# HIGHER SECONDARY SECOND YEAR EXAMINATION – SEPTEMBER 2023

## PHYSICS KEY ANSWER

**Note:**

1. Answers written with **Blue** or **Black** ink only to be evaluated.
2. Choose the most suitable answer in Part A, from the given alternatives and write the option code and the corresponding answer.
3. For answers in Part-II, Part-III and Part-IV like reasoning, explanation, narration, description and listing of points, students may write in their own words but without changing the concepts and without skipping any point.
4. In numerical problems, if formula is not written, marks should be given for the remaining correct steps.
5. In graphical representation, physical variables for X-axis and Y-axis should be marked.

### PART – I

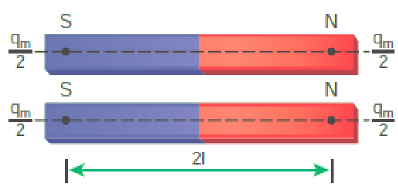
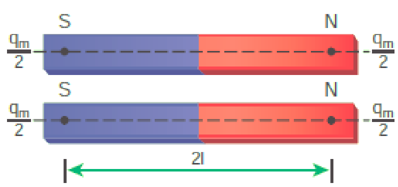
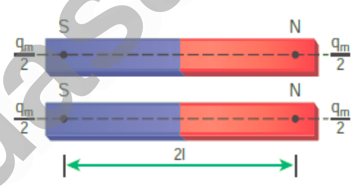
Answer all the questions. 15x1=15

| Q. No. | OPTION | TYPE – A | Q. No. | OPTION | TYPE – B |
|---|---|---|---|---|---|
| 1 | (b) | 8 mC | 9 | (d) | 5 μF |
| 2 | (a) | 6.25 x $10^{18}$ electrons | 10 | (b) | 0.83 |
| 3 | (c) | uniformly charged infinite plane | 11 | (c) | back emf is eual to applied emf |
| 4 | (c) | 3.5 Ω | 12 | (d) | Infrared |
| 5 | | All answer is wrong **(E value changes in English medium QP : E=1.2 given)** | 13 | (c) | an accelerating charge |
| 6 | (b) | $\frac{2E}{p}$ | 14 | (c) | refraction |
| 7 | (b) | $\frac{3}{\pi}$ $p_m$ | 15 | (a) | If the rays incident on the mirror are converging |
| 8 | (a) | 2 | | | |

### PART – II

Answer any **six** questions. Question number **24** is compulsory. 6x2=12

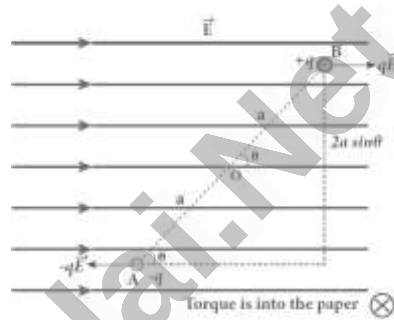
| | | | |
|---|---|---|---|
| 16 | **Smaller the radius of curvature, larger the charge density**. Hence charges are accumulated at the sharp points. Due to this, the electric field **near this sharp edge is very high and it ionized the surrounding air.** The **positive ions are repelled and negative ions are attracted** towards the sharp edge.<br>This **reduces the total charge of the conductor near the sharp edge.** This is called action of points or corona discharge | 2 | 2 |

<table>
<tr><td>17</td><td>It states that the heat develops in an electrical circuit due to the flow, current varies directly as (i) the square of the current (ii) the resistance of the circuit and (iii) the time of flow (i. e) H = $I^2Rt$</td><td>2</td><td>2</td></tr>
<tr><td>18</td><td>Generally alloys manganin / constantan / nichrome are used in metre bridge, because these materials have low temperature coefficient of resistivity and high melting point.</td><td>2</td><td>2</td></tr>
<tr><td>19</td><td>It state that the line integral of magnetic field over a closed loop is $\mu_0$ times net current enclosed by the loop.<br>(OR) $\oint \vec{B}.\vec{dl} = \mu_0 I_0$</td><td>2<br><br>1</td><td>2</td></tr>
<tr><td>20</td><td>Consider a bar magnet of magnetic moment. When a bar magnet first cut in two pieces. Along the axis, their magnetic moment is $\frac{M}{2}$<br><br><br>$\frac{M}{2}$<br>Each pieces is further cut into two pieces.<br><br><br>$-\frac{M}{4}$<br>$-\frac{M}{4}$<br><br><br>$-\frac{M}{4}$<br>$-\frac{M}{4}$<br>Their magnetic moment of each pieces $\frac{M}{4}$</td><td>1<br><br>1</td><td>2</td></tr>
<tr><td>21</td><td>When the frequency of the applied source is equal to the natural frequency of the RLC circuit, the current in the circuit reaches it maximum value. Then the circuit is said to be in electrical resonance. The frequency at which resonance takes place is called resonant frequency. Hence the condition for resonance is: $X_L = X_C$</td><td>2</td><td>2</td></tr>
<tr><td>22</td><td>When the spectrum obtained from the Sun is examined, it consists of large number of dark lines (line absorption spectrum). These <u>dark lines in the solar spectrum are known as Fraunhofer lines.</u><br>The absorption spectra for various materials are compared with the Fraunhofer lines in the solar spectrum, which helps to identifying elements present in the Sun's atmosphere.</td><td>1<br><br>1</td><td>2</td></tr>
<tr><td>23</td><td>When light entering water from outside is seen from inside the water, the view is restricted to a particular angle equal to the critical angle $i_C$. The restricted illuminated circular area is called Snell's window.</td><td>2</td><td>2</td></tr>
</table>

