PHYSICS

SECTION – A

Q. No.	1	2	3	4	5	6	7	8	9	10
Ans.	B	C	B	A	D	C	A	C	B	C
Q. No.	11	12	13	14	15	16				
Ans.	D	B	A	C	A	B				

SECTION – B

17. The electric field is E = V/d

$$=\frac{0.50\,\text{V}}{5.0\times10^{-7}\,\text{m}}=1.0\times10^{6}\,\text{V/m}.$$ **[2]**

18. **Photoelectric effect :** The phenomenon of emission of electron by metal plate on falling radiations of suitable frequency at it's surface is known as photoelectric effect.

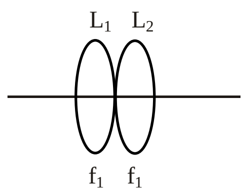
Factors affecting photoelectric current -

(1) Intensity of incident radiation.

(2) Potential of anode with respect to cathode. **[2]**

19. Given: $f_1 = 15$ cm, $f_2 = 30$ cm

Power of combination, $P = P_1 + P_2$



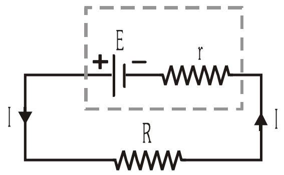
$$P=\frac{1}{f_1}+\frac{1}{f_2}\Rightarrow P=\frac{f_1+f_2}{f_1f_2}$$

$$P=\frac{45}{15\times30}=\frac{1}{10\times10^{-2}}\ \text{(D)}$$

$$P = 10\text{(D)}$$ **[2]**

20. Given

$E = 12$ V, $r = 2\Omega$, $I = 0.5$ A



Terminal voltage :

$V = E - Ir$

$V = 12 - 0.5 \times 2$

$V = 12 - 1 \Rightarrow \boxed{V = 11\text{ V}}$

Resistance of resistor :

$$V = IR \quad \Rightarrow R=\frac{V}{I}$$

$$R=\frac{11}{0.5}=22\ \Omega$$ **[2]**

21. Given that,

$d = 1 \text{ mm} = 1 \times 10^{-3}$ m,

$D = 1$ m

$\lambda = 500 \text{ nm} = 500 \times 10^{-9}$ m

or $\lambda = 5 \times 10^{-7}$ m

Now, $\beta = \dfrac{D\lambda}{d} = \dfrac{1 \times 5 \times 10^{-7}}{1 \times 10^{-3}}$

$\therefore \boxed{\beta = 5 \times 10^{-4} \text{m}}$ **[2]**

OR

In air, $\dfrac{1}{f_a} = (n_g - 1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$

In water, $\dfrac{1}{f_w} = \left(\dfrac{n_g}{n_w} - 1\right)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$

$$\Rightarrow \frac{f_w}{f_a} = \left(\frac{n_g - 1}{\frac{n_g}{n_w} - 1}\right)$$

$$f_w = \frac{\left(\frac{3}{2} - 1\right)}{\left(\frac{3/2}{4/3} - 1\right)} \times 25$$

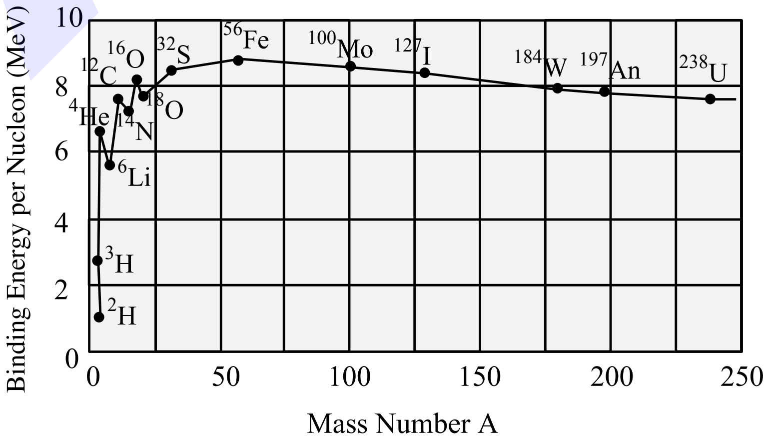
$f_w = 4 \times 25 = 100$ cm

SECTION – C

22. Using, $\dfrac{1}{\lambda} = R\left[\dfrac{1}{n_f^2} - \dfrac{1}{n_i^2}\right] = R\left[\dfrac{1}{1^2} - \dfrac{1}{\infty}\right] = R$

$\lambda = \dfrac{1}{R} = \dfrac{1}{1.097 \times 10^7 \text{m}^{-1}} = 0.9115 \times 10^{-7}$ m ≈ 912 Å **[3]**

OR



The value of binding energy per nucleon gives a measure of the stability of that nucleus. Greater is the binding energy per nucleon of a nucleus, more stable is the nucleus.

