P510/2 PHYSICS PAPER 2

PROPOSED U.A.C.E. JJEB MARKING GUIDE - 2020

Half tick(½ Mark)
Full Tick (1 mark)

SECTION A

1. (a) (i) **Reflection** – is the bouncing off the light rays from the reflecting surface back into the same optical medium. **[01]**

(ii)

Convex mirrors	Plane mirrors
- Images are diminished	- Images are of the same size as that of the object.
- Image distance from the mirror may differ from the object distance from the same mirror.	- Image distance is equal to object distance from the same mirror
- Objects can be seen from a wider field of view of the mirror.	- Objects are seen from narrow field of view of mirror.

[03]

(b) (i) The incident ray, the normal and the refracted ray at the point of incidence, all lie in the same plane.
The ratio of the sine of the angle of incidence to the sine of the angle of refraction is equal to a constant for a given pair of optical media. **[02]**

(ii) From A to B $\Longrightarrow {}_An_B = \frac{\sin\theta_1}{\sin\theta_2} = \frac{v_A}{v_B}$ Where, $v_A = \frac{C}{n_1}$, and $v_B = \frac{C}{n_2}$

C, is the speed of light in vacuum or air, $\Longrightarrow {}_1n_2 = \frac{\sin\theta_1}{\sin\theta_2} = \frac{C}{n_1} \times \frac{n_2}{C}$

$$\Longrightarrow {}_1n_2 = \frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}, thus\ \ n_1\sin\theta_1 = n_2\sin\theta_2 \ldots\ldots\ldots\ldots\ldots(i)$$

From B to C $\Longrightarrow {}_Bn_C = \frac{\sin\theta_2}{\sin\theta_3} = \frac{V_B}{V_C}$ Where, $v_B = \frac{C}{n_2}$, and $v_C = \frac{C}{n_3}$

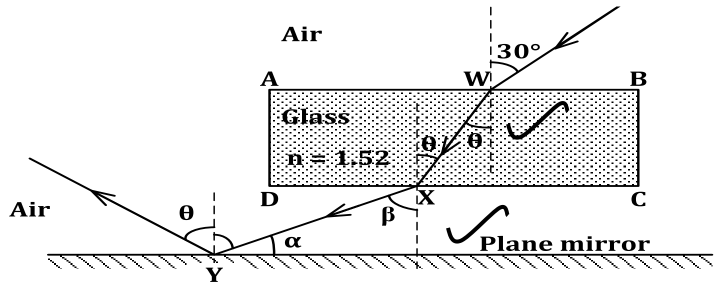
C, is the speed of light in vacuum or air, $\Longrightarrow {}_2n_3 = \frac{\sin\theta_2}{\sin\theta_3} = \frac{C}{n_2} \times \frac{n_3}{C}$

$$\Longrightarrow {}_2n_3 = \frac{\sin\theta_2}{\sin\theta_3} = \frac{n_3}{n_2}, thus\ \ n_2\sin\theta_2 = n_3\sin\theta_3 \ldots\ldots\ldots\ldots..(ii)$$

From (i) and (ii)

$n_1\sin\theta_1 = n_2\sin\theta_2 = n_3\sin\theta_3$ Hence, Snell's law. **[04]**

(c) (i) Using the principles of refraction and reflection of light at W , X and Y



[01]

(ii) Using $n\,sin\,i\ =\ a\ constant$ and applying it at point W.

$\sin 30° \ =\ 1.52\ sin\ \theta$

$\therefore\ \theta =\ 19.2°$

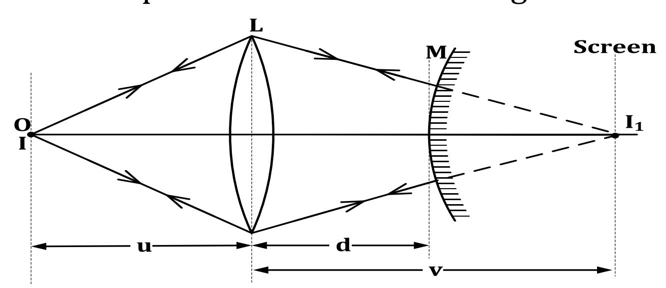
At point **X**: $n_g \sin\theta\ =\ n_a \sin\beta \implies 1.52 \sin 19.2° = \sin\beta$

$\therefore\ \beta =\ 29.99°\ \cong 30°$

$\therefore\ \alpha =\ (90° - 30°)\ = 60°$

Hence, $\boldsymbol{\theta} =\ \mathbf{30°}$ **[04]**

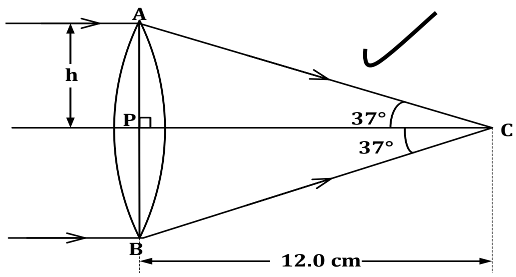
(d) Ray diagram below helps to understand the image formation.



- An illuminated object, **O**, is set up in front of a convex lens **L** of known focal length, $\mathbf{f_L}$ and a vertical screen is placed behind the lens, **L**.
- Starting with a distance, $u > f_L$, the screen is moved to and fro the lens, until the lens forms a real sharp image $\mathbf{I_1}$ on the screen.
- A distance, v, from the lens up to the screen is measured using a metre rule and recorded down.
- A convex mirror **M** is now introduced and placed coaxially with the lens, **L** in between the lens **L** and the screen.
- Mirror **M** is then moved to and fro until the sharp image, **I** of the object, **O**, is formed on the screen just besides the object, **O**
- The distance, **d** from **L** to **M** is also noted.
- The focal length of a convex mirror is calculated from, $|f| = \frac{(v-d)}{2}$ **[05]**

2. (a) (i) Aperture is the effective diameter of the lens. **[01]**

(ii) From Δ ACP $\tan 37° = \frac{h}{12.0}$ where h = half the diameter of the lens.



