# SHRI VIDHYABHARATHI MATRIC HR.SEC.SCHOOL

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## PUBLIC EXAMINATION – MARCH– 2024

## TENTATIVE ANSWER KEY

**XII -PHYSICS** **TOTAL MARKS : 70**

| Q.N | PART – I | | MARKS |
|---|---|---|---|
| | TYPE – A | TYPE – B | |
| 1. | (a) Photovoltaic action | (c) 1.1 eV | 1 |
| 2. | (c) 900 $Vm^{-1}$ | (c) 480 W | 1 |
| 3. | (c) 480 W | (a) $\frac{Q}{\sqrt{2}}$ | 1 |
| 4. | (a) 3 | (d) 3750Å | 1 |
| 5. | (c) polarisation | (d) 6 μF | 1 |
| 6. | (a) $\frac{Q}{\sqrt{2}}$ | (a) Photovoltaic action | 1 |
| 7. | (d) $\frac{3}{\pi} P_m$ | (d) its wavelength | 1 |
| 8. | (d) its wavelength | (c) 900 $Vm^{-1}$ | 1 |
| 9. | (b) $\frac{\pi}{4}$ | (d) $\frac{3}{\pi} P_m$ | 1 |
| 10. | (a) more than before | (b) $\frac{\pi}{4}$ | 1 |
| 11. | (d) 6 μF | (a) more than before | 1 |
| 12. | (d) 3750Å | (a) 3 | 1 |
| 13. | (a) plane polarised | (c) polarisation | 1 |
| 14. | (a) Albert Einstein | (a) plane polarised | 1 |
| 15. | (c) 1.1 eV | (a) Albert Einstein | 1 |
| | **PART – II** | | |
| 16. | **Hysteresis:** The phenomenon of **lagging of magnetic induction behind the magnetising field** is called hysteresis. Hysteresis means **'lagging behind'**. | | 2 |
| 17. | **Malus' law:** When a beam of plane polarised light of intensity $I_0$ is incident on an analyser, the light transmitted of intensity $I$ from the analyser varies directly as the square of the cosine of the angle $\theta$ between the transmission axis of polariser and analyser $I = I_0 \cos^2\theta$ ***(Formula only award 1 mark)*** | | 2 |

| | | |
|---|---|---|
| 18. | **Electrostatic potential:**<br>The electrostatic potential at a point is equal to the **work done by an external force to bring a unit positive charge with constant velocity from infinity to the point P** in the region of the external electric field $\vec{E}$.<br>$\mathbf{V_p = -\int_{\infty}^{P} \vec{E}.\vec{dr}}$ (or) $\mathbf{V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}}$ ***(Formula only award 1 mark)*** | 2 |
| 19. | Given:<br>$d\phi_B$ = 4mWb = 4X10$^{-3}$ Wb, dt = 0.4s<br>sol: $\varepsilon = \frac{d\phi_B}{dt}$<br>$= \frac{4\times10^{-3}}{0.4}$<br>= 10X 10$^{-3}$ = 10mV. ***(without unit Reduce ½ mark)*** | ½<br>½<br>1 |
| 20. | **Applications Seebeck effect**<br>➢ Seebeck effect is **used in thermoelectric generators** (Seebeckgenerators).These thermoelectric generators are used in power plants to convert waste heat into electricity.<br>➢ This effect is utilized in automobiles as **automotive thermoelectric generators for increasing fuel efficiency**.<br>➢ Seebeck effect is **used in thermocouples and thermopiles to measure the temperature difference** between the two objects.<br>***(Any 2 points 2X1=2)*** | 2 |
| 21. | Given: $T_{\frac{1}{2}}$ = 5.01 days = 5.01X 24X60X60 s<br>sol: $\lambda = \frac{0.6931}{T_{\frac{1}{2}}}$<br>$= \frac{0.6931}{5.01X24X60X60}$<br>= 1.6X10$^{-6}$ s$^{-1}$. ***(without unit Reduce ½ mark)*** | ½<br>½<br>1 |
| 22. | **Electromagnetic waves:**<br>An electromagnetic wave is **radiated by an accelerated charge which propagates through space** as coupled electric and magnetic fields, oscillating perpendicular to each other and to the direction of propagation of the wave. | 2 |
| 23. | **Biasing:**<br>Biasing means **providing external energy to charge carriers to overcome the barrier potential** and make them move in a particular direction.<br>**Two types of biasing:**<br>i) Forward bias<br>ii) Reverse bias | 1<br>1 |
| 24. | Given: f = 150cm = 150X10$^{-2}$m.<br>sol: $P = \frac{1}{f}$<br>$= \frac{1}{150X10^{-2}} = \frac{1}{1.5m}$<br>= 0.67D ***(without unit Reduce ½ mark)*** | ½<br>½<br>1 |