<table>
<tr><td>24</td><td>The maximum torque experienced by the dipole is when it is aligned perpendicular to the applied field.<br>$\tau_{max} = pE \sin 90^0$ ; = 3.4 x$10^{-30}$ x 3x$10^4$ N m<br>$\tau_{max} =$ 10.2x$10^{-26}$ Nm.</td><td>1½<br>½</td><td>2</td></tr>
</table>

## PART – II

Answer **any six** questions. Question number **33 is compulsory.** 6x3=18

<table>
<tr><td>25</td><td>Let a dipole of moment $\vec{p}$ is placed in an uniform electric field $\vec{E}$<br><br>The force on '+ q' = + q$\vec{E}$<br>The force on '−q' = − q $\vec{E}$<br>Then the total force acts on the dipole is zero. But these two forces constitute a couple and the dipole experience a torque which tends to rotate the dipole along the field. The total torque on the dipole about the point 'O'<br>$\vec{\tau} = \overrightarrow{OA} \times \left(-q\vec{E}\right) + \overrightarrow{OB} \times \left(+q\vec{E}\right)$ ;<br>$|\vec{\tau}| = \left|\overrightarrow{OA}\right|\left|-q\vec{E}\right|\sin\theta + \left|\overrightarrow{OB}\right|\left|q\vec{E}\right|\sin\theta$<br>$\tau$ = (OA + OB) q$E$ sin θ ; $\tau$ = 2 $a$ q E sin θ    ∵ [OA = OB = $a$]<br>$\tau$ = $p$ E sin θ (Where, 2 $a$ q = $p$ ⟶ dipole moment)<br>In vector notation, $\vec{\tau} = \vec{p} \times \vec{E}$ . The torque is maximum, when θ = $90^0$</td><td>3</td><td>3</td></tr>
<tr><td>26</td><td><table><tr><th>Drift velocity</th><th>Mobility</th></tr><tr><td>The average velocity acquired by the free electrons inside the conductor when it is subjected to an electric field is called drift velocity ($\vec{v}_d$). Its unit is $ms^{-1}$</td><td>The magnitude of drift velocity acquired by the free electrons per unit electric field is called mobility ($\mu$). Its unit is $m^2V^{-1}$ $s^{-1}$</td></tr></table></td><td>3</td><td>3</td></tr>
<tr><td>27</td><td>An ammeter is used to measure the current in a circuit.<br>An ammeter is a low resistance device.<br>Low resistance is due to the fact that it can draw up current with minimal loss in a circuit.<br>It is connected in series with the circuit.<br>If it is connected in parallel all the current would flow through the ammeter thus damaging the meter.<br>An ammeter is connected in series to a circuit to measure the amount of current flowing through the circuit with high accuracy.</td><td>1 ½<br>1 ½</td><td>3</td></tr>
</table>

| | | | |
|---|---|---|---|
| 28 | **Curie temperature.**<br>As **temperature increases, the ferromagnetism decreases** due to the increased thermal agitation of the atomic dipoles. At a particular temperature, ferromagnetic material becomes paramagnetic. This temperature is known as Curie temperature ($T_C$).<br>**Curie - Weiss law.**<br>The susceptibility of the material above the Curie temperature is given by $\chi_m = \frac{C}{T - T_0}$ Where, C → Curie law; T → Kelvin temperature<br>This relation is called Curie - Weiss law. | 1 ½<br>1 ½ | 3 |
| 29 | **Energy losses in a transformer:**<br>**(i) Core loss or Iron loss:**<br>Hysteresis loss and eddy **current loss** are known as **core loss or Iron loss.** When transformer core is magnetized or demagnetized repeatedly by the alternating voltage applied across primary coil, hysteresis takes place and some energy lost in the form of heat. It is **minimized by using silicone steel in making transformer core.**<br>Alternating magnetic flux in the core induces eddy currents in it. Therefore, there is energy loss due to the flow of eddy current called **eddy current loss.** It is **minimized by using very thin laminations of transformer core.**<br>(ii) Copper loss:<br>The primary and secondary coils in transformer have electrical resistance. When an electric current flows through them, some amount of energy is dissipated due to **Joule's heating** and it is known as **copper loss**. It is **minimized by using wires of larger diameter (thick wire)**<br>(iii) Flux leakage:<br>The magnetic flux linked with primary coil is **not completely linked** with secondary. Energy loss due to this flux leakage is **minimize by winding coils one over the other.**<br>(Losses only write ) | 1<br>1<br>1<br>1 | 3 |
| 30 | $L$ = 400 x $10^{-3}$ H; $I_{eff}$ = 6 x $10^{-3}$A ; $f$ = 1000 Hz<br>**Inductive reactance, $X_L = L\omega = L \times 2\pi f$**<br>= 2 x 3.14 x 1000 x 0.4 ; =2512 Ω<br>Voltage across L, V = $IX_L$ = 6 x $10^{-3}$ x 2512<br>**V = 15.072V**$_{(RMS)}$ | 1<br>1<br>1 | 3 |
| 31 | Electromagnetic waves are **produced by any accelerated charge.** They do not require any medium for propagation. So **electromagnetic waves are non-mechanical wave**. They are **transverse in nature**, (i.e) the oscillating electric field vector, oscillation magnetic field vector and direction of propagation are mutually perpendicular to each other. They **travel with speed of light in vacuum or free space** and it is given by, C = $\frac{1}{\sqrt{\varepsilon_0 \mu_0}}$ = $3 \times 10^8 ms^{-1}$ | | 3 |