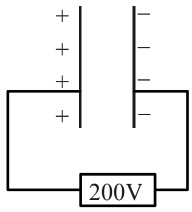
The above graph shows binding energy per nucleon drawn against mass number A.

The saturation effect of nuclear forces is the property responsible for the approximate constancy of binding energy in range 30 < A < 170.

Fission : B.E. of lighter nuclei formed is greater than that of heavy parent nucleus, so excess energy liberates in the form of heat.

Fusion : B.E. of nucleus formed is much more than that of nuclei forming it so the difference of energy liberates in the form of heat.

23. Given, $A = 6cm^2$, $d = 2 \times 10^{-3}m$



Capacitance of parallel plate capacitor $C = \left(\frac{\varepsilon_0 A}{d}\right) = \frac{8.85\times10^{-12}\times6\times10^{-4}}{2\times10^{-3}}$

$= 8.85 \times 10^{-12} \times 3 \times 0.1 = 26.55 \times 10^{-13}$ F

Now, $Q = CV = 26.55 \times 10^{-13} \times 200$

$= 53.1 \times 10^{-11}$ C **[3]**

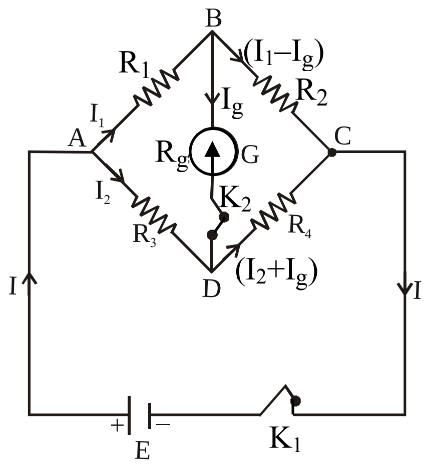
24. H_α is a specific deep-red visible spectral line in the Balmer series with a wavelength of 656.28 nm, it occurs when a hydrogen electron transits from its 3rd to 2nd lowest energy level. This transition produces H-alpha photon & the 1st line of Balmer series.

$$\frac{1}{\lambda} = R\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right] = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$$

$$\frac{1}{\lambda} = 1.097\times10^7\left[\frac{5}{36}\right]$$

$$\nu = \frac{c}{\lambda} = \frac{3\times10^8\times1.097\times10^7\times5}{36} = \boxed{4.57\times10^{14}\,\text{Hz}}$$ **[3]**

25. Let the current in galvanometer be I_g and resistance of galvanometer is R_g.



Apply Kirchhoff's voltage law in loop ABDA-

$- I_1R_1 - I_gR_g + I_2R_3 = 0$ .....(1)

Apply KVL in loop BCDB -

$- (I_1 - I_g)R_2 + (I_2 + I_g)R_4 + I_gR_g = 0$ .....(2)

In balanced Wheat Stone Bridge ($I_g = 0$)

From eq. (1) & (2)

$I_1R_1 = I_2 R_3$ .....(3)

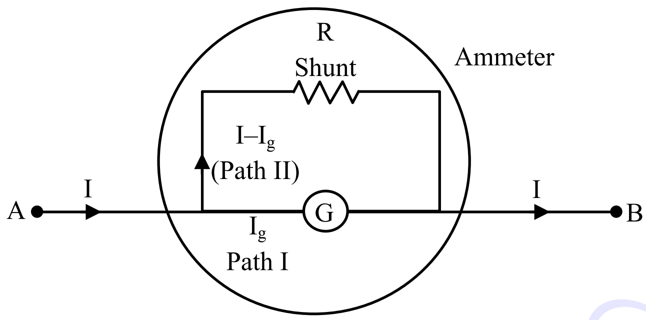
$I_1R_2 = I_2R_4$ .....(4)

eq. (3)÷(4)

$\boxed{\frac{R_1}{R_2} = \frac{R_3}{R_4}}$ This is the condition of balanced Wheat Stone Bridge. **[3]**

26. Conversion of MCG into Ammeter

An ammeter is a device that measures current in an electric circuit. For an ideal ammeter, resistance is almost zero. A MCG can be converted into an ammeter by connecting a low resistance called 'Shunt in parallel with it.