**25.** **β+ decay Process:**

- In β+ decay, the atomic number is decreased by one and the mass number remains the same. — 1

$${}^{A}_{Z}X \rightarrow {}^{A}_{Z-1}Y + e^{+} + \nu$$ — ½

for each β + decay, a proton in the nucleus of X is converted into a neutron by emitting a positron ($e+$) and a neutrino.

$$p \rightarrow n + e^{+} + \nu$$ — 1

Example:

$${}^{22}_{11}Na \rightarrow {}^{22}_{10}Ne + e^{+} + \nu$$ — ½

**26.** Given: A = 0.5 mm² = $0.5\times10^{-6}m^2$, I = 0.2A, n = $8.4\times10^{28}m^{-3}$.

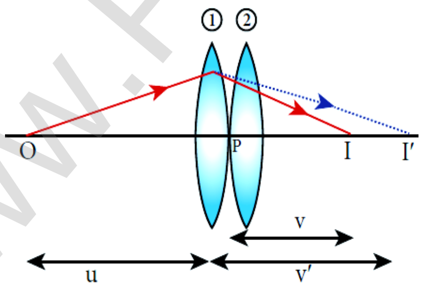
sol: $V_d = \frac{I}{neA}$ — 1

$$= \frac{0.2}{8.4\times10^{28}\times1.6\times10^{-19}\times0.5\times10^{-6}}$$ — 1

$= 0.03 \times10^{-3}$ m/s (or) $ms^{-1}$ ***(without unit Reduce ½ mark)*** — 1

**27.** **Effective focal length for lenses in contact:**

- Let us consider two lenses 1and 2 of focal length $f_1$ and $f_2$ are placed coaxially inContact with each other so that they have a common principal axis.
- For an object placed at O beyond the focus of the first lens 1 on the principal axis, an image is formed by it at $I'$. — ½
- This image $I'$ acts as an object for the second lens 2 and the final image is formed at I




— ½

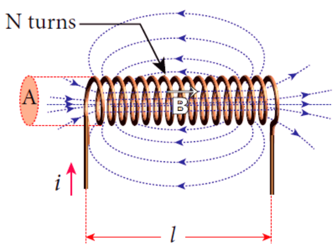
For the lens (1), the object distance $PO$ is $u$ and the image distance $PI'$ is $v'$. For the lens (2), the object distance $PI'$ is $v'$ and the image distance $PI$ is $v$.

Writing the lens equation for first lens 1,

$$\frac{1}{v'} - \frac{1}{u} = \frac{1}{f_1}$$

Writing the lens equation for second lens 2,

$$\frac{1}{v} - \frac{1}{v'} = \frac{1}{f_2}$$ — 1

| | | |
|---|---|---|
| | $$\frac{1}{v}-\frac{1}{u}=\frac{1}{f_1}+\frac{1}{f_2} \quad \ldots\ldots\ldots (1)$$ **(or)** $$\frac{1}{v}-\frac{1}{u}=\frac{1}{f} \quad ,\ldots\ldots\ldots\ldots(2)$$ Comparing equations (1) and (2) $$\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}$$ **(or)**<br>equation can be extended for any number of lenses in contact as, $$\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}+\frac{1}{f_3}+\frac{1}{f_4}+\ldots\ldots\ldots$$ | ½<br><br>½ |
| 28. | **Current sensitivity of a galvanometer:**<br><br>It is defined as the deflection produced per unit current flowing through it.<br>**(or)** $I_S = \frac{\theta}{I} = \frac{NAB}{K} = \frac{1}{G}$<br><br>**The current sensitivity of a galvanometer can be increased:**<br>by increasing<br>➢ the number of turns (N)<br>➢ the magnetic induction (B)<br>➢ the area of the coil (A)<br>➢ by decreasing the couple per unit twist of the suspension wire (K). | 1<br><br>2 |
| 29. | Given: $P = 50mW = 50X10^{-3}W$, $\lambda = 640nm = 640X10^{-9}$.<br><br>**sol:** **n** = $\frac{P\lambda}{hc}$<br><br>$= \frac{50\times10^{-3}\times640\times10^{-9}}{6.626\times10^{-34}\times3\times10^{8}}$<br><br>$= 1.61\times10^{17}$ per second. ***(without unit Reduce ½ mark)*** | 1<br><br>1<br><br>1 |
| 30. | **Induction of a solenoid:**<br>• Consider a long solenoid of length *l* and cross-sectional area *A*. Let *n* be the number of turns per unit length (or turn density) of the solenoid.<br>• When an electric current is passed through the solenoid, a magnetic field is produced by it which is almost uniform and is directed along the axis of the solenoid as shown in Figure.<br>• The magnetic field at any point inside the solenoid is given by<br>$$B = \mu_o n i$$ | ½<br><br>½ |

$$\Phi_B = \int_A \vec{B}.d\vec{A} = BA\cos\theta = BA \text{ since } \theta = 0°$$
$$= (\mu_0 ni)A$$