| | | | |
|---|---|---|---|
| | In a medium with permittivity '$\varepsilon$' and permeability '$\mu$', the speed of electromagnetic wave is less than speed in free space or vacuum. (i.e.) $\boldsymbol{v < c}$<br>Hence**, refractive index of the medium** is, $\mu = \frac{c}{v} = \sqrt{\varepsilon_r \mu_r}$<br>They are **not deflected by electric or magnetic field.**<br>They **show interference, diffraction and polarization**.<br>The energy density (energy per unit volume) associated with and electromagnetic wave propagating in free space is $u = \varepsilon_0 E^2 = \frac{1}{\mu_0} \mathrm{B}^2$<br>The average energy density for electromagnetic wave is<br>$\langle u \rangle = \frac{1}{2} \varepsilon_0 E^2 = \frac{1}{2\mu_0} \mathrm{B}^2$<br>The **energy crossing per unit area per unit time and perpendicular to the direction of propagation of electromagnetic wave** is called the intensity.<br>They carry energy and momentum. The force exerted by an electromagnetic surface is called radiation pressure.<br>If the electromagnetic wave incident on a material surface is completely absorbed, then the energy delivered is 'U' and the momentum imparted on the surface is $p = \frac{U}{c}$,<br>If the incident electromagnetic wave of energy 'U' is totally reflected from the surface, then the momentum delivered to the surface is<br>$\Delta p = \frac{U}{c} - \left(-\frac{U}{c}\right) = 2\frac{U}{c}$<br>The rate of flow of energy crossing a unit area is known as pointing vector for electromagnetic waves. $\vec{S} = \frac{1}{\mu_0}\left(\vec{E} \mathrm{x} \vec{B}\right) = c^2 \varepsilon_0 \left(\vec{E} \mathrm{x} \vec{B}\right)$ | Any 6<br>6 x ½<br>=3 | |
| 32 | **Critical angle.**<br>The **angle of incidence in the denser medium for which the refracted ray graces the boundary** is called critical angle $i_c$<br>**Total internal reflection.**<br>**If the angle of incidence in the denser medium is greater than the critical angle, there is no refraction possible in the rarer medium**. The entire light is **reflected back in to the denser medium** itself; this phenomenon is called total internal reflection. | 1<br><br>2 | 3 |
| 33 | $R_T = R_0 (1 + \alpha T)$ ;<br>= 10[1+(0.004 x 100 - 20⁰]<br>$R_T$ = 10(1+0.004 x 80) = 10 (1+ 0.32) ; $R_T$ = 13.2 Ω<br>**As the temperature increases the resistance of the wire also increases.** | 1<br>1<br>1 | 3 |

## PART – IV

Answer **all** the questions. 5x5=25

34 **Van de Graff Generator:**

It is designed by Robert Van de Graff.

It produces large **electro static potential difference** of about **$10^7$ V**

**Principle:**

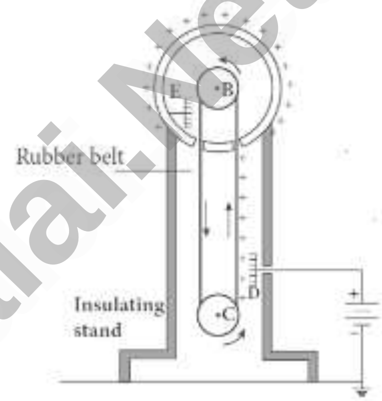
Electro static induction, Action of points

**Construction:**

It consists of large **hollow spherical conductor 'A'** fixed on the insulating stand.

**Pulley 'B'** is mounted at the centre of the sphere and another **pulley 'C'** is fixed at the bottom. A belt made up of insulating material like silk or rubber runs over the pulleys. 1

The **pulley 'C'** is driven continuously by **the electric motor**. Two comb shaped metallic conductor D and E are fixed near the pulleys. The comb 'D' is maintained at a **positive potential of $10^4$ V** by a power supply. The upper **comb 'E'** is connected to the inner side of the **hollow metal sphere.** 1




**Working:**

Due to the high electric field near comb 'D', air between the belt and comb 'D' gets ionized. **The positive charges are pushed towards the belt and negative charges are attracted towards the comb 'D'.** 5

The positive charges stick to the belt and move up. When the positive charges reach the comb 'E' a large amount of negative and positive charges are induced on either side of comb 'E' due to electrostatic induction. 1

