.m.f. across each rod is the same as that calculated in (iii) 01

∴maximum e.m.f. generated = 0.08 V (or 0.1 V)..... 01
(when rods are in field region)

minimum e m.f. generated = 0
(when rods are not in field region)

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(vi)



Correct time scale 01

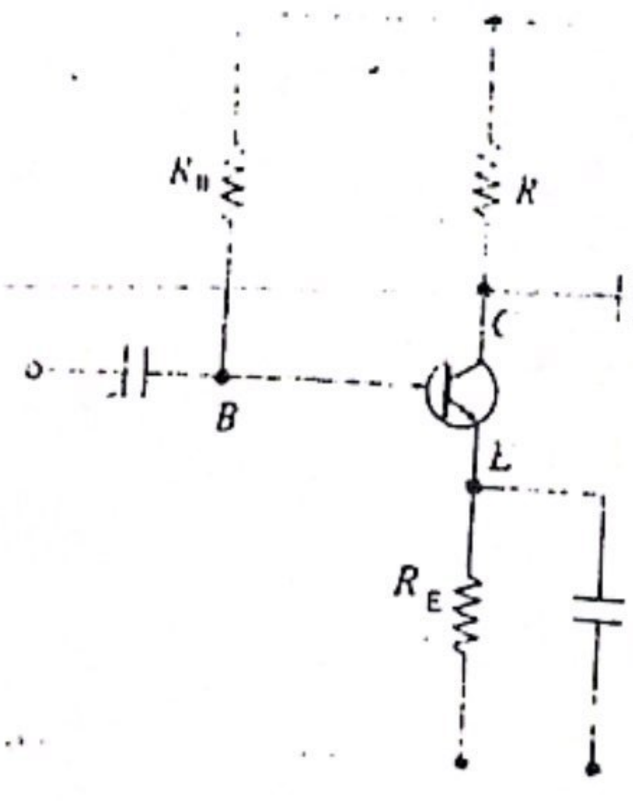
Correct graph 02

(0) or zero)

(Disregard the E value in the Y-axis)

(b) With the aid of a clear labelled diagram show the structure of a junction transistor

What are the configurations in which a transistor can be used in electronic circuits? Illustrate these configurations with simple circuits. Which of these is commonly used in amplifier circuits? Give the reasons for this.



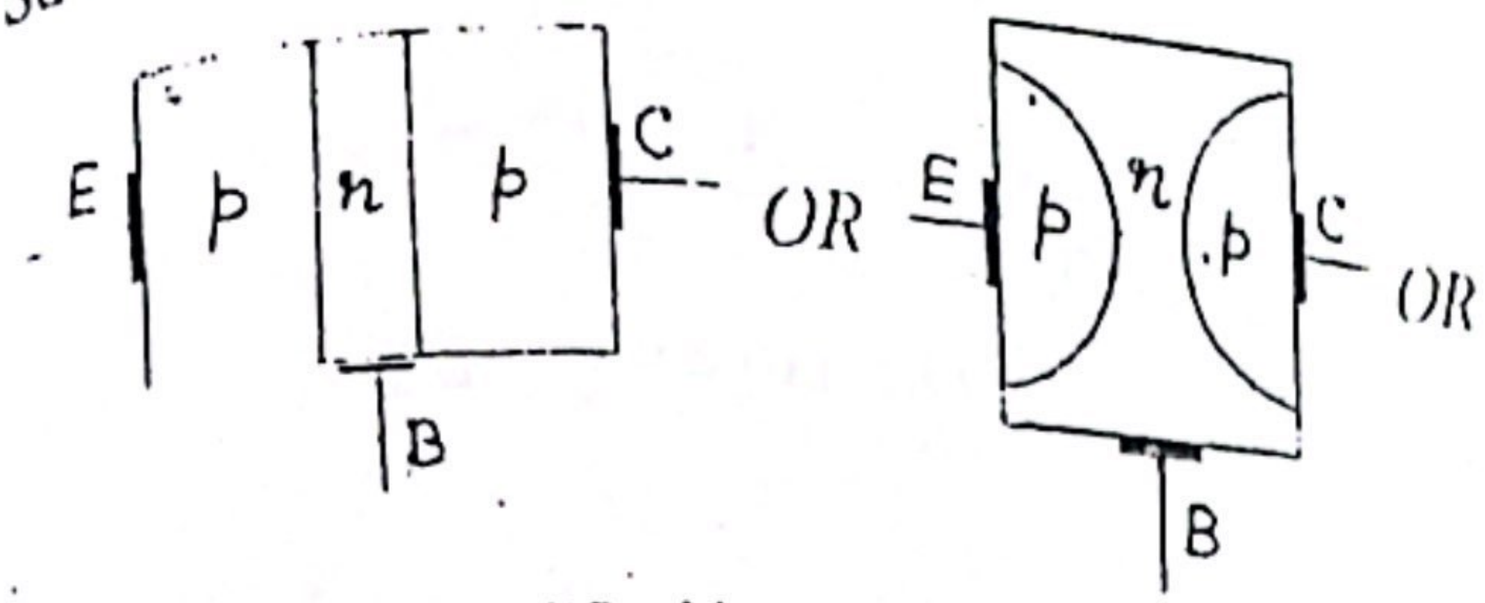
In the amplifier circuit shown it is desired to have $I_C = 2.0$ mA, $V_{CE} = 6$ V and $V_E = 1.2$ V. If $\beta = 100$ and $V_{BE} = 0.6$ V find suitable values for R_E, R_C and R_B. Write down the values of V_{in} and V_E.