In parallel grouping of resistances, potential must be equal

$V_{\text{path I}} = V_{\text{path II}}$

$I_g G = (I - I_g)\, R$

$$\boxed{R(\text{shunt}) = \left(\frac{I_g}{I - I_g}\right) G}$$ **[1½]**

Conversion of MCG into Voltmeter

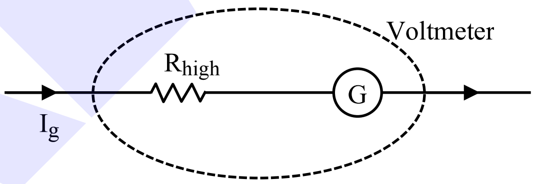
A voltmeter is a device that measures potential difference across two points. For ideal voltmeter, it's resistance is inifinite.

A moving coil galvanometer can be converted into a voltmeter by connecting a very high resistance in series with it.

$V = I_g R_h + I_g G$

$V = I_g (R_h + G)$

$$\frac{V}{I_g} = R_h + G$$

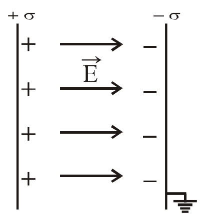


$$\boxed{R_h = \frac{V}{I_g} - G}$$ **[1½]**

27. Displacement Current : The current which is generated by changing electric field and electric flux between plates of capacitor is called displacement current.

Formula for displacement current :

For parallel plate capacitor :



$$E = \frac{\sigma}{\varepsilon_0} \Rightarrow \boxed{E = \frac{Q}{\varepsilon_0 A}} \qquad ...(1)$$

$$E = \frac{\phi_E}{A} \qquad ...(2)$$

From eq. (1) & (2)

$$\frac{\phi_E}{A} = \frac{Q}{\varepsilon_0 A} \Rightarrow Q = \varepsilon_0 \phi_E \qquad (A \Rightarrow \text{Plate area})$$

$$\frac{dQ}{dt} = \varepsilon_0 \left(\frac{d\phi_E}{dt}\right)$$

$$\varepsilon_0 \left(\frac{d\phi_E}{dt}\right) = I_d \quad \text{(Displacement current)}$$

Ampere-Maxwell's law : This law states that the line integral of the magnetic field around any closed path is equal to μ_0 time of sum of conduction current (I_c) and displacement current (I_d).

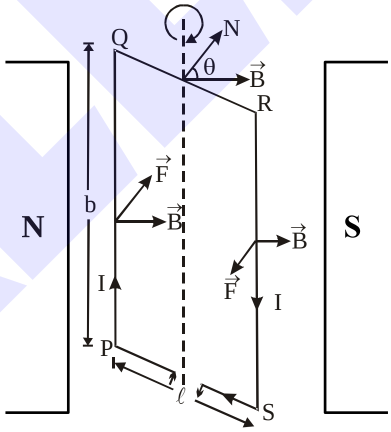
$\oint \vec{B} \cdot \vec{d\ell} = \mu_0 (I_c + I_d)$. **[3]**

28. **(1)** **Hysteresis loss:** Transformer cores are magnetised and demagnetised repeatedly, so lot of electrical energy is wasted in the form of heat in this process. To reduce this loss cores are made of soft iron, which has small hysteresis loop area. **[1½]**

(2) **Eddy current loss :** The alternating magnetic flux induces eddy currents in the iron core causes heating. The effect is reduced by laminating the core.
To reduce electrical energy losses in the form of heat energy, power is transmitted at high voltage up to large distances. **[1½]**

OR

We consider a rectangular coil PQRS placed in a uniform magnetic field B, with it's axis perpendicular to the field.



Let I be the current flowing through the coil PQRS, ℓ and b are the sides of the coil PQRS.

$A = \ell b$ = area of the coil and θ is the angle between $\vec{B}$ and $\vec{A}$.

According to Fleming's left hand rule, the magnetic forces on sides PS and QR are equal, opposite and collinear (along the axis of the loop), so their resultant is zero.
The side PQ experiences a normal inward force equal to IbB while the side RS experiences an equal normal outward force. These two forces form a couple which exerts a torque.