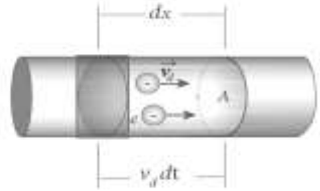
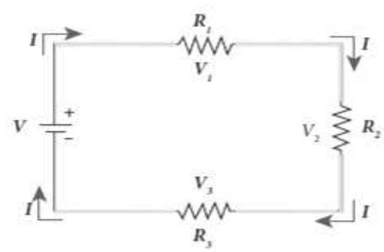
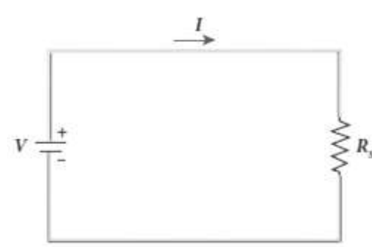
As a result, the positive charges are pushed away from the **comb 'E' and they reach the outer surface of the sphere.**

These positive charges are distributed uniformly on the outer surface of the hollow sphere. At the same time, **the negative charges neutralize the positive charges in the belt due to corona discharge before it passes over the pulley.** When the belt descends, it has almost no net charge.

This process continues until the outer surface produces the **potential difference of the order of $10^7$ V** which is the limiting value. Beyond this, the charge starts leaking to the surroundings due to ionization of air. It is prevented by enclosing the machine in a gas filled steel chamber at very high pressure.

**Applications:** 1

The high voltage produced in this **Van de Graff generator** is used to **accelerate positive ions (Protons and Deuterons**) for nuclear disintegrations and other applications.

<table>
<tr>
<td>34</td>
<td>
Microscopic model of current and Ohm' law:<br>
<br>
Area of cross section of the conductor = A<br>
Number of electrons per unit volume = $n$, Applied electric field $=\vec{E}$<br>
Drift velocity of electrons $= \boldsymbol{vd}$,<br>
Charge of an electrons = $e$<br>
Let '$dx$' be the distance travelled by the electron in time '$dt$', then<br>
$v_d = \frac{dx}{dt}$ $(or)$ $dx = v_d\ dt$<br>
The number of electrons available in the volume of length '$dx$' is<br>
= A $dx$ X n ; = A $v_d$ $dt$ X n<br>
Then the total charge in this volume element is, $dQ = A\ v_d\ dt\ n\ e$<br>
By definition, the current is given by I = $\frac{dQ}{dt}$ ; = $\frac{A\ v_d\ dt\ n\ e}{dt}$ ; I = n e A V<sub></sub>$_d$<br>
Current density (J):<br>
Current density (J) is defined as the current per unit area of cross section of the conductor. J = $\frac{I}{A}$ ; = $\frac{n\,e\,A\,v_d}{A}$. J = ne $v_d$. Its unit is $Am^{-2}$<br>
In vector notation, $\vec{J} = ne\vec{v}_d$ ; $\vec{J} = ne\left[-\frac{e\tau}{m}\vec{E}\right]$ ; $= -\frac{ne^2\tau}{m}\vec{E}$<br>
Where, $\frac{ne^2\tau}{m} = \sigma \rightarrow$ Conductivity; $\therefore \vec{J} = -\sigma\vec{E}$<br>
But conventionally, we take the direction of current density as the direction of electric field. So the above equation becomes, $\vec{J} = \sigma\vec{E}$<br>
This is called microscopic form of Ohm's law.
</td>
<td>1<br><br>1<br><br>1<br><br>1<br><br>1</td>
<td>5</td>
</tr>
<tr>
<td>35</td>
<td>
Resistors in Series:<br>
When two or more resistors are connected end to end, they are said to be in series. Let $R_1$, $R_2$, $R_3$ be the resistances of three resistors connected in series. Let "V" be the potential difference applied across this combination. In series connection i) Current through each resistor will be same (I) ii) But potential difference across different resistor will be different.<br>
<br>
<br>
(a) Three resistors in series<br>
<br>
<br>
(b) Equivalent resistance ($R_s$) has the same current<br>
Let $V_1$, $V_2$, $V_3$ be the potential difference across $R_1$, $R_2$, $R_3$ respectively, then from Ohm's law. $V_1 = IR_1$ ; $V_2 = IR_2$, $V_3 = IR_3$<br>
Total potential difference, $V = V_1 + V_2 + V_3$ ;<br>
$= IR_1 + IR_2 + IR_3$<br>
$V = I[R_1 + R_2 + R_3]$ ................ (1)<br>
Let Rs be the equivalent resistance in series connection, then<br>
$V = IR_s$ ...........(2)
</td>
<td>2 ½</td>
<td>5</td>
</tr>
</table>

From equation (1) and (2), we have

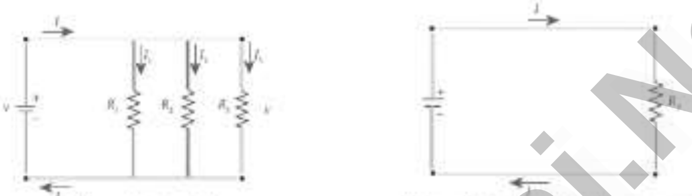
$IR_s = I\,[R_1 + R_2 + R_3]$ ; $\therefore R_s = R_1 + R_2 + R_3$

When resistances are connected in series, **the equivalent resistance** is the **sum of the individual resistances**. The equivalent resistance in series connection will be **greater than each individual resistance**.