If a small sinusoidal voltage is connected to the input of the amplifier sketch the input and output voltages on the same time scale.

Usually V_{CE} is kept at $\frac{V_{cc}}{2}$. Explain the reason for this.

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Structure of a transistor :



(*OR* with npn labels)

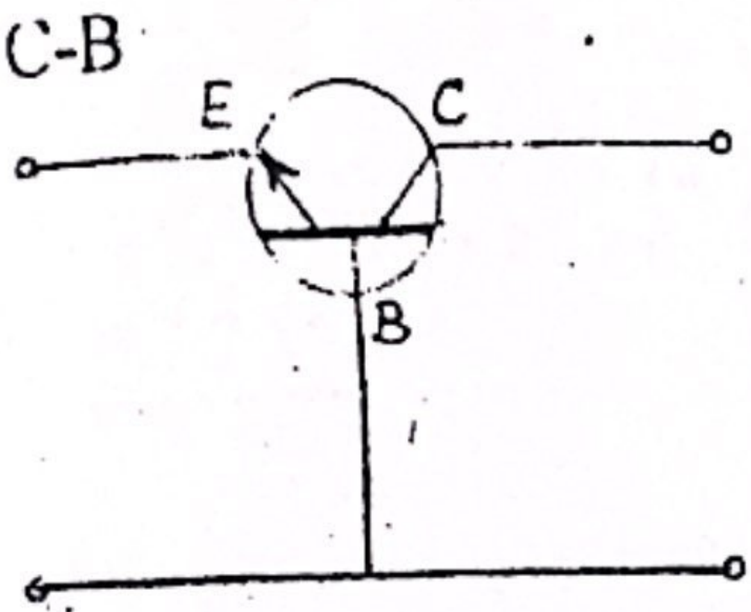
Three different configurations: 01

(1) Common base
(2) Common emitter
(3) Common collector

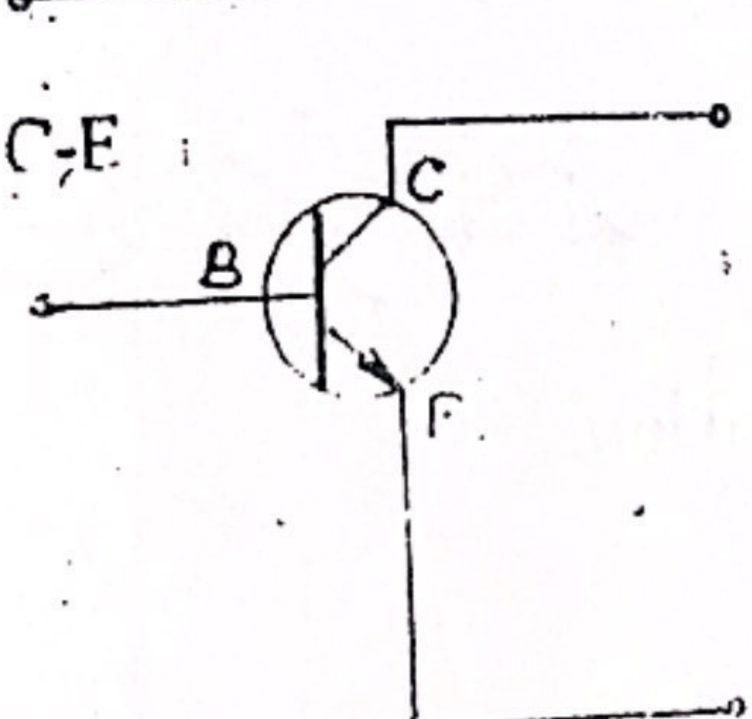
} (all three) 01

npn transistor

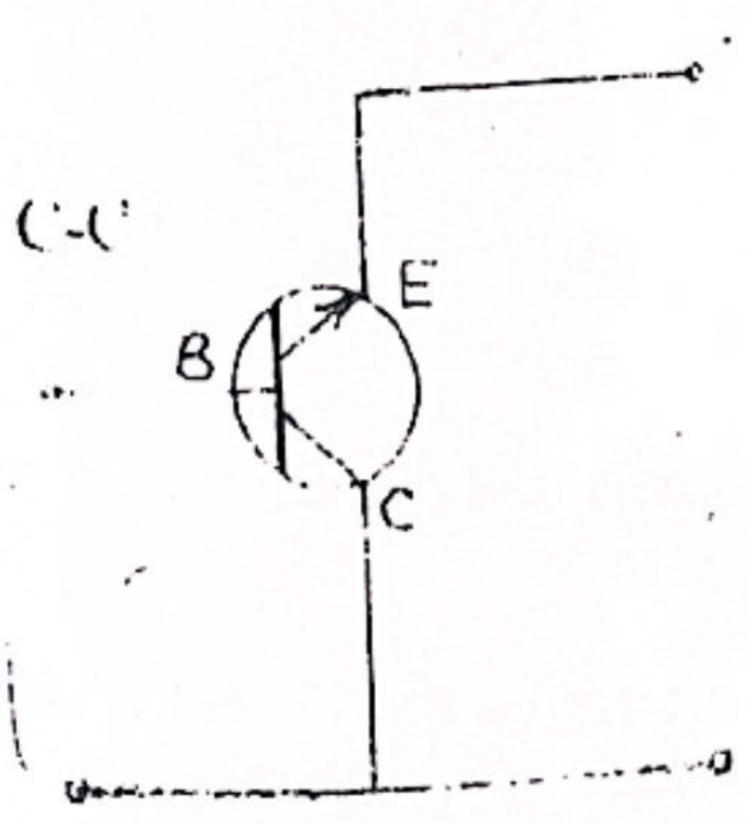
C-B