τ = Force × perpendicular distance

$= IbB \times \ell \sin\theta = IBA \sin\theta \qquad [\because A = \ell \times b]$

If the rectangular loop has N turns, then

$\tau = BINA \sin\theta$

$\tau = MB \sin\theta$ [Magnetic moment of the loop, M = NIA]

In vector form $\boxed{\vec{\tau} = \vec{M} \times \vec{B}}$

The direction of the torque is such that it rotates the loop clockwise about the axis. **[3]**

SECTION – D

29. (i) (c)

Here, d = 0.1 mm, λ = 6000 Å, D = 0.5 m

For third dark band, $d \sin\theta = 3\lambda$; $\sin\theta = \frac{3\lambda}{d} = \frac{y}{D}$

$$y = \frac{3D\lambda}{d} = \frac{3 \times 0.5 \times 6 \times 10^{-7}}{0.1 \times 10^{-3}} = 9 \times 10^{-3} \text{m} = 9\text{mm}$$ **[1]**

(ii) (b)

Given d = 0.2 mm = 0.2×10^{-3} m, D = 2m

λ = 5000 Å = 5×10^{-7} m

The distance between the first minimum on other side of the central maximum.

$$x = \frac{2\lambda D}{d} = \frac{2 \times 5 \times 10^{-7} \times 2}{0.2 \times 10^{-3}} \Rightarrow x = 10^{-2} \text{ m}$$ **[1]**

(iii) (a)

Here, λ = 600 nm = 6×10^{-7} m

a = 0.2 mm = 2×10^{-4} m, θ = ?

Angular width of central maxima,

$$\theta = \frac{2\lambda}{a} = \frac{2 \times 6 \times 10^{-7}}{2 \times 10^{-4}} = 6 \times 10^{-3} \text{rad}$$ **[1]**

(iv) (d)

When red light is replaced by blue light ($\lambda_B < \lambda_R$), the diffraction pattern bands becomes narrow and crowded together. **[1]**

OR

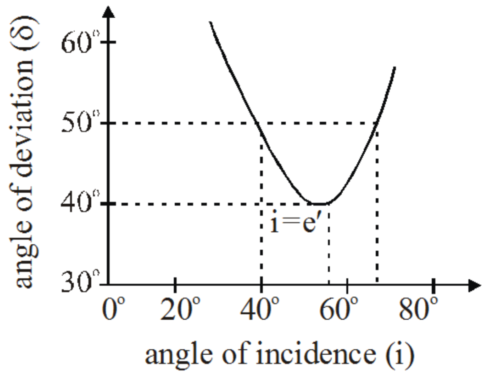
(d)

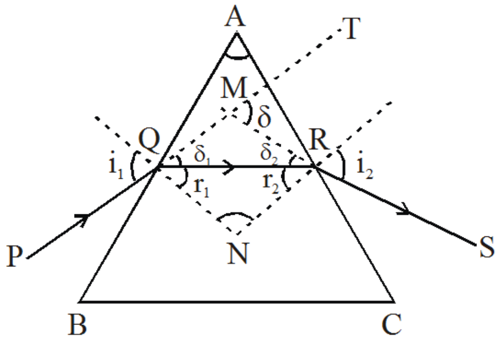
To observe diffraction, the size of the obstacle should be of the order of wavelength. **[1]**

30. (i) c (ii) b (iii) a (iv) a OR a

SECTION – E

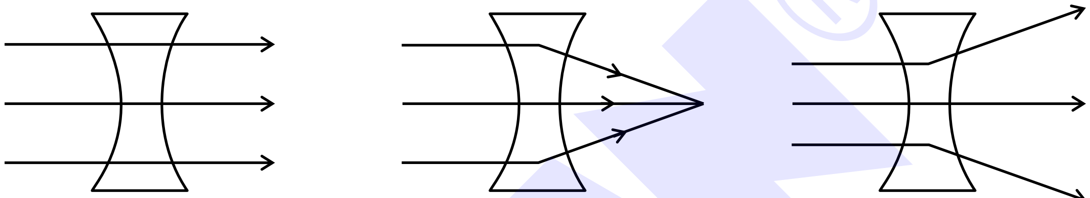
31. (a)





Angle of deviation, $\delta = (i_1 + i_2) - A$ **[1½]**

(b)