**Resistors in Parallel:**

When two or more resistors are connected across the same potential difference, they are said to be in parallel. Let **$R_1$, $R_2$, $R_3$ be the resistances of three resistors connected in parallel.** Let **"V" be the potential difference** applied across this combination.

In parallel connection, i) Potential difference across each resistance will be the same (V) ii) But current flows through different resistors will be different.



(a) Three resistors in parallel (b) Equivalent resistance ($R_p$) has the same current

Let $I_1$, $I_2$, $I_3$ be the currents flow through $R_1$, $R_2$, $R_3$ respectively, then from Ohm's law. $I_1 = \frac{V}{R_1}$ ; $I_2 = \frac{V}{R_2}$ ; $I_3 = \frac{V}{R_3}$

$I = I_1 + I_2 + I_3$ ; $= \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$ ; $I = V\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right]$ .........(1)

Let $R_p$ be the equivalent resistance in parallel connection, then

$$I = \frac{V}{R_p} \quad \text{....................} \ (2)$$

From equation (1) and (2), we have $\frac{V}{R_p} = V\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right]$

$$\therefore \frac{1}{R_p} = \left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right]$$

When resistances are connected in parallel, the reciprocal of equivalent resistance is **equal to the sum of the reciprocal** of the values of resistance of the individual resistor.

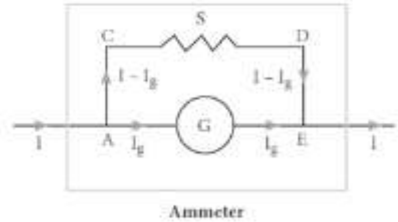
The equivalent resistance in **parallel connection will be lesser than** each individual resistance.

2 ½

35 **Galvanometer to an Ammeter:**

Ammeter is an instrument used to measure current. A galvanometer is **converted into an ammeter by connecting a low resistance called shunt in parallel with the galvanometer**. 1

Diagram




The scale is calibrated in amperes. ½

Galvanometer resistance = $R_{G;}$

Shunt resistance = S

Current flows through galvanometer = $I_G$

Current flows through shunt resistance = $I_S$

Current to be measured = I

**The potential difference across galvanometer is same as the potential difference shunt resistance.** (i.e.) $V_{Galvanometer} = V_{shunt}$

$I_g R_g = I_S S$

$I_g R_g = (I - I_g) S \quad --- (1)$ ; $\quad S = \frac{I_g}{I - I_g} R_g$ **(OR)**

From equation (1) $I_g R_g = S I - I_G S$ 1

$I_g (S + R_g) = S I$ ; $I_G = \frac{S}{S + R_g} I$

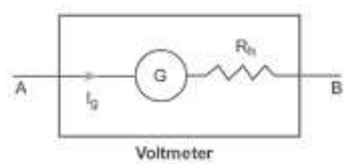
Let Ra be the resistance of ammeter, then $\frac{1}{R_{eff}} = \frac{1}{R_G} + \frac{1}{S}$ **(OR)**

$\Longrightarrow R_{eff} = \frac{R_g S}{R_g + S}$ **(OR)** $\theta = \frac{1}{G} I_g$ **(OR)** $\theta \propto I_g$ **(OR)** $\theta \propto I$

Here, $R_G > S > R_a$ 5

Thus an ammeter is a low resistance instrument, and it always **connected in series to the circuit. An ideal ammeter has zero resistance.** ½

**Galvanometer to a voltmeter:**




A voltmeter is an instrument used to measure potential difference across any two points. **A galvanometer is converted in to voltmeter by connecting high resistance in series** with the galvanometer. ½

The scale is calibrated in volts.

Galvanometer resistance = $R_G$,

High resistance = $R_h$ ½

Current flows through galvanometer= $I_G$

Voltage to be measured = V, Total resistance of this circuit = $R_G + R_h$

Here the **current in the electrical circuit is same as the current passing through the galvanometer**. (i.e) $I_G = I$ 1

$I_G = \frac{V}{R_G + R_h}$ (or) $R_G + R_h = \frac{V}{I_G}$ ; $\therefore R_h = \frac{V}{I_G} - R_G$

Let $R_V$ be the resistance of voltmeter, then $R_V = R_G + R_h$. Here,

$R_G < R_h < R_v$ ½

Thus an voltmeter is a high resistance instrument, and it always **connected in parallel to the circuit element. An ideal ammeter has zero resistance.**

36 **Cyclotron:**

It is a device used to **accelerate the charged particles to gain large kinetic energy.** It is also called as **high energy accelerator**. It is invented by Lawrence and Livingston.