½

The total magnetic flux linked or flux linkage of the solenoid with $N$ turns (the total number of turns $N$ is given by $N = n\,l$) is

$$N\Phi_B = (nl)(\mu_0 ni)A$$
$$N\Phi_B = (\mu_o n^2 Al)\,i$$
$$N\Phi_B = Li$$

½

- Comparing equations

$$L = \mu_o n^2 Al$$

If the solenoid is filled with a dielectric medium of relative permeability, then

$$L = \mu n^2 Al \quad or \quad L = \mu_o \mu_r n^2 Al$$

1

**31.** **Differences between interference and diffraction:**

| S.No. | Interference | Diffraction |
|---|---|---|
| 1 | Equally spaced bright and dark fringes | Central bright is double the size of other fringes |
| 2 | Equal intensity for all bright fringes | Intensity falls rapidly for higher order fringes |
| 3 | Large number of fringes are obtained | Less number of fringes are obtained |

3

**32.** **Gauss law from Coulomb's law:**

We can calculate the totalelectric flux through the closed surface of the sphere

$$\Phi_E = \oint \vec{E}\cdot d\vec{A} = \oint E\,dA\cos\theta$$

1/2

The electric field of the point charge is directed radially outward at all points on the surface of the sphere. Therefore, the direction of the area element $\overrightarrow{dA}$ is along the electric field $\vec{E}$ and $\theta = 0^0$.

$$\Phi_E = \oint E\,dA \qquad \text{since } \cos 0^0 = 1$$

$E$ is uniform on the surface of the sphere,

$$\Phi_E = E\oint dA$$

Substituting for $\oint dA = 4\pi r^2$ and

$$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$$

*(upto)* 1

$$\Phi_E = \frac{1}{4\pi\varepsilon_o}\frac{Q}{r^2}\times 4\pi r^2 = 4\pi\frac{1}{4\pi\varepsilon_o}Q$$

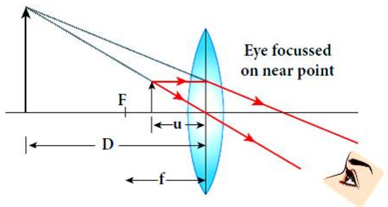
| | | |
|---|---|---|
| | $\Phi_E = \frac{Q}{\varepsilon_\circ}$<br>This equation is called as Gauss' law.<br>• Gauss's law states that **if a charge Q is enclosed by an arbitrary closed surface, then the total electric flux $\Phi_E$ through the closed surface is $\frac{1}{\varepsilon_0}$ times the net charge enclosed by the surface.**<br>$\Phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{Q_{encl}}{\varepsilon_\circ}$<br>where $Q_{encl}$ denotes the charges within the closed surface. | 1/2<br>1 |
| 33. | Given: $E_g$ = 1.875 eV, h = 6.6X$10^{-34}$Js.<br>sol: $\lambda = \frac{hc}{E_g}$<br>$= \frac{6.6\times10^{-34}\times3\times10^{8}}{1.875\times1.6\times10^{-19}}$<br>= 660nm<br>❖ Red colour light. | 1<br>½<br>½<br>1 |
| | **PART – IV** | |
| 34.<br>a) | **Simple microscope:**<br>• A simple microscope is a single magnifying (convex) lens of small focal lengthwhich must produce an erect, magnified and virtual image of the object.<br>• The object must be placed within the focal length f (between the points F and P) on one side of the lens and viewed through the other side of it. The nearest point where an eye can clearly see is called the near point and the farthest point up to which an eye can clearly see is called the far point. For a healthy eye, the distance of the near point is 25 cm, which is denoted as D and the far point should be at infinity.<br>**Near point focusing**<br>• The eye is least strained when image is formed at near point, i.e. 25 cm. The near point is also called as *least distance of distinct vision*. This is shown in Figure .<br>• The object distance *u* should be less than *f*. The image distance is the near point *D*. The magnification *m* of this lens is given by the equation<br>$m = \frac{v}{u}$ *since* $(v = -D \quad u = -u,)$<br>(or)<br>$m = \frac{D}{u}$<br>$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ in | 1<br>½ |