(a) $n_2 = n_1$ (b) $n_2 > n_1$ (c) $n_2 < n_1$

[1½]

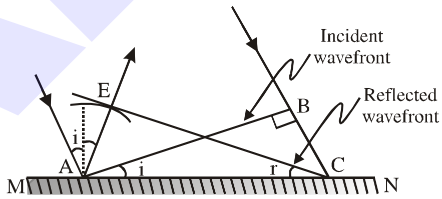
(c) Optical fibre works on the principle of total internal reflection of light. Two applications are as follows-

1. It is used for medical examination "endoscopy".

2. It is used for transmitting and receiving electrical signals which are converted to light by suitable transducers. **[2]**

OR

(a) The wavefront is the locus of all points that are in the same phase.



Let speed of the wave in the medium be 'ν'

Let the time taken by the wave front, to advance from point B to point C is 'τ'

Hence $BC = \nu\tau$

Let CE represent the reflected wave front, Distance $AE = \nu\tau = BC$

ΔAEC and ΔABC are congruent

$\therefore \angle BAC = \angle ECA$, $AE = BC$, $AC = AC$

$\Rightarrow \angle i = \angle r$ **[2]**

(b) If the width of the slit is made double then the size of the central maxima reduces to half and intensity increases upto four times. **[1]**

(c) We have,

$$\text{M.P.} = \frac{f_0}{f_e}$$

$$8 = \frac{f_0}{f_e} \Rightarrow f_o = 8f_e$$

Length of the telescope.

$$L = f_0 + f_e$$

$$45 = 8f_e + f_e \Rightarrow 45 = 9f_e \Rightarrow \therefore f_e = \frac{45}{9} = 5 \text{ cm}$$

Focal length for objective lens

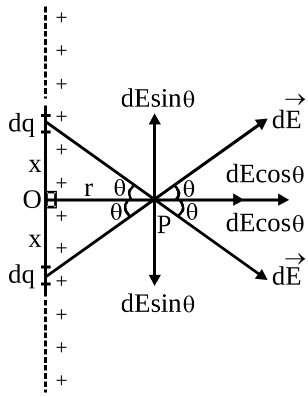
$\therefore$ $f_0 = 8f_e \Rightarrow f_o = 8 \times 5 \Rightarrow f_o = 40$ cm **[2]**

32. (a) **Electric flux :-** It is proportional to the total no. of electric field lines passing perpendicular to given area. It is given as :

$\boxed{\phi_E = EA\cos\theta}$ where θ is the angle between $\vec{E}$ and $\vec{A}$

Expression for electric field at a point due to uniformly charged straight conductor of infinite length :-

At a point P, electric field intensity due to infinite charged straight wire is perpendicular to it. Let linear charge density on wire is λ. Now, considering a cylindrical Gaussian surface of radius r and length ℓ.



Using Gauss' law,

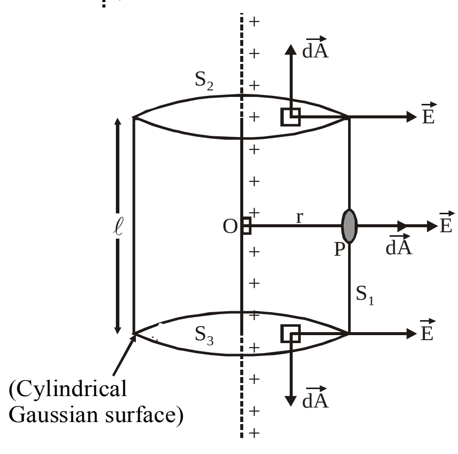
$$\oint E\,dA\cos\theta = \frac{q_{enclosed}}{\varepsilon_0}$$

$$\int_{S_1} E\,dA\cos 0° + \int_{S_2} E\,dA\cos 90° + \int_{S_3} E\,dA\cos 90° = \frac{\lambda\ell}{\varepsilon_0}$$

$$\Rightarrow \quad E\int_{S_1} dA + 0 + 0 = \frac{\lambda\ell}{\varepsilon_0} \quad \{E \Rightarrow \text{constant}$$

$$\Rightarrow \quad E \times 2\pi r\ell = \frac{\lambda\ell}{\varepsilon_0}$$

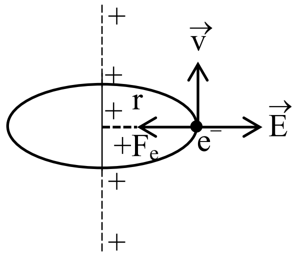
$$\Rightarrow \quad E = \frac{\lambda}{2\pi\varepsilon_0 r} \Rightarrow \boxed{E = \frac{2k\lambda}{r}}$$