**Principle:**

When a **charged particle** moves normal to the **magnetic field**, it experience **magnetic Lorentz force.**

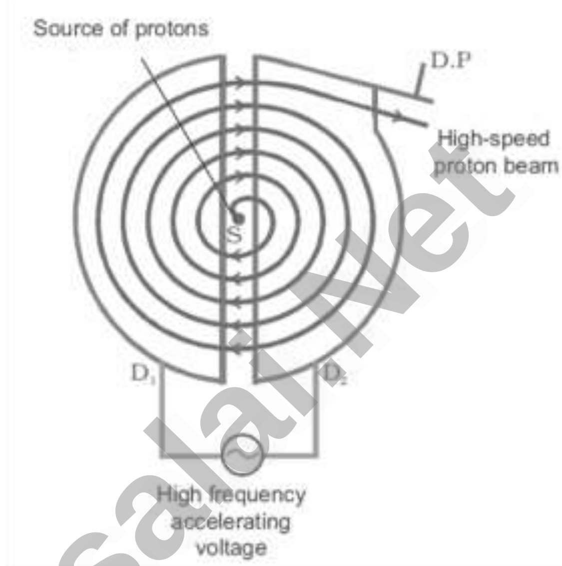
**Construction**:

It consists two semicircular metal containers called Dees.

The Dees are enclosed in an evacuated chamber and it is kept in a region of uniform magnetic field acts normal to the plane of the Dees. 1 1

The two Dees are kept separated with a gap and the source 'S' of charged particles to be accelerated is placed at the centre in the gap between the Dees.

Dees are connected to high frequency alternating potential difference. 5




**Working:**

Let the positive ions are ejected from source 'S'. It is accelerated towards a Dee-1 which has negative potential at that instant. Since the magnetic field is normal to the plane of the Dees, the ion undergoes circular path. After one semi-circular path in Dee-1, the ion reaches the gap between Dees. 1

At this time the polarities of the Dees are reversed, so that the ion is now accelerated towards Dee-2 with a greater velocity. For this circular motion, the centripetal force of the charged particle is provided by Lorentz force, then $\frac{mv^2}{r} = Bqv$ ; $r = \frac{m\,v}{Bq}$ ; $\therefore \quad r \propto v$

Thus the increase in velocity increases the radius of the circular path. Hence the particle undergoes spiral path of increasing radius. Once it reaches near the edge, it is taken out with help of deflector plate and allowed to hit the target T. 1 The important condition in cyclotron is the resonance condition. (i.e.) the frequency '$f$' of the charged particle must be equal to the frequency of the electrical oscillator '$f_{osc}$' . Hence

$$f_{osc} = \frac{Bq}{2\pi m}$$

The time period of oscillation is, $T = \frac{2\pi m}{Bq}$ , 1

The kinetic energy of the charged particle is, $KE = \frac{1}{2}mv^2 = \frac{B^2q^2r^2}{2m}$

<table>
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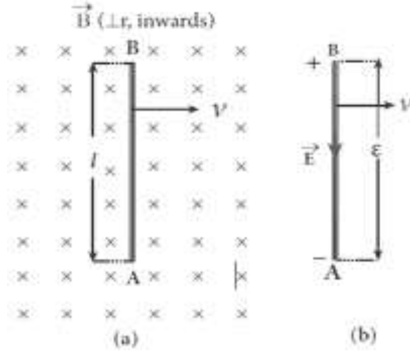
<tr><td>36</td><td>

**Motional emf from Lorentz force:**

Consider a straight conductor rod AB of length ‘$l$’ in a uniform magnetic field $\vec{B}$, which is directed perpendicularly in to plane of the paper. Let the rod move with a constant velocity $\vec{v}$ towards right side. When the rod moves, the free electrons present in it also move with same velocity $\vec{v}$ in $\vec{B}$.




As a result, the Lorentz force acts on free electron in the direction from B to A and it is given by,

$\vec{F}_B = -e(\vec{v} \times \vec{B})$ ............ (1)

Due to this force, all the free electrons are accumulate at the end A which produces the potential difference across the rod which in-turn establishes an electric field $\vec{E}$ directed along BA. Due to the electric field, the Coulomb force starts acting on the free electron along AB and it is given by,

$$\vec{F}_E = -e\vec{E} ---- (2)$$

At equilibrium, $|\vec{F}_B| = |\vec{F}_E|$ ; $|e(\vec{v} \times \vec{B})| = |-e\vec{E}|$

B e v sin 90$^0$ = eE ; Bv = E ............ (3)

The potential difference between two ends of the rod is, $V = E\,l = Bvl$

Thus the Lorentz force on the free electrons is responsible to maintain this potential difference and hence produces an emf

$$\epsilon = B\,l\,v \quad ---- (4)$$

Since this emf is produced due to the movement of the rod, it is often called as motional emf.