$m = \frac{v}{u}$ We get $m = 1 - \frac{v}{f}$

v = –D

$$m = 1 + \frac{D}{f}$$

*(upto)* 1




½

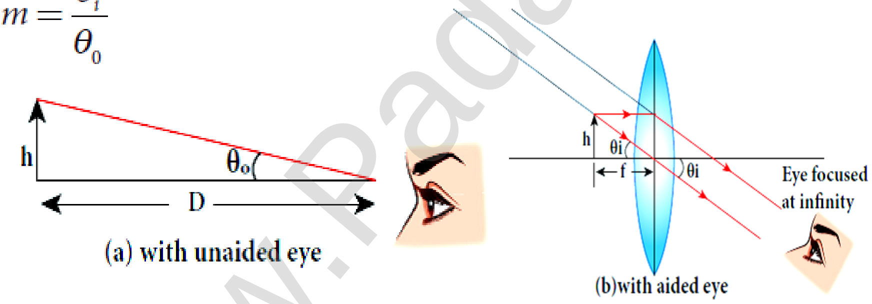
**Normal focusing**

- The eye is most relaxed when the image is formed at infinity. The focusing is called normal focusing when the image is formed at infinity. To find the magnification *m*, if we take theratio of the height of image to the height of object

  $$\left(m = \frac{h'}{h}\right)$$

- **The *angular magnification* is defined as the ratio of angle $\theta_i$ subtended by the image with aided eye to the angle $\theta_0$ subtended by the object with unaided eye.** ½

  $$m = \frac{\theta_i}{\theta_0}$$




½

For unaided eye shown in Figure

$$\tan\theta_0 \approx \theta_0 = \frac{h}{D}$$

For aided eye shown in Figure ½

$$\tan\theta_i \approx \theta_i = \frac{h}{f}$$

The angular magnification is,

$$m = \frac{\theta_i}{\theta_0} = \frac{h/f}{h/D}$$

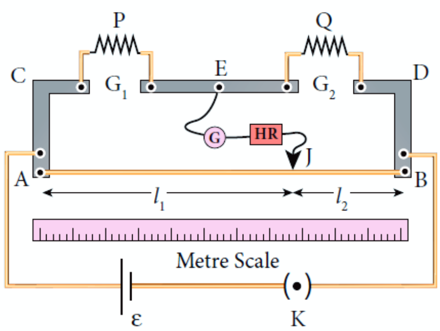
½

$$m = \frac{D}{f}$$

34. (OR) (b)

**Meter bridge:**

- The meter bridge is another form of Wheatstone's bridge. It consists of a uniform manganin wire AB of one meter length.
- This wire is stretched along a meter scale on a wooden board between two copper strips C and D.
- Between these two copper strips another copper strip E is mounted to enclose two gaps $G_1$ and $G_2$ as shown in Figure.
- An unknown resistance P is connected in $G_1$ and a standard resistance Q is connected in $G_2$. 1
- A jockey (conducting wire) is connected to the terminal E on the central copper strip through a galvanometer (G) and a high resistance (HR).
- The exact position of jockey on the wire can be read on the scale.
- A Lechlanche cell and a key (K) are connected across the ends of the bridge wire.

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- The position of the jockey on the wire is adjusted so that the galvanometer shows zero deflection. Let the point be J.
- The lengths AJ and JB of the bridge wire now replace the resistance R and S of the Wheatstone's bridge. Then

$$\frac{P}{Q} = \frac{R}{S} = \frac{r.\mathrm{AJ}}{r.\mathrm{JB}}$$ ½

$$\frac{P}{Q} = \frac{AJ}{JB} = \frac{l_1}{l_2}$$

$$P = Q\frac{l_1}{l_2}$$

*(upto)* 1

- **The bridge wire is soldered at the ends of the copper strips. Due to imperfect contact, some resistance might be introduced at the contact.These are called end resistances**. ½
- **This error can be eliminated, if another set of readings are taken with P and Q interchanged and the average value of P is found.**
- To find the specific resistance of the material of the wire in the coil P, the radius aand length *l* of the wire is measured.
- The specific resistance or resistivity ρ can be calculated using the relation

$$\text{Resistance} = \rho\frac{l}{A}$$

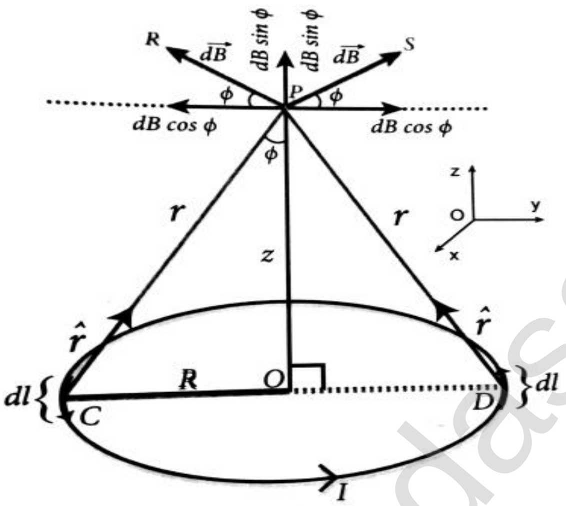
$$\rho = \text{Resistance} \times \frac{A}{l}$$