(ii)

[3]

(b) An electric force provide a necessary centripetal force in moving an e^- in circular path around an infinite linear charge.



$$\Rightarrow \quad \frac{M_e v^2}{r} = eE$$

$$\Rightarrow \quad \frac{M_e v^2}{r} = e\left(\frac{2k\lambda}{r}\right)$$

$$v = \sqrt{\frac{2k\lambda e}{M_e}}$$

$$v = \sqrt{\frac{9\times10^{9}\times1.6\times10^{-19}\times10^{-6}\times2}{9\times10^{-31}}}$$

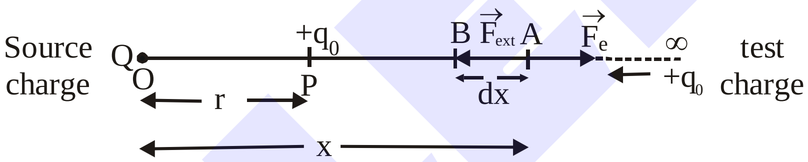
$$\Rightarrow \quad v = \sqrt{2\times16\times10^{14}}$$

$$\Rightarrow \quad v = 5.65\times10^{7}\ \text{m/s}$$ **[2]**

OR

(a) **Electric potential :-** The amount of work needed to bring a unit positive charge from infinity to a specific point inside the electric field of a charge is called electric potential at that point.

Potential due to point charge :-



electrostatic force on $+q_0$ at point A due to charge Q

$$F_e = \frac{1}{4\pi\varepsilon_0}\frac{Qq_0}{x^2}$$

Work done in moving a charge $+q_0$ in short displacement from A to B

$$dW = F_e dx = \frac{Qq_0}{4\pi\varepsilon_0}\times\frac{1}{x^2}(-dx)$$ [–ve sign indicates that x is decreasing]

Total work done in moving a charge q_0 from ∞ to r -

$$W = -\frac{Qq_0}{4\pi\varepsilon_0}\int_{\infty}^{r}\frac{1}{x^2}dx$$

$$W = -\frac{Qq_0}{4\pi\varepsilon_0}\left[-\frac{1}{x}\right]_{\infty}^{r}$$

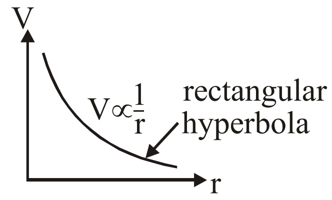
$$W = \frac{Qq_0}{4\pi\varepsilon_0}\left[\frac{1}{r}-\frac{1}{\infty}\right] \Rightarrow W = \frac{Qq_0}{4\pi\varepsilon_0 r}$$

From definition of potential

$$V = \frac{W}{q_0} \Rightarrow V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$$

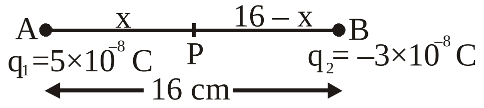
$$\boxed{V = \frac{kQ}{r}} \Rightarrow \boxed{V \propto \frac{1}{r}}$$

Graph between V and r :-



[3]

(b)



Let at point P potential is zero

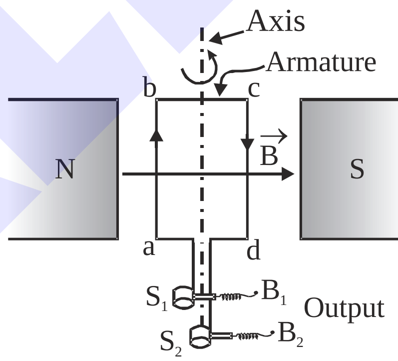
$$V_P = \frac{kq_1}{x} + \frac{kq_2}{(16-x)} = 0$$

$$k\left[\frac{5\times10^{-8}}{x} - \frac{3\times10^{-8}}{16-x}\right] = 0 \Rightarrow \frac{5\times10^{-8}}{x} = \frac{3\times10^{-8}}{16-x}$$

$\boxed{x = 10\text{cm}}$ **[2]**

33. (a) Alternating current Generator :

In figure, N and S are two powerful magnetic poles used for producing magnetic field. 'abcd' is an armature coil consists of insulated copper wire wound on iron core. The two ends of armature coil are connected with the two slip rings S_1 and S_2 made of brass. These slip rings are rotated with armature coil. Two carbon brushes B_1 and B_2 are always in contact with the slip rings S_1 and S_2. During rotation, B_1 and B_2 remain stationary in order to obtain an output through load. The function of brushes is to provide constant supply of the current in the armature.