$h = 12.0 \tan 37° = 9.04\ cm$

$\therefore \textit{The lens aperture}, d = 2h,$

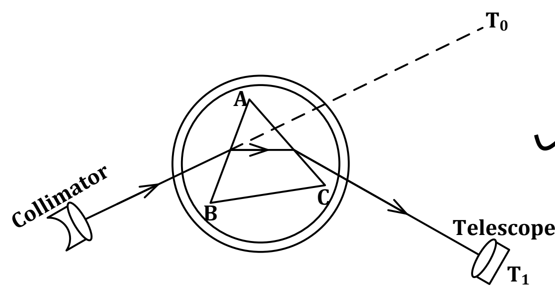
$\textit{Thus}, d = 2 \times 9.04$

$\textit{Hence}, \boldsymbol{d = 18.08\ cm}$

[03]

(b) (i) The telescope – is adjusted to ***receive a parallel beam*** of light rays at the cross wires.
The collimator – is adjusted to ***produce parallel beam*** of light rays
The turn table – is ***levelled*** to make its axis of rotation parallel to the refracting edge of the triangular prism placed on it. **[03]**

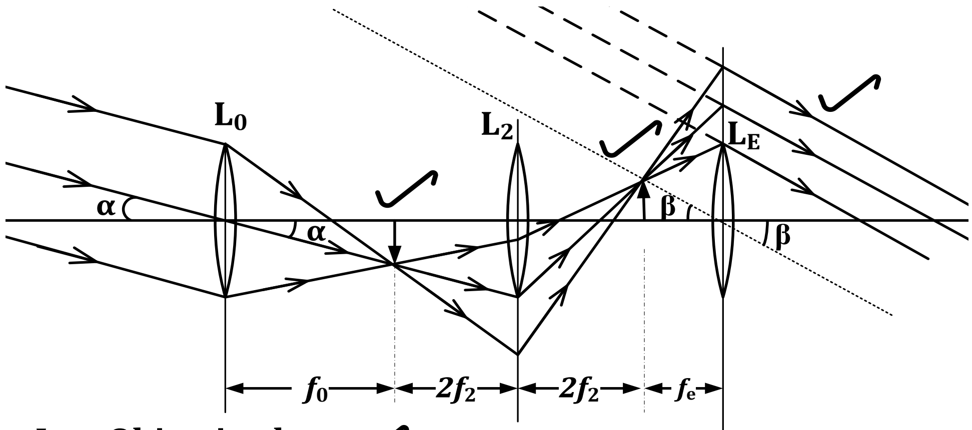
(ii) The prism is placed on the turntable of the adjusted spectrometer with its refracting angle, A, facing away from the collimator.



- The telescope is turned towards the base **AB**, of the prism until the image of the slit is received at the centre of the cross wires.
- The telescope and the turn table are then turned simultaneously in the same direction, until the image of the slit ***just starts to move off*** in the opposite direction.
- The corresponding position $\mathbf{T_1}$ of the telescope against the scale of the instrument is noted.
- The prism is then removed from the turntable.
- The telescope is turned in opposite direction until it is aligned with the collimator.
- The corresponding position $\mathbf{T_0}$ of the telescope on the scale is noted.
- The angle, $\mathbf{D_{min}}$ between the two positions is $\mathbf{T_1}$ and $\mathbf{T_0}$ of the telescope is then measured.

- The refractive index η of the material of the prism is calculated from the expression. $\eta = \dfrac{\sin\frac{1}{2}(D_{min}+A)}{\sin\frac{1}{2}(A)}$ **[04]**

(c) (i) The **Terrestrial telescope** in ***normal adjustment***



L_0 = Objective lens
L_2 = Erecting lens
L_E = Eyepiece lens

$M = \frac{\beta}{\alpha}$, *For α and β being small angles in radians,*

$tan\alpha \approx \alpha = \frac{h_1}{f_0}$ and $tan\beta \approx \beta = \frac{h_1}{f_e}$

Therefore, $M = \frac{\beta}{\alpha} = \frac{h_1}{f_e} \times \frac{f_0}{h_1} = \frac{f_0}{f_e}$

$Angular\ magnification, M = \frac{f_0}{f_e}$ **[05]**

(ii) $f_2 = 10\ cm\ f_0 = ?,\ f_e = 5.0\ cm$

$M = 4.0\ , f_0 = (4.0 \times 5.0) = 20.0\ cm\ ,\ \ M = \frac{f_0}{f_e}\ \ \ but\ f_0 = \ 20.0\ cm$

$The\ length\ of\ the\ telescope, \overline{L_0L_e} = (f_0 + 4f_2 + f_e)$

$\overline{L_0L_e} = [20.0 + (4 \times 10.0) + 5.0] = 65.0\ cm$

Hence, the Length of terrestrial telescope = 65.0 cm **[03]**

(d) Since $M = \frac{D}{f}$ $\quad M \propto \frac{1}{f}$

Thus, using a convex lens of a ***shorter focal length***, increases the magnifying power of the microscope. **[01]**

SECTION B

3. (a) (i) **Pitch** is the measure of ***how high or low the frequency of a given note is while***

Loudness is the measure of ***amount of energy intensity or amplitude*** of a given sound energy entering the ear.

Pitch depends on frequency of sound ***while loudness depends on intensity*** and amplitude of a sound note. **[03]**

(ii) ***Fundamental frequency*** – is the lowest predominant frequency note produced by a given musical instrument, ***while***

Overtones – are higher frequency notes that are multiples of the fundamental frequency note produced along side the fundamental frequency note. **[02]**

(b) **Open ended pipe**

$L_1 = 0.530$ m

Fundamental frequency

$$f_0 = \frac{v}{2(L_1+2e)}$$

$$1^{st}\ overtone, f_1 = 2f_0 = \frac{v}{(L_1+2e)}$$

Plucked wire

$L_2 = 0.810$ m

$\mu = 9.0 \times 10^{-4} kgm^{-1}$

$$f_3 = 3f_0 = \frac{3}{2L_2}\sqrt{\frac{T}{\mu}}$$

Now since 1st overtone resonates with the 3rd harmonic of a wire

$$\Rightarrow \frac{v}{(L_1+2e)} = \frac{3}{2L_2}\sqrt{\frac{T}{\mu}}$$

$$\frac{330}{(0.530+2e)} = \frac{3}{(2\times 0.810)}\sqrt{\frac{100}{9.0\times10^{-4}}}$$

$$\therefore \boldsymbol{e = 2.30\times10^{-3}\ m\ or\ 2.3\ mm}$$ **[04]**

(c) (i) **Beats** – are *periodic rise and fall in intensity* of sound heard by the observer when two sound notes of *nearly equal frequencies* and *similar amplitudes* are sounded together. **[02]**

(ii) A standard source of sound or source of known frequency f_1 is sounded at the same time at the same location with a source of unknown frequency f_2.

- The number of beats generated by the two sound notes f_b is noted.
- Some small piece of plasticine is stuck on the instrument of known frequency f_1 so as to slightly lower its frequency.
- The new beat frequency f_b' is noted.