$$\rho = P\frac{\pi a^2}{l}$$

*(upto)* 1

**35. a) Magnetic field at a point P on the axis of the circular coil:**

- Consider a current carrying circular loop of radius R and let I be the current flowing through the wire in the direction as shown in Figure.
- The magnetic field at a point P on the axis of the circular coil at a distance $z$ from its center of the coil O. ½
- It is computed by taking two diametrically opposite line elements of the coil each of length$\vec{dl}$ at C and D. Let $\vec{r}$be the vector joining the current element (I$\vec{dl}$ ) at C to the point P.

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- 
- According to Biot-Savart's law, the magnetic field at P due to the current element $C$is

$$d\vec{B} = \frac{\mu_\circ}{4\pi}\frac{I\vec{dl} \times \hat{r}}{r^2}$$

- The magnitude of $\vec{dB}$ is

$$dB = \frac{\mu_\circ}{4\pi}\frac{Idl\sin\theta}{r^2} = \frac{\mu_\circ}{4\pi}\frac{Idl}{r^2}$$

*(upto)* 1

- where θ is the angle between I$\vec{dl}$ and $\vec{r}$. Here $\theta = 90^0$.
- The direction of $\vec{dB}$ is perpendicular to the current element I$\vec{dl}$ and CP. It is therefore along PR perpendicular to CP.
- The magnitude of magnetic field at P due to current element at D is the same as that for from the coil. But its direction is along PS
- The magnetic field $\vec{dB}$due to each current element is resolved into two components: dB cos Φ along y direction and dB sin Φ along z direction.
- The horizontal components cancel out while the vertical components along contribute to the net magnetic field $\vec{B}$ at the point P.

$$\vec{B} = \int d\vec{B} = \int dB \sin\phi \, \hat{k}$$

$$= \frac{\mu_0 I}{4\pi} \int \frac{dl}{r^2} \sin\phi \, \hat{k}$$

From ΔOCP,

$$\sin\phi = \frac{R}{\left(R^2 + z^2\right)^{1/2}} \quad \text{and} \quad r^2 = R^2 + z^2$$

$$\vec{B} = \frac{\mu_0 I}{4\pi} \frac{R}{\left(R^2 + z^2\right)^{3/2}} \hat{k} \left(\int dl\right)$$

1

***(upto)***

- If we integrate the line element from 0 to $2\pi R$, we get the net magnetic field $\vec{B}$ at point P due to the current-carrying circular loop.

$$\vec{B} = \frac{\mu_0 I}{2} \frac{R^2}{\left(R^2 + z^2\right)^{3/2}} \hat{k}$$

- If the circular coil contains N turns, then the magnetic field is

$$\vec{B} = \frac{\mu_0 N I}{2} \frac{R^2}{\left(R^2 + z^2\right)^{3/2}} \hat{k}$$

1/2

- The magnetic field at the centre of the coil is

$$\vec{B} = \frac{\mu_0 N I}{2R} \hat{k} \qquad \text{since } z = 0$$

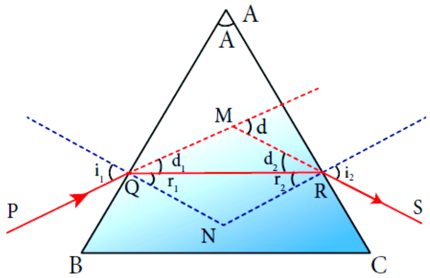
1

35. (OR) b)

**Angle of deviation:**

- Consider a prism ABC. the faces AB and AC are polished and the face BC is rough.
- Let light ray PQ is incident on one of the refracting faces of the prism.
- The angles of incidence and refraction at the first face AB are $i_1$ and $r_1$.
- The path of the light inside the prism is QR.
- The angle of incidence and refraction at the second face AC is $r_2$ and $i_2$ respectively.
- RS is the ray emerging from the second face.
- Angle $i_2$ is also called angle of emergence.
- The angle between the direction of the incident ray PQ and the emergent ray RS is called the angle of deviation d.
- The two normals drawn at the point of incidence Q and emergence R are QN and RN. They meet at point N.
- The incident ray and the emergent ray meet at a point M.