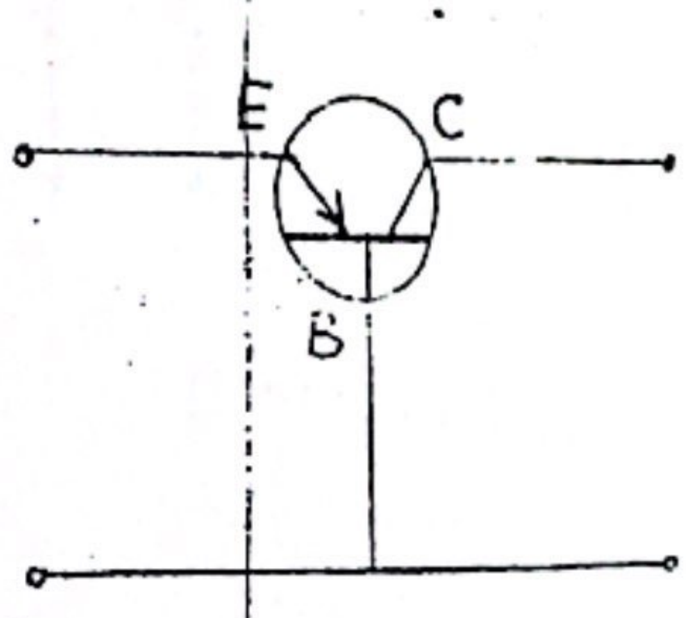
C-E

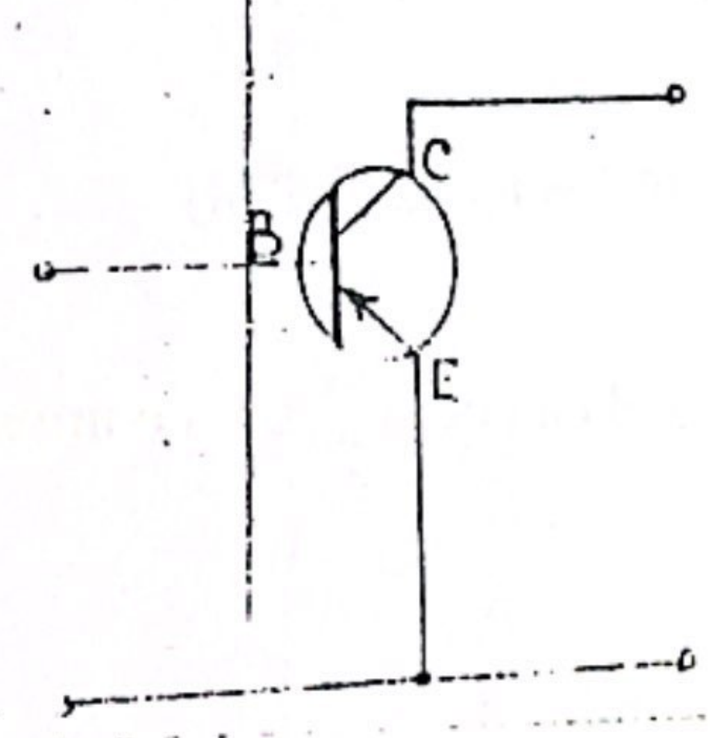


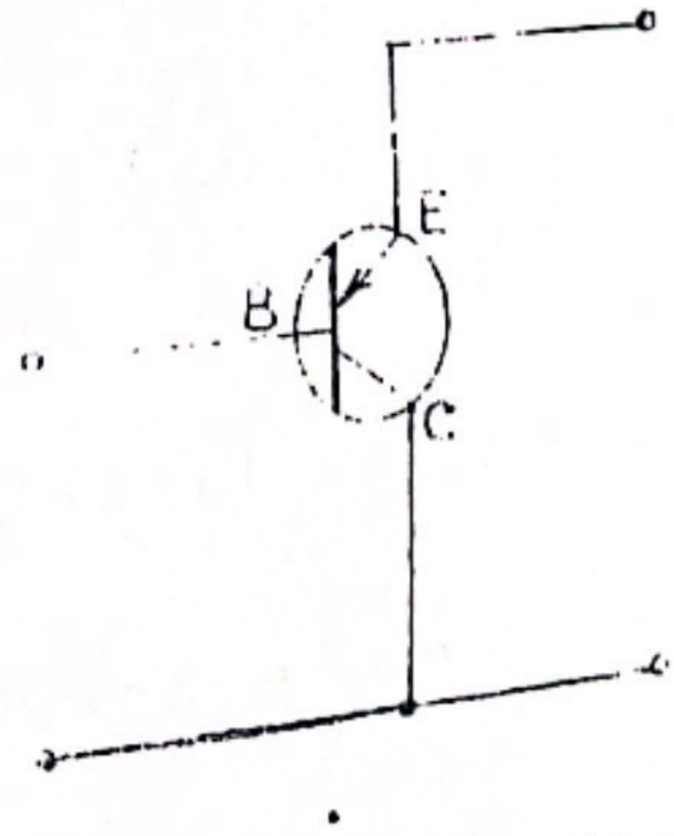
C-C



pnp transistor







All Three 02

(Any two 01 mark)

Disregard biasing of the transistor and resistors connected to each circuit. Look only for