  From $f_2 - f_1 = f_b \ldots\ldots\ldots\ldots\ldots\ldots.(i)$

Or $f_1 - f_2 = f_b{}' \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(ii)$

- The new beat frequency f_b' is compared with the original beat frequency f_b.
  If f_b'> f_b then f_2=f_b+ f_1 is calculated $\Longrightarrow f_2 > f_1$
- However, If f_b'< f_b $\Longrightarrow f_2 = f_1 - f_b \quad \Longrightarrow f_2 < f_1$
- Hence, the actual frequency, of unknown value f_2 is then calculated from (i) or (ii) **[05]**

(d) (i) ***Doppler effect*** – is the apparent change in the frequency of the sound waves received by the observer due to relative motion between the source of the waves and the observer. **[01]**

(ii) $u_0 = 10\, ms^{-1}\;\; u_s = 10\, ms^{-1}, f = 78\, kHz = 78 \times 10^3 Hz$

Apparent frequency, f' of the reflected waves as received by the bat

$f' = \left(\frac{v - u_0}{v + u_s}\right) f \quad \Longrightarrow \quad f' = \left(\frac{330-10}{330+10}\right) 78 \times 10^3$

$\therefore \boldsymbol{f' = 7.34 \times 10^4\;\; Hz}$ **[03]**

4. (a) (i) **Plane polarized light** – is the light whose electric vector is restricted to vibrate in only in one plane normal to the direction of propagation of light **[01]**

(ii) Using, $\tan i_p = \frac{n_2}{n_1} \quad \Longrightarrow \quad i_p = tan^{-1}\left(\frac{1.52}{1.00}\right)$

$\therefore \boldsymbol{i_p = 56.7°}$ **[02]**

(b) (i) Huygens's principle states that every point on the wave front is considered as a source of secondary spherical wavelets that spread outwards with wave velocity and the tangents to the new wavelets becomes the new wave front. **[01]**

(ii) Using, $\Longrightarrow {}_1n_2 = \frac{\sin i}{\sin r} = \frac{v_1}{v_2}$ But, $v_1 = \frac{c}{n_1} = f\lambda_1$ and $v_2 = \frac{c}{n_2} = f\lambda_2$

$\Longrightarrow \quad \frac{\sin i}{\sin r} = \frac{f\lambda_1}{f\lambda_2} = \frac{\lambda_1}{\lambda_2} \quad \therefore \lambda_2 = \frac{\lambda_1 \sin r}{\sin i} = \frac{0.527 \times \sin 19.5°}{\sin 30°}$

$\therefore \boldsymbol{\lambda_2 = 0.352\, m}$ **[03]**

(c) (i) $y = \frac{D\,\lambda}{a}$ Where, y is the fringe separation.
D is distance from the slits to the screen.
λ is the wavelength of the light used. **[01]**
a is the silts' separation.

(ii) Since $y \propto \frac{1}{a}$ *when a reduces, y increases*

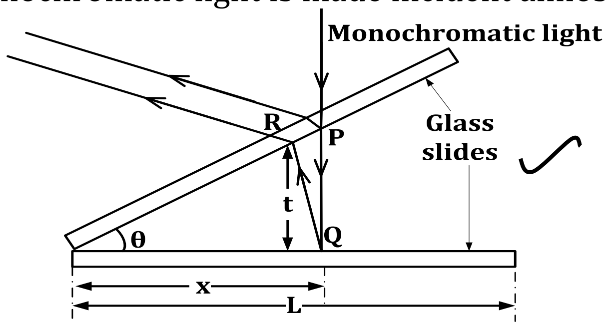
$\Longrightarrow$ *The* ***fringe separation increases*** when the slits separation is reduced. **[01]**

(d) (i)

Constructive interference	Destructive interference
- Occurs when a trough meets a trough or a crest meets a crest. - Reinforcement takes place in the waves. - The resultant intensity is higher or maximum.	- Occurs when a trough meets a crest. - Cancellation takes place in waves. - The resultant intensity is lowered or reduced.

[03]

(ii) Monochromatic light is made incident almost normally onto the top slide.



- The light *is partly reflected by the lower surface* ***P*** *of the top slide* and partly transmitted through the air gap between the slides and gets *reflected from the top surface* ***Q****, of the bottom slide.*
- The two wave trains are coherent and so ***interfere*** above the top slide to *produce alternate dark and bright fringes* that are parallel to the line of intersection of the two slides.
- Where the path difference 2t is an integral multiple of full wavelength, a dark fringe is obtained due to 180^0 phase change equivalent to an extra path length of λ/2 travelled by the wave when reflected at Q.
  i.e. $2t = n\lambda$ (***dark fringes***) *are observed.*
- Where the path difference $2t = (n - \frac{1}{2})\lambda$ is an integer multiple of a half wavelength, ***bright fringes*** are formed, n = 1,2,3, . . . **[04]**

(e) $\tan\theta = \frac{t}{x} \Longrightarrow t = x\tan\theta$ thus, $2t = 2x\tan\theta = n\lambda$

$\therefore \boldsymbol{x_n} = \frac{n\lambda}{2\tan\theta}$ *and* $\boldsymbol{x_{n-1}} = \frac{(n-1)\lambda}{2\tan\theta}$

$\Longrightarrow Fringeseparation, y = (x_{n-1} - x_n) = \frac{\lambda}{2\tan\theta} \quad \therefore \tan\theta = \frac{\lambda}{2y} = \frac{d}{L}$

Hence, $d = \frac{\lambda L}{2y} = \frac{6.0 \times 10^{-7} \times 15.0 \times 10^{-2}}{2 \times 1.8 \times 10^{-3}} = \boldsymbol{2.50 \times 10^{-5}\, m}$

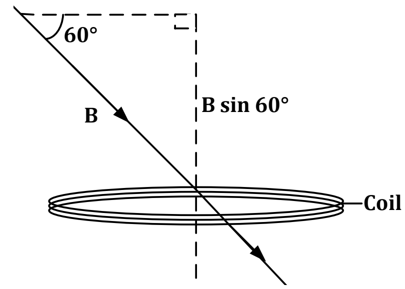
$\therefore \boldsymbol{d = 2.50 \times 10^{-5}\, m}$ is the thickness of the razor blade

SECTION C

5. (a) (i) **Magnetic flux density** – is the force exerted on a one metre length of a conductor carrying a current of one ampere in a direction normal to the field.