½

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- The deviation $d_1$ at the surface AB is,

$$angle\ \angle RQM = d_1 = i_1 - r_1$$

- The deviation $d_2$ at the surface AC is,

$$angle\ \angle QRM = d_2 = i_2 - r_2$$

- Total angle of deviation d produced is,

$$d = d_1 + d_2$$

$$d = (i_1 - r_1) + (i_2 - r_2)$$

$$d = (i_1 + i_2) - (r_1 + r_2)$$

*(upto)* 1

- In the quadrilateral AQNR, two of the angles (at the vertices Q and R) are right angles.

Therefore, the sum of the other angles of the quadrilateral is 180°.

$$\angle A + \angle QNR = 180^\circ$$

From the triangle $\Delta QNR$,

$$r_1 + r_2 + \angle QNR = 180^\circ$$

- Comparing these two equations

$$r_1 + r_2 = A$$

- Substituting this equation for angle of deviation,

$$d = i_1 + i_2 - A$$

*(upto)* 1

**Angle of minimum deviation:**

**The minimum value of angle of deviation** 1/2

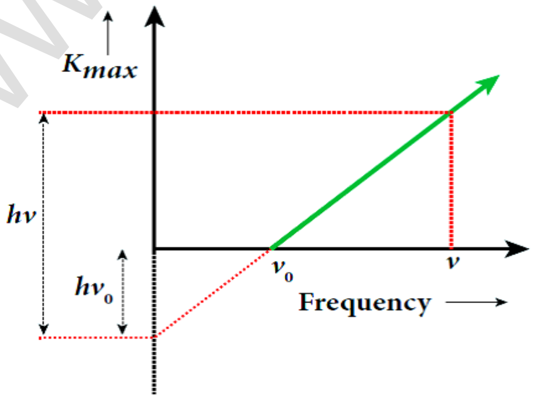
At minimum deviation (d= D) **,**

$i_1 = i_2 = I$ and $r_1 = r_2 = r$

D = $i_1 + i_2 - A$ = $2i - A$ (or) $i = \frac{(A+D)}{2}$ ½

$r_1 + r_2 = A$ = $2r = A$ (or) $r = \frac{A}{2}$ ½

$n = \frac{\sin i}{\sin r} \Longrightarrow n = \frac{\sin\frac{(A+D)}{2}}{\sin\frac{A}{2}}$ ½

| | | |
|---|---|---|
| 36. a) | **Einstein's photoelectric equation:**<br>• **When a photon of energy $h\nu$ is incident on a metal surface, it is completely absorbed by a single electron and the electron is ejected.**<br>• In this process, **a part of the photon energy is used for the ejection of the electrons from the metal surface (photoelectric work function $\phi_0$) and the remaining energy as the kinetic energy of the ejected electron**. From the law of conservation of energy,<br>$h\nu = \phi_0 + \frac{1}{2}m\upsilon^2$ ……………… (1)<br>where $m$ is the mass of the electron and $\upsilon$ its velocity.<br>• If we reduce the frequency of the incident light, the speed or kinetic energy of photo electrons is also reduced.<br>• At some frequency $\nu_0$ of incident radiation, the photo electrons are ejected with almost zero kinetic energy<br>$h\nu_0 = \phi_0$<br>where $\nu_0$ is the threshold frequency. Byrewriting the equation<br>$h\nu = h\nu_0 + \frac{1}{2}m\upsilon^2$ ……………… (2)<br>• The equation is known as **Einstein's photoelectric equation.**<br>•<br>• If the electron does not lose energy by internal collisions, then it is emitted with maximum kinetic energy $K_{max}$. Then<br>$K_{max} = \frac{1}{2}m\upsilon^2_{max}$<br>where $\upsilon_{max}$ is the maximum velocity of the electron ejected. Equation (1) becomes<br>$K_{max} = h\nu - \phi_0$ ………… (3)<br><br> | 1<br>1<br>1<br>1<br>½<br>½ |

36 (OR) b)

**Pure inductive Circuit:**

- Consider a circuit containing a pure inductor of inductance $L$ connected across an alternating voltage source. The alternating voltage is given by the equation.

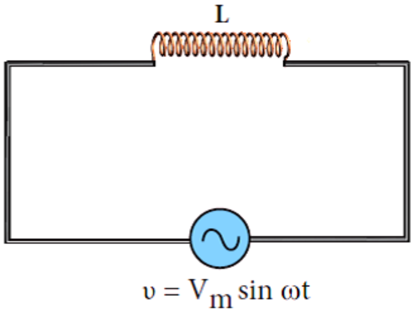
$$\upsilon = V_m \sin \omega t$$

- The alternating current flowing through the inductor induces a self-induced emf or back emf in the circuit. The back emf is given by

$$\text{Back emf}, \varepsilon = -L\frac{di}{dt}$$

1

- By applying Kirchoff's loop rule to the purely inductive circuit, we get




½

-
$$\upsilon + \varepsilon = 0$$
$$V_m \sin \omega t = L\frac{di}{dt}$$
$$di = \frac{V_m}{L}\sin \omega t \; dt$$