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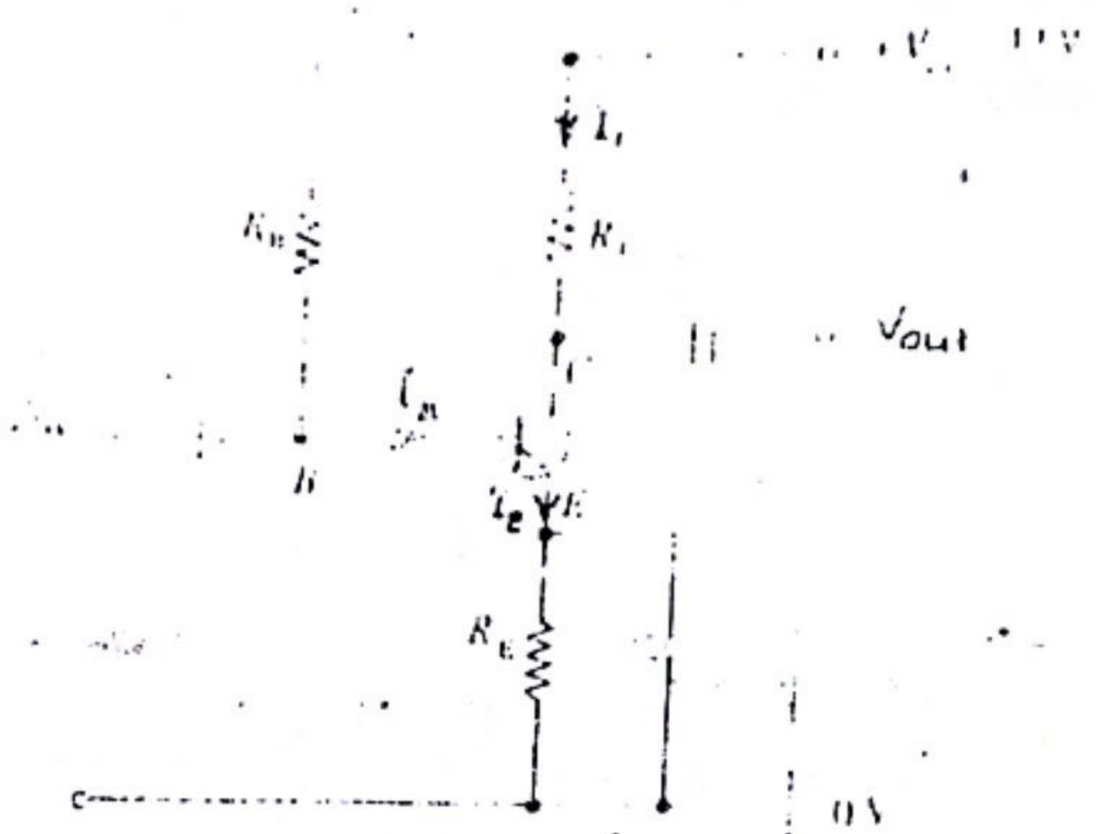
Common emitter configuration 01

Reason:

This circuit gives

large current amplification } OR large power gain 01

large voltage gain }



$I_E = I_B + I_C$

$I_B = \frac{I_C}{\beta}$

$= \frac{2}{100} = 2 \times 10^{-2}\ mA\ (or\ 2 \times 10^{-5}\ A)$ 01

$\because$ I_B is very small and can be neglected compared to I_C.

$\therefore$ $I_b \approx I_C = 2\ mA$

OR $I_E = 2 + 0.02 = 2.02\ mA$

$R_E = \frac{V_b}{I_E}$

$\frac{1.2}{2 \times 10^{-3}}$ or $\frac{1.2}{2.02 \times 10^{-3}}$ 01

$= 600\ \Omega$ or $594\ \Omega$

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Now, $V_{CC} = I_C R_C + V_{CE} + V_E$ 01

$$\therefore R_C = \frac{V_{CC} - V_{CE} - V_E}{I_C} = \frac{12 - 6 - 1.2}{2 \times 10^{-3}} = \frac{4.8}{2 \times 10^{-3}}$$

$= 2.4\ k\Omega$ 01

Similarly, $V_{CC} = I_B R_B + V_{BE} + V_E$ 01

$$\therefore R_B = \frac{V_{CC} - V_{BE} - V_E}{I_B} = \frac{12 - 0.6 - 1.2}{2 \times 10^{-5}}$$ 01

$$= \frac{10.2}{2 \times 10^{-5}}$$

$= 510\ k\Omega$ .....