S.I unit is **tesla** (T) **[02]**

(ii) N=10 turns, r = 5.0 cm, B=0.85 T, θ = 60°



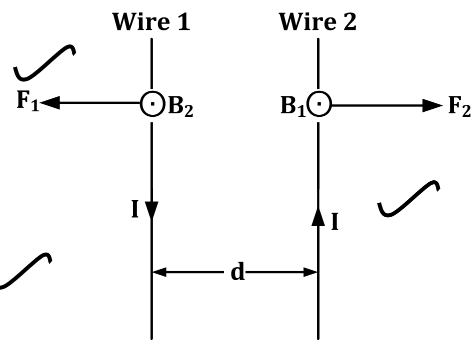
Magnetic flux linkage $N\Phi$

$= NBA \sin 60^0$

$= 10 \times 0.85 \times \pi \times (0.05)^2 \times \sin 60^0$

$= \boldsymbol{N\Phi = 5.78 \times 10^{-2}\, Wb}$ **[03]**

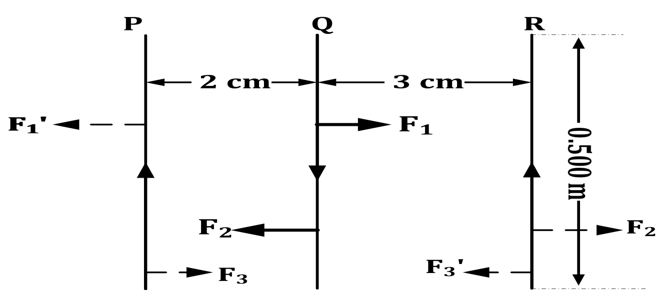
(b) (i) Force exerted on wire 1, $F_1 = B_2\, I\, L$



$F_1 = \left(\frac{\mu_0\, I}{2\pi d}\right) I\, L$

$F_1 \frac{\mu_0\, I^2\, L}{2\pi\, d}$ acting ***outwards*** **[03]**

(ii) Suppose $\mathbf{F_1}$ is the force exerted on wire **Q** due current through wire **P** and Let, $\mathbf{F_2}$ is the force exerted on wire **Q** due current through wire **R**



Using, $F_1 = \frac{\mu_0\, I_P\, I_Q\, L}{2\pi\, d_1} = \frac{4\pi \times 10^{-7} \times 2 \times 5 \times 0.500}{2\pi \times (0.03)} = 1.50 \times 10^{-4}\, N$ to the right.

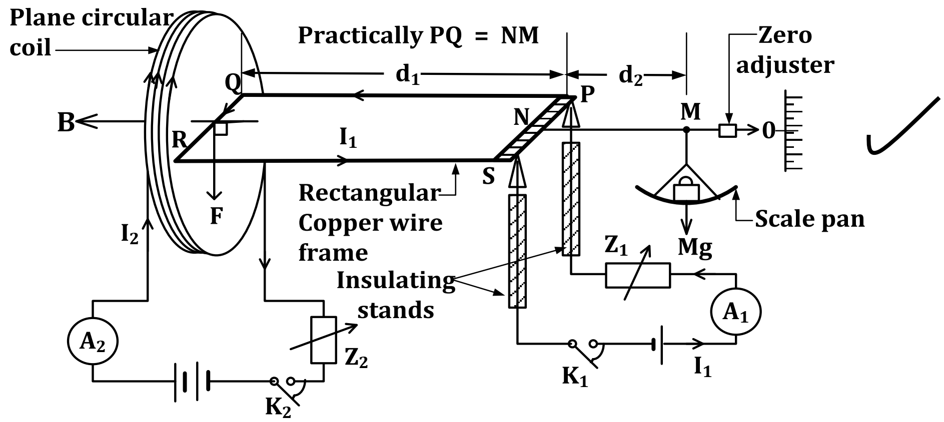
$F_2 = \frac{\mu_0\, I_R\, I_Q\, L}{2\pi\, d_2} = \frac{4\pi \times 10^{-7} \times 6 \times 5 \times 0.500}{2\pi \times (0.02)} = 3.33 \times 10^{-5}\, N$ to the left.

Resultant force on wire Q $F = F_1 - F_2$ *in the direction of* F_1

$F = (1.50 \times 10^{-4} - 3.33 \times 10^{-5})$

$\boldsymbol{F = 1.17 \times 10^{-4}}$ ***to the right*** **[05]**

(c) The ***simple current balance*** below is used.



The experiment is set up as shown in the diagram above.

- When the switches K_1 and K_2 are both open, the rigid rectangular wire frame PQRS is made horizontal.
- Switches K_1 and K_2 are closed and currents adjusted using Z_1 and Z_2 so as to produce a measurable down ward force **F** on the wire QR.
- Starting with a coil of known number of turns, N, switches K_1 and K_2 are closed and wire QR is observed to move downwards.
- Small weights are added into the scale pan until the frame PQRS balances horizontally.
- The total weight Mg in the scale pan is noted together with length, L, of the wire QR and current $\mathbf{I_1}$.
- The experiment is repeated using different samples of coils of different number N of turns.
- In each case the total weight –Mg in the scale pan is noted
- The results are then tabulated in a suitable table including values of N and Mg.
- A graph of N against Mg is then plotted and gives a straight line through the origin.

  Since $N \propto mg \text{ and } mg \propto B$
- $\Longrightarrow N \propto B$ *i.e. Magnetic flux density at the centre of a coil varies directly with the number of turns of the coil.* **[06]**

(d) **Magnets are used in**;

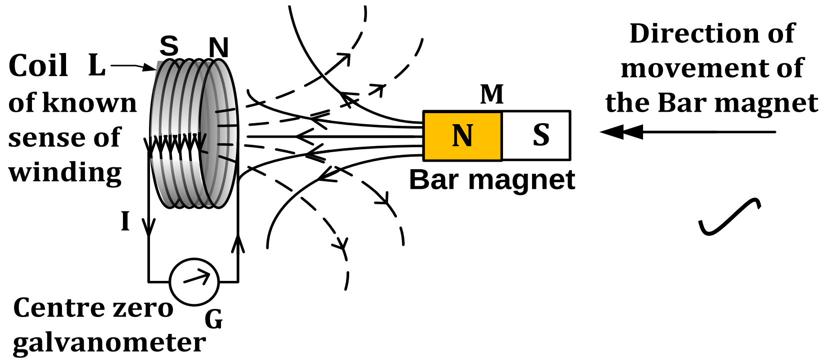
- Moving coil loud speakers
- Fridge doors
- Microphones
- Separating magnetic materials from non-magnetic type.
- Moving coil microphones
- Operation of MAGLEV trains.
- Compass needles.
- Electric bells. e.t.c.