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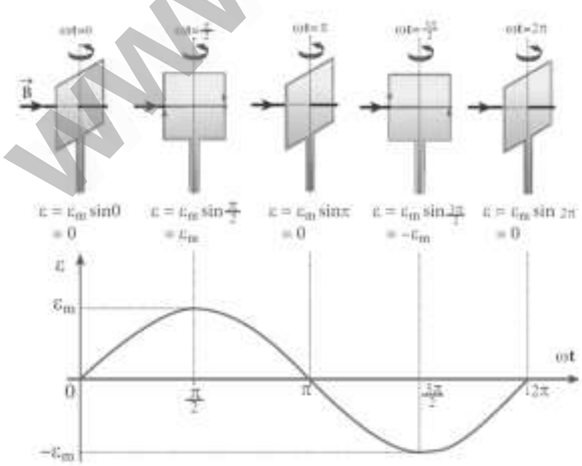
**Induction of emf by changing relative orientation of the coil with the magnetic field:**




Consider a rectangular coil of ‘N’ turns kept in a uniform magnetic field ‘B’. The coil rotates in anti-clockwise direction with an angular velocity ‘$\omega$’ about an axis. Initially let the plane of the coil be perpendicular to the field ($\theta$ = 0) and the flux linked with the coil has its maximum value.

(i.e.) $\Phi_m = B\,A$

In time‘t’, let the coil be rotated through an angle $\theta$ (= $\omega t$), then the total flux linked is,

$N\Phi_B = N\,B\,A\cos\omega t = N\Phi_m \cos\omega t$

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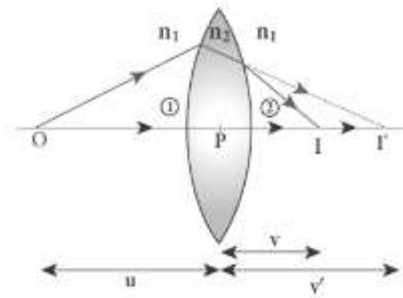
| | According to Faraday's law, the emf induced at that instant is,<br>$\in = -\frac{d}{dt}(N\Phi_B) = -\frac{d}{dt}(N\Phi_m \cos\omega t)$<br>$-N\Phi_m(-\sin\omega t)$<br>$\in = \boldsymbol{N\Phi_m \,\omega \sin \omega t}$ ................. (1)<br>When $\theta$ = 90°, then the induced emf becomes maximum and it is given by, $\in_m = \boldsymbol{N\Phi_m\omega}$ **; = N B A** $\boldsymbol{\omega}$ ................. (2)<br>Therefore, the value of induced emf at that instant is then given by,<br>$\in = \in_m \boldsymbol{\sin \omega t}$................. (3)<br>Thus the induced emf varies as sine function of the time angle and this is called sinusoidal emf or alternating emf.<br>If this alternating voltage is given to a closed circuit, a sinusoidal varying current flows in it. This current is called alternating current an is given by,<br>$\boldsymbol{i} = I_m \boldsymbol{\sin \omega t}$ – – – – – (4)<br>Where, $I_m$ → peak value of induced current | 1<br><br>1<br><br>1 | |
| 37 | **Emission spectra:**<br>The **light from self-luminous source gives emission** spectrum.<br>Each source has its own characteristic emission spectrum.<br>The emission spectrum can be divided in to three types;<br>**(i) Continuous emission spectra:**<br>Incandescent solids, liquids give continuous spectra.<br>It consists of wavelengths containing all the visible colours ranging from violet to red.<br>**(e.g.) Spectrum obtained from carbon arc, incandescent filament lamp, etc**<br>**(ii) Line emission spectra:**<br>**Light from excited atoms gives line spectrum. They are also known as discontinuous spectra.**<br>The line spectra are sharp lines of definite wavelengths or frequencies. It is different for different elements<br>**(e.g.) spectra of atomic hydrogen, helium, etc**<br>**(iii) Band emission spectra:**<br>**The light from excited molecules gives band spectrum. It consists of several numbers of very closely spaced spectral lines which overlapped together forming specific coloured** bands. This spectrum has a sharp edge at one end and fades out at the other end.<br>Band spectrum is the characteristic of the molecule.<br>**(e.g.) spectra of hydrogen gas, ammonia gas in the discharge tube, etc** | ½<br><br>1 ½<br><br>1 ½<br><br>1 ½ | 5 |

38 **Lens maker's formula:**

A thin lens of refractive index $n_2$ is placed in a medium of refractive index $n_1$. Let $R_1$ and $R_2$ be radii of curvature of two spherical surfaces ① and ② respectively

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Let P be pole of the lens and O be the Point object.

Here $I'$ be the image to be formed due the refraction at the surface ① and $I$ be the final image obtained due the refraction at the surface ②

We know that, equation for single spherical surface

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

1

For refracting surface ①, the light goes from $n_1$ to $n_2$, Hence

$$\frac{n_2}{v'} - \frac{n_1}{u} = \frac{n_2 - n_1}{R_1} \quad \text{.............. (1)}$$

For refracting surface ②, the light goes from $n_2$ to $n_1$, Hence

$$\frac{n_1}{v} - \frac{n_2}{v'} = \frac{n_1 - n_2}{R_2} \quad \text{.............. (2)}$$

1

Adding equation (1) and (2), we get,

$$\frac{n_2}{v'} - \frac{n_1}{u} + \frac{n_1}{v} - \frac{n_2}{v'} = \frac{n_2 - n_1}{R_1} + \frac{n_1 - n_2}{R_2}$$

5

$$\frac{n_1}{v} - \frac{n_1}{u} = (n_2 - n_1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{v} - \frac{1}{u} = \frac{(n_2 - n_1)}{n_1}\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

1

$$\frac{1}{v} - \frac{1}{u} = \left(\frac{n_2}{n_1} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \quad \text{...........(3)}$$

If the object is at infinity, the image is formed at the focus of the lens. Thus, $u = \infty, v = f$

Then equation becomes, $\frac{1}{f} - \frac{1}{\infty} = \left(\frac{n_2}{n_1} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

$$\frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \quad \text{..............(4)}$$

1

Here first medium is air and hence $n_1 = 1$ and let the refractive index of second medium be $n_2 = n$. Therefore $\frac{1}{f} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$..............(5)

The above equation is called lens maker's formula.