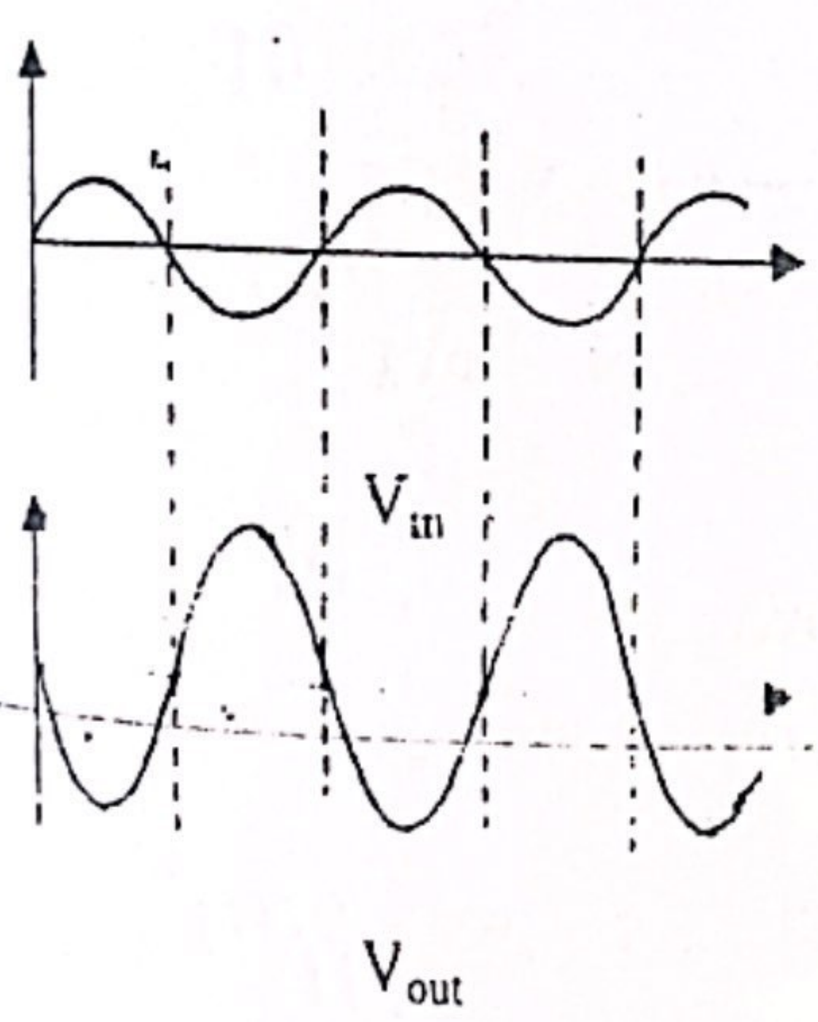
$V_B = V_E + V_{BE} = 1.2 + 0.6$

$= 1.8\ V$

$V_C = V_E + V_{CE} = 1.2 + 6.0$

$= 7.2\ V$

(for both values) 01



..... 01

To obtain maximum undistorted output signal

OR To obtain maximum symmetric swing for the output. 01

OR To have maximum dynamic range.

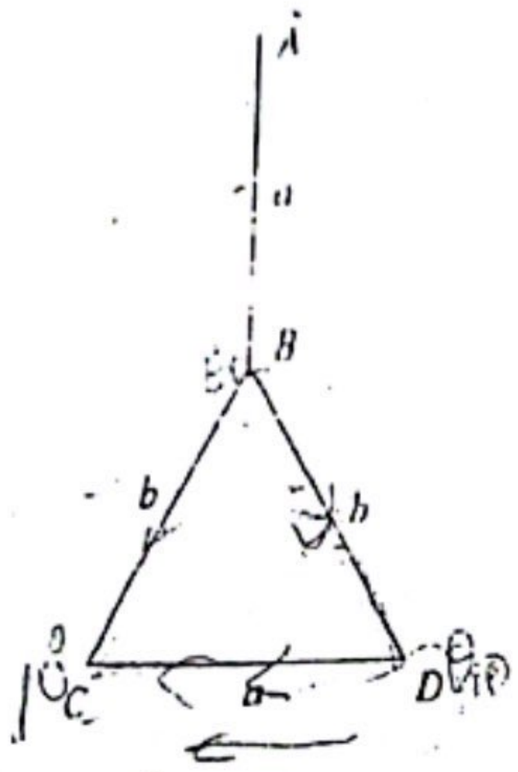
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9Q 31

6. **Answer either part (a) or part (b).**

(a) The metal frame shown in the figure is made [illegible] of two different materials and is
All the [illegible]
a is twice that [illegible] the material and b is [illegible] the temperature
If the [illegible] of the material [illegible] 0 °C and the temperature
of the [illegible] in the steady state.

If the frame is made of the same material and end A and junction C are maintained at 50 °C and 10 °C respectively as before, what would be the temperatures of the junctions B and D in the steady state?



Let the cross-sectional area and the length of the rods be A and L respectively.

Let the temperatures of junctions B and D be θ_B and θ_D respectively

Let K be the thermal conductivity of the material b.