Any correct response @ 1 mark (Maximum)

[01]

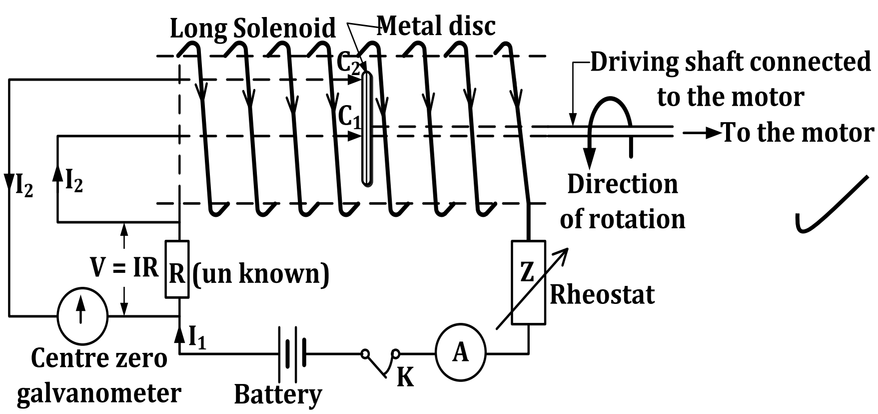
6. (a) (i) **Lenz's law** states that – the e.m.f induced in a coil or conductor acts in such a direction as to oppose the change causing it. **[01]**

(ii) **Lenz's law and the conservation of energy.**



- A coil of known sense of winding is connected in series with a centre- zero galvanometer G.
- When a bar magnet is mechanically moved towards the coil, an e.m.f. is induced in the coil that causes a current to flow in such a direction as to create a magnetic **like pole** at the end of the coil, that oppose the approaching or receding pole of the magnet.
- Mechanical energy is converted to electrical energy in the coil and vice versa i.e. electrical energy in the coil produces a magnetic field that repels or attracts the pole of the approaching or receding bar magnet respectively.
- This again causes work to be done in order to pull back the magnet being attracted by the side of the coil next to the bar magnet. **[03]**

(b) The set up below is used.



- The experiment is set up as shown on the diagram in the figure above.
- The metal (copper) disc of a known or measured radius, **r**, is placed at the centre of a solenoid of, known number, of turns per metre, **n**, with the plane of the disc perpendicular to the axis of the solenoid.

- Switch, K is closed and the rheostat, Z, is adjusted to a suitable value, then copper disc is rotated via the shaft connected to an electric motor, in an appropriate direction to reduce the value of current flowing through, G, to zero.
- The speed of rotation of the motor, is adjusted until the centre – zero galvanometer, G, shows no deflection.
- The number of revolutions per second, **f**, made by the metal disc is noted from the revolution meter attached to the motor.
- Using p.d. across, R, equals the induced e.m.f. $IR = B\,\pi\,r^2 f \;\; where$ $B = \mu_0 n I \;\; \Longrightarrow IR = \mu_0 n I \pi\, r^2 f$

  Hence, the resistance, R, is calculated from, $\boldsymbol{R = \mu_o n \pi r^2 f}$ is calculated.

[06]

(c) (i) $E = BLv \qquad = 0.45 \times 0.35 \times 3.4$

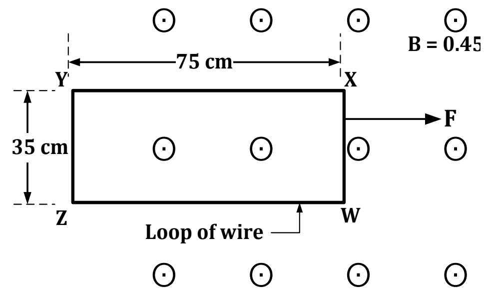
Induced e.m.f. = 0.536 V **[02]**

(ii) At constant velocity, Mechanical power = Electrical power

i.e. $Fv = EI \; where \; I = \frac{E}{R}$

$\therefore \; F = \frac{E^2}{v\,R} \;\; = \frac{(0.536)^2}{3.4 \times \; 0.23}$

$\therefore \; \boldsymbol{F = \; 0.367 \;\; N \; to \; the \; right}$ **[03]**



(d) (i) $I_1 = 550\,mA = 550 \times 10^{-3}\,A, \;\; \Phi = 2.7 \times 10^{-5}\,Wb\,, \frac{dI}{dt} = 6.0\,A\,s^{-1}$

Using, $N_2\Phi_2 = M\,I_1 \qquad \Longrightarrow M = \frac{N_2\Phi_2}{I_1} \;\; = \frac{3 \times 2.7 \times 10^{-5}}{550 \times 10^{-3}}$

$\therefore \;\; \boldsymbol{M = 1.473 \times 10^{-4}}\; H$ **[03]**

(ii) $E_2 = -\frac{M\,dI_1}{dt} \qquad but \; E_2 = I_2 R$

$$\Longrightarrow E_2 R = -\frac{M\,dI_1}{dt}$$

$$\therefore \; R = \left|\left(\frac{\frac{-MdI}{dt}}{I_1}\right)\right| = \frac{6.0 \times 1.473 \times 10^{-4}}{3.6 \times 10^{-4}}$$

$\therefore \;\; \boldsymbol{R = 2.455}\,\Omega$ **[03]**

7. (a) (i) Root mean square value of alternating current – is the value of steady current that dissipates heat in a given resistor at the same rate as the alternating current. **[01]**

(ii) $I = I_0 \sin 2\pi ft$.

Let R = resistance of the resistor

Instantaneous power dissipated in R; $P = I^2 R$

$P = {I_0}^2 R(\sin 2\pi f t)^2$

The average power dissipated over a complete cycle.

$< P > = < {I_0}^2 R \ \sin^2 2\pi f t >$

$= {I_0}^2 R < \sin^2 2\pi f t > \ but \ < \sin^2 2\pi f t > = \frac{1}{2}$

$\therefore < \boldsymbol{P} > = \frac{1}{2} \boldsymbol{I_0}^2 \boldsymbol{R}$ **[03]**

(b) (i) Capacitive reactance – is non-resistive or non – dissipative opposition to the passage of alternating or changing current through a capacitor. **[01]**

(ii) $I = 7.07 sin\ (100\pi t)\ is$ compared to $I = I_0 \sin 2\pi f t$.