*(upto)* 1

- Integrating both sides, we get

$$i = \frac{V_m}{L}\int \sin \omega t \, dt$$
$$i = \frac{V_m}{L\omega}(-\cos \omega t) + \text{constant}$$

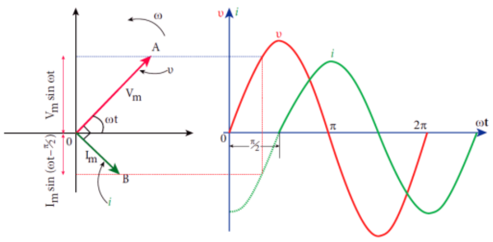
-
$$i = \frac{V_m}{\omega L}\sin\left(\omega t - \pi/2\right)$$
$$\text{or} \quad i = I_m \sin\left(\omega t - \pi/2\right)$$

1

$$\text{where} \frac{V_m}{\omega L} = I_m,$$

- From equations, it is evident that current lags behind the applied voltage by in an inductive circuit.
- **the current lags the voltage by 90°**

½

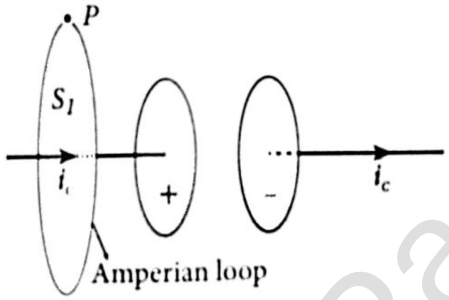



1

| | | |
|---|---|---|
| 37. (a) | **Advantages of FM**<br>i) Large decrease in noise. This leads to an increase in signal-noise ratio.<br>ii) The operating range is quite large.<br>iii) The transmission efficiency is very high as all the transmitted power is useful.<br>iv) FM bandwidth covers the entire frequency range which humans can hear. Due to this, FM radio has better quality compared to AM radio.<br>***(Any 2 or 3 points)*** | 2 (or) 3 |
| | **Limitations of FM**<br>i) FM requires a much wider channel.<br>ii) FM transmitters and receivers are more complex and costly.<br>iii) In FM reception, less area is covered compared to AM.<br>***(Any 2 or 3 points)*** | 2 (or) 3 |

37. (OR) (b)

- In order to understand how the changing electric field induces magnetic field, let us consider a situation of charging a parallel plate capacitor which contains non conducting medium between the plates.
- Let a time dependent current $i_c$, called conduction current be passed through the wire to charge the capacitor.

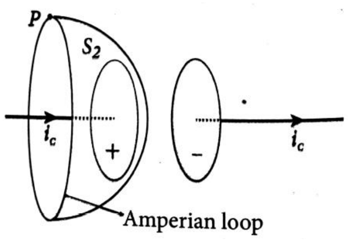



- Ampere's circuital law can be used to find the magnetic field produced around the current carrying wire.
- To calculate the magnetic field at a point P near the wire and outside the capacitor, let us draw a circular amperian loop which encloses the circular surface S1.
- Using ampere's circuital law for this loop we get

$$\oint_{\text{enclosing } S_1} \vec{B}\cdot d\vec{l} = \mu_0 i_C$$

***(upto)*** 1

- where $\mu_o$ is the permeability of free space.



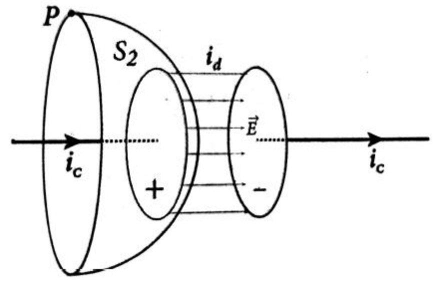

- Now the same loop is enclosed by balloon shaped surface $S_2$ such that boundaries of two surfaces $S_1$ and $S_2$ are same but the shape of the surfaces is different.

- As ampere's law applied for a given closed loop does not depend on the shape of the enclosing surface, the integrals should give the same answer. But by applying Ampere's circuital law for the surface $S_2$, we get

$$\oint_{\text{enclosing } S_2} \vec{B}\cdot d\vec{l} = 0$$

***(upto)*** 1

- The right hand side of equation is zero because the surface S2 nowhere touches the wire carrying conduction current and further, there is no current flowing between the plates of the capacitor.
- So the magnetic field at a point P is zero.
- Time varying electric field (or time varying electric flux) produces a current. This is known as displacement current flowing between the plates of the capacitor.