Then, in the steady state the rate of heat flow through the rod AB

$$\frac{2K(50-\theta_B)A}{L} \quad \text{.....01}$$

Similarly, rate of heat flow through the rod BC

$$\frac{K(\theta_B-10)A}{L} \quad \text{.....01}$$

Similarly, rate of heat flow through the rod BD

$$\frac{K(\theta_B-\theta_D)A}{L} \quad \text{.....01}$$

Now, for the junction B in steady state,

Heat flowing in = Heat flowing out

$$\frac{2K(50-\theta_B)A}{L} = \frac{K(\theta_B-10)A}{L} + \frac{K(\theta_B-\theta_D)A}{L} \quad \text{.....01}$$

$100 - 2\theta_B = 2\theta_B - 10 + \theta_B$ (for equating)

$4\theta_B - \theta_D = 110$ ----------(1) 01

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Similarly for the junction D

$$\frac{K(\theta_B - \theta_D)A}{L} \quad \frac{2K(\theta_D - 10)A}{L}$$ 02

(01 mark for the R.H.S ; 01 mark for equating)

$\theta_B - 3\theta_D = -20$ ----------(2).....01

$(1)\times 3 \Rightarrow 12\theta_B - 3\theta_D = 330$ ------(3)

$(3)-(2) \Rightarrow 11\theta_B = 350$

$\theta_B = 31.8\ ^0C$ 01

and $\theta_D = 17.3\ ^0C$ 01

If the rods are made of the same material, then

$$\frac{K(50 - \theta'_B)A}{L} \quad \frac{K(\theta'_B - 10)A}{L} \quad \frac{K(\theta'_B - \theta'_D)A}{L}$$ 01

$3\theta'_B - \theta'_D = 60$ --------(4) 01

$$\frac{K(\theta'_B - \theta'_D)A}{L} \quad \frac{K(\theta'_D - 10)A}{L}$$

OR

$\theta'_B - 2\theta'_D = -10$ -------(5) 01

$(4)\times 2 \Rightarrow 6\theta'_B - 2\theta'_D = 120$ ----(6)

$(6)-(5) \Rightarrow 5\theta'_B = 130$ 01

$\theta'_B = 26\ ^0C$ 01

$\theta'_D = 18\ ^0C$

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(i)Curves B and C 01

They have the same stopping potential *OR* they meet the voltage axis

at the same point. 01

(ii)Curve D 01

It has the highest stopping potential *OR* It meets the voltage axis

at the highest point. 01

(iii)Curve E 01

(iv)Curve D 01

(v) $K_{max} = hf - \phi$ 01

(vi)Identifying that Planck constant is given by the gradient of the graph

OR substituting two sets of K_{max} and f values in the above equation and then subtracting one from the other

..... 01

$$\text{Planck constant} = \frac{(2.0-1.0)\times 1.6\times 10^{-19}}{(7.5-5.0)\times 10^{14}}$$

$$= 6.4\times 10^{-34}\ \text{J s} \quad \text{..... 01}$$

$$(6.1-6.7)\times 10^{-34}\ \text{J s}$$

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(2) Identifying that threshold frequency is given by the point at which the line meets the frequency axis 01

Threshold frequency = 2.5×10^{14} Hz 01

$(2.4-2.6)\times10^{14}$ Hz

(3) Measuring the intercept by extrapolating the line *or* using the photo-electric equation,

$$2.0\times1.6\times10^{-19} = 6.4\times10^{-34}\times7.5\times10^{14} - \phi$$

Work function = 1 eV 01

(0.9 eV – 1.1 eV)

(4) The corresponding K_{max} value for $f = 7.5\times10^{14}$ Hz

= 2.0 eV 01

∴ the stopping potential = 2 V 01

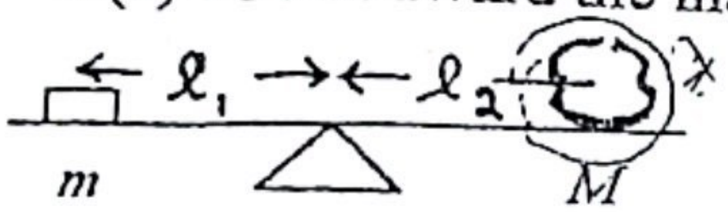
No, ... 01

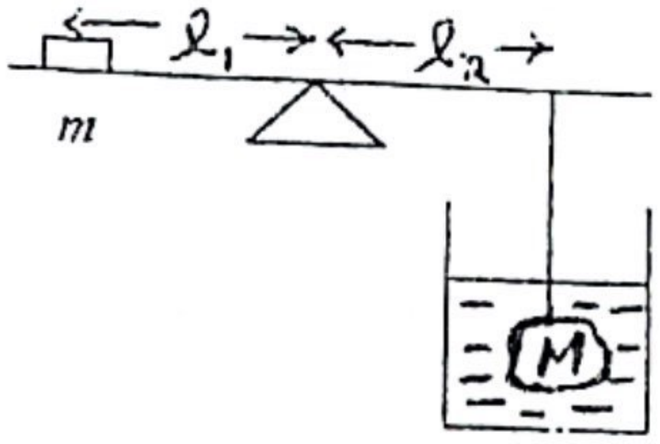
K_{max} is independent of intensity. *OR* K_{max} depend only on the frequency.