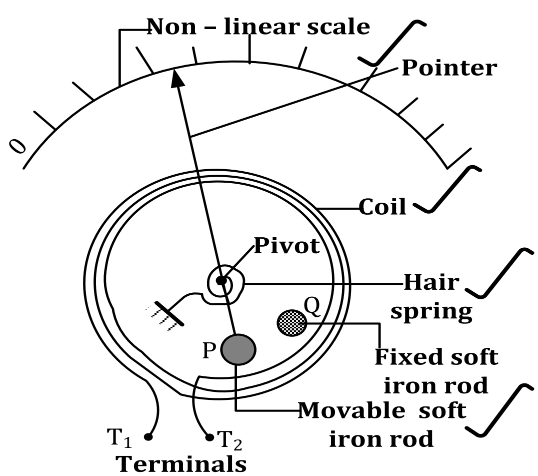
$\Longrightarrow Peak\ value\ I_0 = 7.07\ A, frequency, f = 50\ Hz, C = 16\ \mu F$

Using $Q_0 = C\, V_0 \quad and\ from\ X_c = \frac{1}{2\pi\, f\, C}$

$\Longrightarrow V_0 = \frac{I_0}{2\pi f\, C} \quad \therefore\ Q_0 = \frac{I_0}{2\pi f} = \frac{16 \times 10^{-6}}{2\pi \times 50}$

$\therefore\ Q_0 = 5.09 \times 10^{-9}\, C$ **[03]**

(c) (i) **The repulsion Moving iron ammeter**.



- Current I is fed into the coil via terminals T_1 and T_2, creating a magnetic field at the centre of the coil.
- The two soft iron rods **P** and **Q** get *magnetized in the same sense* and begin to *repel each other with an average force* which is proportional to the square of the current flowing through the coil.
- The fixed soft iron rod **Q** repels rod **P**, causing it to rotate about the pivot and moves over the scale through an angle, **θ**, until it is stopped by the restoring couple due to a pair of hair springs.
- The deflection **θ** produced is proportional to the average of the square current. i.e. $\theta \; \alpha \; \langle I^2 \rangle$
- $Hence\ the\ instrument\ has\ a\ non-linear\ scale.$ **[05]**

(ii)

Moving coil ammeter	Moving iron ammeter
- Their operation depends on the magnetic torque of the coil.	- Their operation depends on magnetic repulsion between two soft iron rods
- They have a linear scale.	- Have non-linear scales.
- They measure only d.c. but not a.c.	- They measure both a.c and d.c
- They are more expensive to manufacture.	- They are generally cheap to manufacture
- They are very delicate and not durable since coil can be overloaded and burns up.	- They are long lasting and less delicate since they have no delicate coil to be overloaded.
Accept any three correct corresponding pairs @ pair 1 mark	

(d) L = 2.0 H R=5.0 Ω V_{rms} = 240 V, f = 50Hz

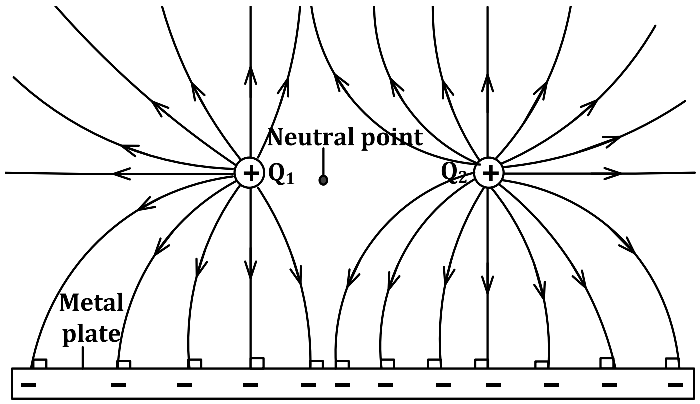
Using $V_{rms} = I_{rms}\sqrt{R^2 + {X_L}^2} \quad \Longrightarrow I_{rms} = \frac{V_{rms}}{\sqrt{R^2+(2\pi f L)^2}}$

$$I_{rms} = \frac{240}{\sqrt{(5.0)^2+(2\pi \times 50\times 5.0)^2}}$$

$I_{rms} = 0.153\ A$ **[03]**

8. (a) (i) An electric field- is a region of space where a charged particle or body experiences an electric force. **[01]**

(ii)



Features:

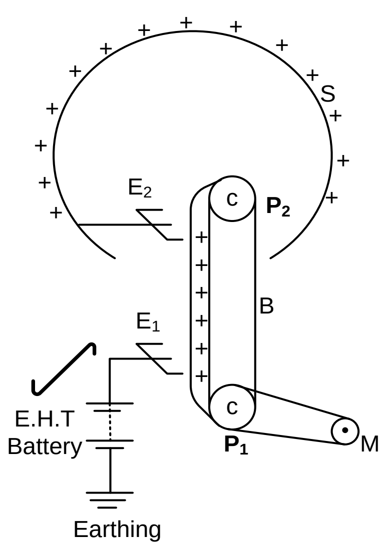
- Field direction for Q_1
- Field direction for Q_2
- Field Patterns.
- No. of field lines on each charge.
- Position of the neutral point.
- Charge on the plate

[03]

(b) (i) Corona discharge is the apparent loss of charge from a sharp pointed metal conductor.

- At the sharp points, there is high charge density.
- A strong electric field is created around the sharp end of the conductor
- Ionization of air around the sharp point occurs.
- Similar sign of charge is repelled away from the conductor into outer space while unlike charges from air are attracted to the conductor and neutralize some of the charges on the conductor.
- This results into a reduction of charge on the conductor as a whole
- This is known as corona discharge. **[03]**

(ii) **Van de Graaff generator**



S – spherical metal dome

E_1, E_2 – metal electrodes

B – silk belt

M – motor

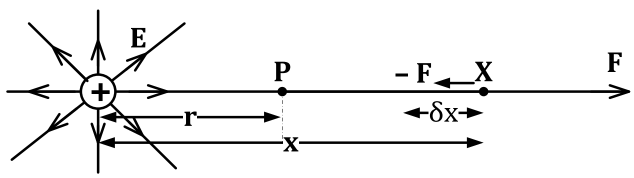
P_1, P_2 – pulleys

- Electrode E_1 is at a high *positive electric potential* relative to the earth.