- From Gauss's law of electrostatics, the electric flux between the plates of the capacitor is

$$\Phi_E = \oint_S \vec{E}\cdot d\vec{A} = EA = \frac{q}{\epsilon_\circ}$$ ½

where A is the area of the plates of capacitor. The change in electric flux is given by

$$\frac{d\Phi_E}{dt} = \frac{1}{\epsilon_o}\frac{dq}{dt} \quad \text{(or)}$$

$$\frac{dq}{dt} = \epsilon_o \frac{d\Phi_E}{dt}$$

$$i_d = \epsilon_o \frac{d\Phi_E}{dt}$$ 1

where dq/dt = id is known as displacement current or maxwell's displacement current

- The displacement current can be defined as **the current which comes into play in the region in which the electric field (or the electric flux) is changing with time.** ½
- whenever the change in electric field takes place, displacement current is produced
- Maxwell modified Ampere's law as

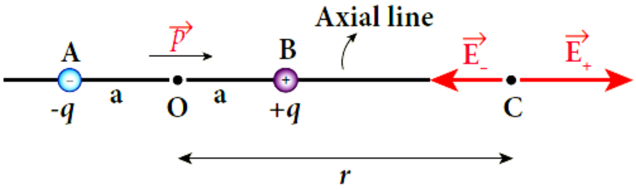
$$\oint_l \vec{B}.d\vec{l} = \mu_0 i = \mu_0 [i_c + i_d]$$

$$\oint_l \vec{B}.d\vec{l} = \mu_0 i_c + \mu_0 \epsilon_0 \frac{d\Phi_E}{dt}$$ 1

38. (a)

**Electric field due to a dipole at a point:**

- Consider an electric dipole placed on the x-axis as shown in Figure. A point C is located at a distance of *r* from the midpoint O of the dipole along the axial line. ½




1

- The electric field at a point C due to +q is

$$\vec{E}_+ = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2} \text{ along BC}$$

- Since the electric dipole moment vector is from –q to +q and is directed along BC, the above equation is rewritten as

$$\vec{E}_+ = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2}\hat{p}$$ ½

- where *p*is the electric dipole moment unit vector from –q to +q.
- The electric field at a point C due to –q is

$$\vec{E}_- = -\frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}\hat{p}$$ ½

- The total electric field at point C is calculated using the superposition principle of the electric field.

$$\vec{E}_{tot} = \vec{E}_+ + \vec{E}_-$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2}\hat{p} - \frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}\hat{p}$$ ½

$$\vec{E}_{tot} = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2}\right)\hat{p}$$

$$\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}q\left(\frac{4ra}{(r^2-a^2)^2}\right)\hat{p}$$ ½

- If the point C is very far away from the dipole then (r >> a). Under this limit the term Substituting this into equation

$$\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}\left(\frac{4aq}{r^3}\right)\hat{p} \quad (r >> a)$$

$$\text{since } 2aq\,\hat{p} = \vec{p}$$ ½

$$\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}\frac{2\vec{p}}{r^3}$$ 1

| | | |
|---|---|---|
| 38. (OR) (b) | **Nuclear reactor:**<br>Nuclear reactor is a system in which the **nuclear fission takes place in a self-sustained controlled manner** and the energy produced is used either for research purpose or for power generation. | 2 |
| | **Moderator:**<br>• The moderator is a material used to **convert fast neutrons into slow neutrons**.<br>**Example:**<br>• **water, heavy water ($D_2O$) and graphite** as moderators. | 1 |
| | **Control rods:**<br>• The control rods are used to adjust the reaction rate. During each fission, on an average 2.5 neutrons are emitted and in order to have the controlled chain reactions, only one neutron is allowed to cause another fission and the remaining neutrons are absorbed by the control rods.<br>**Example:**<br>• Usually **cadmium or boron** acts as control rod material. | 1 |
| | **Cooling system:**<br>• The cooling system removes the heat generated in the reactor core.<br>**Example:**<br>• **Ordinary water, heavy water and liquid sodium** are used as coolant<br>• since they have very high specific heat capacity and have large boiling point under high pressure. | 1 |



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87/100 சரவணன் பா Reg. No. 0551190285
87/100 சர்வேஸ் கோ த Reg. No. 0551190286
85/100 சர்விகா சு Reg. No. 0551190397
83/100 மிதுன்குமார் வெ ஞா Reg. No. 0551190340
81/100 ரோகித் ம Reg. No. 0551190360
81/100 நவினா த Reg. No. 0551190417
81/100 ராஸ்மிகா பு ரா Reg. No. 0551190441
80/100 பிரித்திகா மோ ம Reg. No. 0551190427