Working : When the armature coil rotates between magnetic poles with constant angular velocity (ω) then the magnetic flux linked with the armature coil changes with time. The magnetic flux passing through coil is given by

$\phi = BA\cos\theta$ where $\left\{\begin{array}{l}\theta \Rightarrow \text{Angle between } \vec{B} \text{ and } \vec{A} \\ \theta = \omega t\end{array}\right.$

$\phi = BA\cos\omega t$

If N be the number of turns in the coil then magnetic flux $\boxed{\phi = NBA\cos\omega t}$

Induced e.m.f.

$$\varepsilon = -\frac{d\phi}{dt} \Rightarrow \varepsilon = -NBA\frac{d}{dt}(\cos\omega t)$$

$$\varepsilon = -NBA(-\omega\sin\omega t)$$

$$\boxed{\varepsilon = NBA\omega\sin\omega t} \qquad \varepsilon_0 = NBA\omega(\text{maximum value})$$

$$\boxed{\varepsilon = \varepsilon_0\sin\omega t}$$ **[3]**

(b) **Lenz's law :** "In the phenomenon of electromagnetic induction the direction of induced current is such that it opposes the change or the cause which produces it"

Given : $\ell = 2m$, $B_H = 0.3 \times 10^{-4}$ Tesla and $v = 5$ m/s

Induced e.m.f $\varepsilon = vB_H\ell$

$= 5 \times 0.3 \times 10^{-4} \times 2$

$$\boxed{\varepsilon = 3 \times 10^{-4}\ V}$$ **[2]**

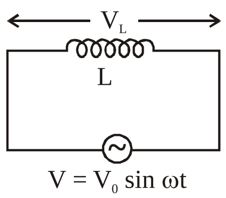
OR

(a) **Advantage of ac over dc :**

With the help of a transformer, ac at any desired voltage can be obtained. That is why power wastage in ac transmission is very low.

Disadvantage of ac over dc :

The ac current is more dangerous than the dc because its peak value is $\sqrt{2}$ times of rms value. **[1]**



Pure inductive ac circuit :-

(i) **Instantaneous value of current :**

Instantaneous value of applied voltage

$$V = V_0\sin\omega t \qquad ....(1)$$

If instantaneous current in inductor is i, then induced emf,

$$V_L = -L\frac{di}{dt} \quad \begin{cases}\text{–ve sign indicates that induced}\\ \text{emf oppose the applied voltage}\end{cases}$$

Applying KVL,

$$V + V_L = 0$$

$$V_0\sin\omega t - L\frac{di}{dt} = 0$$

$$di = \frac{V_0}{L}\sin\omega t\,dt$$

by integration

$$i = \frac{V_0}{L}\int\sin\omega t\,dt \Rightarrow i = \frac{V_0}{L}\left[-\frac{\cos\omega t}{\omega}\right]$$

$$i = \frac{V_0}{\omega L}\sin(\omega t - \pi/2) \quad \left\{\frac{V_0}{\omega L} = i_0(\text{peak value})\right.$$

$$\boxed{i = i_0\sin(\omega t - \pi/2)}$$

(ii) Reactance of a circuit :

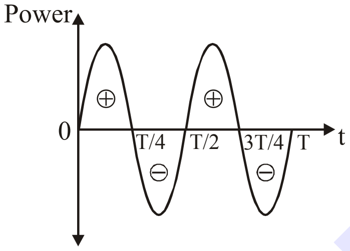
$$i_0 = \frac{V_0}{\omega L} \Rightarrow \omega L = \frac{V_0}{i_0} \Rightarrow \boxed{X_L = \omega L}$$

where X_L is reactance of a circuit.

(iii) Peak value of current :

$$\boxed{i_0 = \frac{V_0}{X_L}}$$ **[3]**

Power curve :



(b) Induced current is anticlockwise in coil AB, if seen from left hand side. **[1]**