- Air near E_1 gets ionized and positive charges are repelled and sprayed onto the silk belt
- The positive charges get carried upwards by the motor driven belt
- Negative charges get attracted onto the spikes of electrode E_2 while positive charges get induced onto the remote end and onto the spherical dome.
- Corona discharge occurs at E_2 and ***negative charges are sprayed*** onto the silk belt and ***neutralize*** it before passing over the upper roller.
- The process repeats itself until the metal sphere attain a very high positive potential of the order of 10^6 V with respect to the earth.

[06]

(c) Consider an electric field due to a charge +Q in free space



The small work done, Δw to move $a\ test\ charge + q\ by\ distance\ \delta x\ towards + Q$

$$\Delta w = -F\delta x \quad where,\ F = \frac{Qq}{4\pi\varepsilon_0 x^2}$$

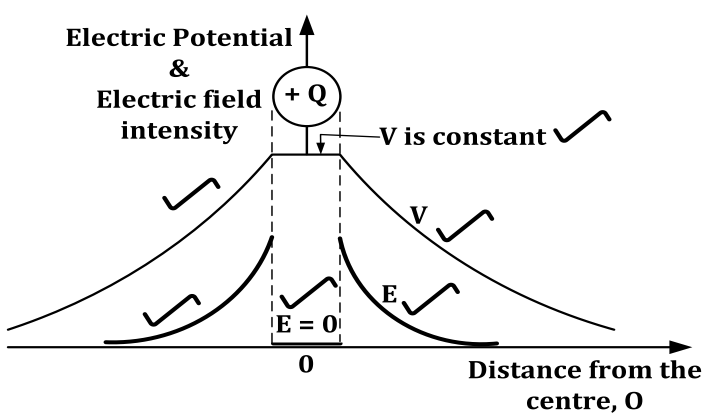
Total work done, $W = \int_{\infty}^{r} -F dx$

$$= -\frac{Qq}{4\pi\varepsilon_0}\int_{\infty}^{r}\frac{1}{x^2}dx$$

$$= \frac{Qq}{4\pi\varepsilon_0 r}$$

Electric potential at point, P, $V = \frac{W}{q} = \boldsymbol{\frac{Q}{4\pi\varepsilon_0 r}}$ **[04]**

(d) Graphs of electric potential and electric field intensity with distance.

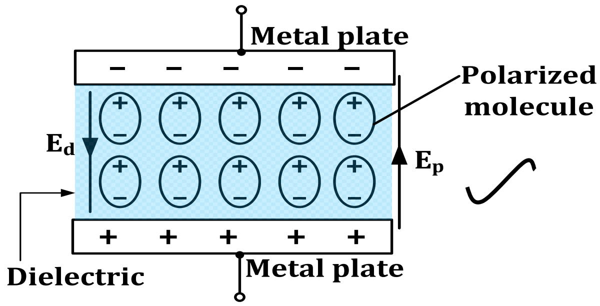


[03]

9. (a) (i) **Dielectric field strength** – is the *maximum potential gradient* that a capacitor should overcome before it breaks down ***while***

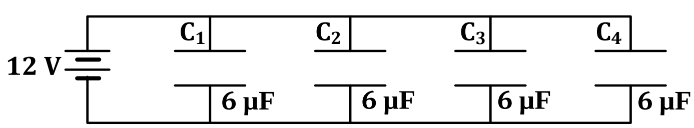
Dielectric constant – is the ratio of capacitance of a capacitor with a dielectric material filling all the space between its plates to the capacitance of the same capacitor with the space between the plates being a vacuum or free space. **[03]**

(ii) Inserting a dielectric material between the plates of the capacitor;



- Causes polarization of the dielectric material.
- An opposite electric field intensity say E_d due to the dielectric is set up to oppose that due to the charge on the plates, E_P
- The net electric field $E = E_p - E_d$ reduces.
- Since E∝V, the pd,v across the plates also reduces
- From c=$\frac{Q}{V}$, a reduction in the p.d causes the capacitance of the capacitor to increase
- Thus, inserting a dielectric material between the plates of the capacitor increases the capacitance of the capacitor **[04]**

(b) (i) Effective capacitance is greatest when the capacitors are in parallel to each Other



[01]

(ii) Effective capacitance, $\boldsymbol{C} = (\boldsymbol{C_1} + \boldsymbol{C_2} + \boldsymbol{C_3} + \boldsymbol{C_4}) = (\mathbf{6+6+6+6})\ \mu F$

$\therefore C = 24\ \mu F$

Energy stored $E = \frac{1}{2}CV^2$

$E = \frac{1}{2} \times 24 \times 10^{-6} \times 12^2$

$\boldsymbol{E = 1.728 \times 10^{-3}}$ **J** **[03]**

(c) Isolated charged capacitor has constant charge on it, implying that only p.d changes with change in distance.

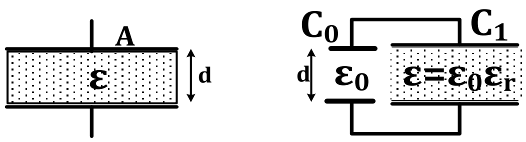
From, $C = \frac{Q}{V} = \frac{\varepsilon_0 A}{d}$ doubling the distance **doubles the p.d**

$\Longrightarrow$ ***Capacitance is halved***

Since $E = \frac{1}{2}QV$ $\Longrightarrow$ ***Energy is also halved*** (***reduced***).

$\Longrightarrow$ *The reduction in energy is due to the* ***work done*** *in pulling the Charged plates against attractive forces.* **[03]**

(d)



Before **After**

Effective capacitance, $C = C_0 + C_1$

$$C = \frac{\varepsilon_0\ A/3}{d} + \frac{\varepsilon_0\ \varepsilon_r\ {}^{2A}/_{3}}{d}$$

$$C = \frac{\varepsilon_0 A}{3\ d} + \frac{2\ \varepsilon_0\ \varepsilon_r\ A}{3\ d}$$

$$\therefore \boldsymbol{C = \frac{\varepsilon_0\ A}{3\ d}\ (1 + 2\varepsilon_r)}$$ **[03]**

(e) **Uses of capacitors**

- Tuning in radios and TVs
- Storing large quantities of charge for industrial use and research.
- Smoothing rectified circuits
- Preventing sparking in circuits
- Charging of phones, torches and Cameras. e.t.c. **[02]**

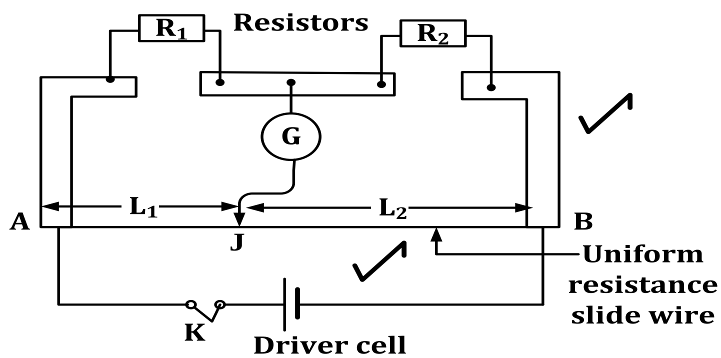
Any 2 correct responses @ 1 mark = (2 Marks Maximum)

10. (a) (i) **Resistance** – is the dissipative opposition to the flow of electric current through a conductor. **[01]**

(ii) When current is passed through the conductor, electrons causing current to flow drift in opposite direction.
On their way, electrons collide with the lattice ions that impinge on their movement.