By comparing equation (3) and (4) $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

This equation is known as lens equation.

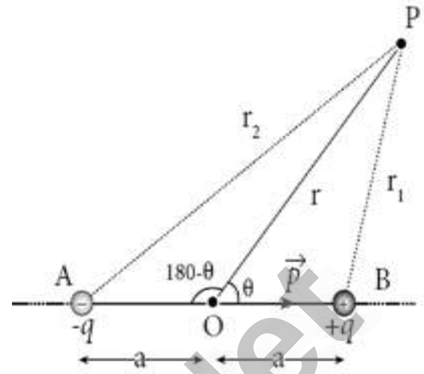
38

**Electrostatic potential due to dipole:**

Consider a dipole AB along X - axis. Its dipole moment be p = 2qa and its direction be along − q to + q

Let 'P' be the point at a distance 'r' from the midpoint 'O'

Let $\angle POA = \theta$, BP = $r_1$ and AP = $r_2$




**Electric potential at P due to +q** $V_1 = \frac{1}{4\pi\varepsilon_0}\frac{q}{r_1}$ 1

**Electric potential at P due to −q**

$$V_2 = -\frac{1}{4\pi\varepsilon_0}\frac{q}{r_2}$$

**Then total potential at 'P' due to dipole is**

**V = $V_1 + V_2$**

$$= \frac{1}{4\pi\varepsilon_0} q\left[\frac{1}{r_1} - \frac{1}{r_2}\right] \quad ................ (1)$$

1

Apply cosine law in Δ BOP

$$r_1^2 = r^2 + a^2 - 2ra\cos\theta \; ; \; r_1^2 = r^2\left[1 + \frac{a^2}{r^2} - \frac{2a}{r}\cos\theta\right]$$

If a << r then neglecting $\frac{a^2}{r^2}$; $r_1^2 = r^2\left[1 - \frac{2a}{r}\cos\theta\right]$

$$r_1 = r\left[1 - \frac{2a}{r}\cos\theta\right]^{\frac{1}{2}} \quad ; \frac{1}{r_1} = \frac{1}{r}\left[1 - \frac{2a}{r}\cos\theta\right]^{-\frac{1}{2}}$$

5

$$\frac{1}{r_1} = \frac{1}{r}\left[1 + \frac{a}{r}\cos\theta\right] \quad ..............(2)$$

1

Apply cosine law in Δ AOP

$$r_2^2 = r^2 + a^2 + 2ra\cos(180^0 - \theta) \; ; \; r_2^2 = r^2\left[1 + \frac{a^2}{r^2} + \frac{2a}{r}\cos\theta\right]$$

If a << r then neglecting $\frac{a^2}{r^2}$; $r_2^2 = r^2\left[1 + \frac{2a}{r}\cos\theta\right]$

$$r_2 = r\left[1 + \frac{2a}{r}\cos\theta\right]^{\frac{1}{2}} \quad ; \frac{1}{r_2} = \frac{1}{r}\left[1 + \frac{2a}{r}\cos\theta\right]^{-\frac{1}{2}}$$

$$\frac{1}{r_2} = \frac{1}{r}\left[1 - \frac{a}{r}\cos\theta\right] \quad ..............(3)$$

1

$$V = \frac{1}{4\pi\varepsilon_0} q\left(\frac{1}{r}\left[1 + \frac{a}{r}\cos\theta\right] - \frac{1}{r}\left[1 - \frac{a}{r}\cos\theta\right]\right)$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}\left[1 + \frac{a}{r}\cos\theta - \left[1 + \frac{a}{r}\cos\theta\right]\right]$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}\frac{2a}{r}\cos\theta \; ; = \frac{1}{4\pi\varepsilon_0}\frac{2qa}{r^2}\cos\theta$$

| | | | |
|---|---|---|---|
| | $= \frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}\cos\theta$ [p = 2qa]<br>Or V = $\frac{1}{4\pi\varepsilon_0}\frac{\vec{p}.\hat{r}}{r^2}$ [pcos $\theta = \vec{p}.\hat{r}$]<br>Here $\hat{r}$ is the unit vector along OP<br>**Special cases**<br>**Case (i)** If the point P lies on the **axial line** of the dipole on the side of +q, then **θ = 0.** Then the electric potential becomes V = $\frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}$<br>**Case (ii)** If the point P lies on the **axial line** of the dipole on the side of –q, **then θ = 180⁰**, then V = $-\frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}$<br>**Case (iii)** If the point P lies on the **equatorial line** of the dipole, then **θ = 90⁰.** Hence V = 0 | 1 | |