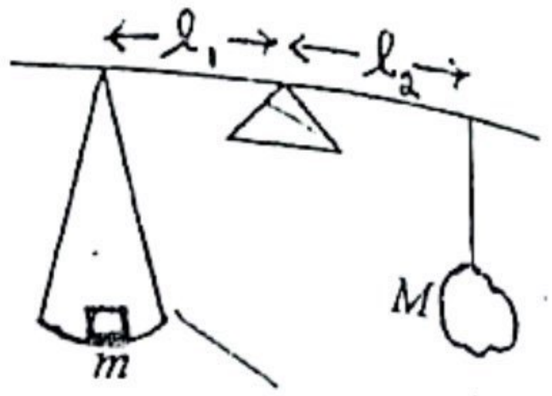
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Structured Essay

1.(a)Do not award the mark for the following diagrams:







But award the mark for the relevant expression in c(ii).

(b) No mark for saying it is easy to take moments.

(c)(i) *OR* l_1 and l_2 are approximately equal. *OR* Several values can be obtained for l_1 and l_2.

2.(f) No mark for $V \propto T$ *OR* $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

3.(d) *OR* Measure the corresponding values of r for different values of i.
Plot a graph of $\sin i$ vs $\sin r$ (or $\sin r$ vs $\sin i$)

4.(a) *OR* To achieve a small potential drop per unit length. *OR* To obtain a small value for k.

No mark for saying; To obtain a small current through the potentiometer wire.

(c) (ii) Award this mark irrespective of the answer(or blank) if the student has attempted the question No. 4.

(d) *OR* $k = \frac{10I}{6}$ or $\frac{5I}{3}$

(f) No mark for: Small temperature changes can be measured accurately.

OR Temperatures can be measured accurately.

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Essay:

3. Total capacitance $= 3.9\times10^{-10}$ F 02

(Deduct 01 mark if the unit is wrong)

4. (i) For the stress term $\frac{T}{1.25\times10^{-9}}$ 01

For the strain(or 1/strain) term $\frac{0.05}{(\pi r - 0.05)}$ 01

For the correct expression. 01

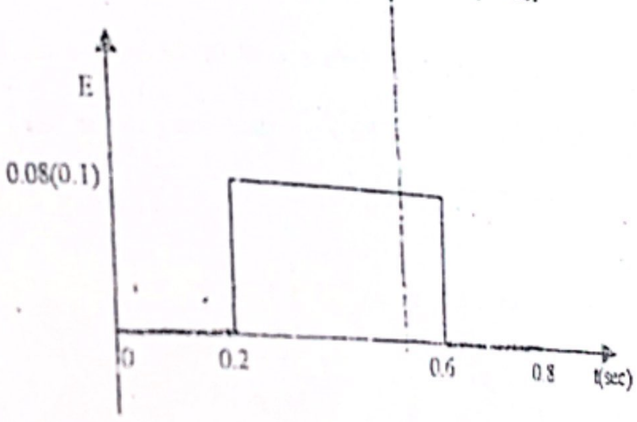
$7\times10^{6} = \frac{2\times2.5\times10^{-2}T}{1.25\times10^{-9}} \times \frac{0.05}{(\pi r - 0.05)}$ 01

(correct substitution for T) 01

(ii) If the student has missed the factor of 2 in the change of the surface area of the film, award the mark assigned for the substitution even without the factor of 2.

(iv) No need to mark the extensible or inextensible parts.

5.(a)
(vi) *OR*



5.(b) Do not look for labeling the junctions E,B, and C.
In the transistor symbols, correct direction of the arrow is essential to represents the emitter. Labeling or circles are not needed.

current amplification (or gain) } *OR* large power gain
voltage amplification (or gain) }

6.(b) (i) *OR* $\phi = hf_o = 6.4\times10^{-34}\times2.5\times10^{15}$

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