Increase in length of the conductor, increases the number of lattice atoms or ions on the straight path of electrons.
More collisions occur along the path of electrons, leading to reduction in current flowing.
Since current is inversely proportional to resistance, a reduction in current leads to increase in resistance.
Hence, resistance increases with increase in length of a conductor and vice Versa. **[03]**

(b) (i)



Suppose, **r** is the resistance per cm of the slide wire AB $\Longrightarrow R_{AJ} = rl_1$

$R_{JB} = r(100 - l_1)$

At balance, current i_1 through R_1 is the same through R_2, since $i_g = 0$

Also current, i_2 through the slide wire AB is constant at the same value.

$P.d\ across\ R_1 = p.d\ across\ AJ$

$P.d\ across\ R_2 = P.d\ across\ JB$

$\Longrightarrow i_1R_1 = i_2\, rl_1$..(i)

and, $i_1R_2 = i_2\, r(100 - l_1)$................................(ii)

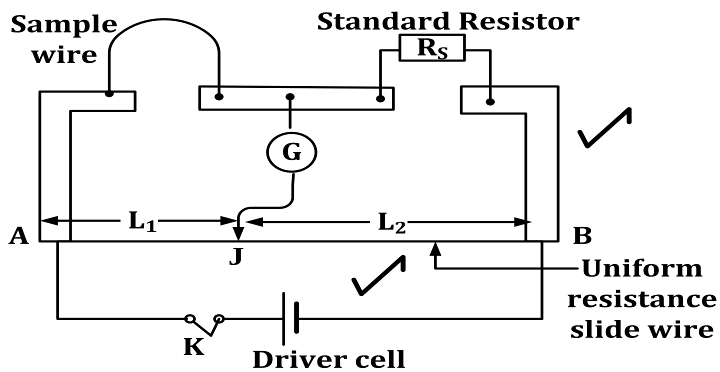
$Equation\ (i) \div (ii)$

$\Longrightarrow \frac{R_1}{R_2} = \frac{l_1}{(100-l_1)}$ is the balance condition of the metre bridge. **[04]**

(ii) Different samples of the test wire of different ***thicknesses*** measured using micrometer screw gauge but of ***equal length*** and the ***same material*** are obtained.

- The average diameter, **d** of each sample is noted.

  A given one at a time is connected to the left hand gap of the meter bridge whose right hand gap has a standard resistance R_S as shown in the figure below.



- Switch K is closed and the jockey is tapped gently along the slide wire AB until the galvanometer shows no deflection.
- The balance length L_1 and L_2 are noted.
- The experiment is ***repeated*** using several other samples of the wire of different diameters.
- The corresponding balance length L_1 and L_2 are noted in each case.
- The results are tabulated in a suitable table including values of $d, d_2, \frac{1}{d_2}, L_1, L_2$ or $(100 - L_1)$ *and* $\frac{L_1}{L_2}$

  A graph of $\frac{1}{d_2}$ against $\frac{L_1}{L_2}$ is plotted and gives a straight line through the origin.

  Since, $A \propto d^2$ and $R \propto \frac{L_1}{L_2}$

  $\Rightarrow R \propto \frac{1}{A}$ *i.e resistance of a conductor is inversely proportional to cross − sectional area.* **[06]**

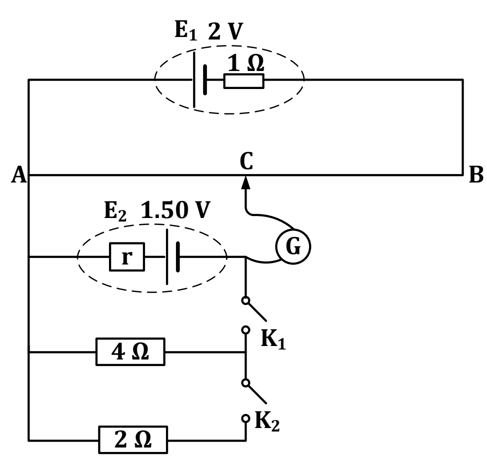
(c) (i) $AB = 100\ cm, R_{AB} = 4\ \Omega$,

$\therefore \frac{R_{AB}}{cm} = \frac{4}{100} = 0.04\ \Omega\ cm^{-1}$

Current supplied by the driver cell

$$i_p = \frac{E_1}{(r_1 + R_{AB})} = \frac{2}{(1+4)}$$

$$i_p = \frac{2}{5} = \mathbf{0.40\ A}$$



$\therefore\ P.d/cm \ = i_p \times \frac{R_{AB}}{cm} \ = (0.4 \times 0.04)$

$\therefore\ P.d/cm \ = \mathbf{0.016\ Vcm^{-1}}$

When switch, K_1 is closed while K_2 is open

$\Longrightarrow \left(\frac{E_2}{r + R_1}\right) R_1 = P.d/cm \times AC$

$\left(\frac{1.50 \times 4}{r + 4}\right) = 0.016 \times 57.7$

$\therefore\ r = \left[\left(\frac{1.50 \times 4}{0.016 \times 57.7}\right) - 4\right]$

$\boldsymbol{r = 2.50}\ \Omega$ **[03]**

(ii) When both K_1 and K_2 are closed, effective external resistance across E_2

$R \ = \left(\frac{4 \times 2}{4 + 4}\right) = \frac{8}{6} \ = 1.33\ \Omega$

At balance, $\left(\frac{E_2}{r + R}\right) R = \text{pd/cm} \times \text{AC}$

$\left(\frac{1.50}{2.50 + 1.33}\right) \times 1.33 \ = \ 0.016 \times AC$

$\therefore$ *The new balance length,* $\boldsymbol{AC} \ = \ \mathbf{32.6\ cm}$ **[03]**

=END=