CBSE Board
Class XII Physics – Set 1
Board Paper - 2008

Time: 3 hours **Total Marks: 70**

General instructions:

1. All questions are compulsory.
2. There are 30 questions in total. Questions 1 to 8 are very short answer type questions and carry one mark each.
3. Questions 9 to 18 carry two marks each, questions 19 to 27 carry three marks each and questions 28 to 30 carry five marks each.
4. There is no overall choice. However, an internal choice has been provided in one question of two marks, one question of three marks and all three questions of five marks each. You have to attempt only one of the given choices in such questions.
5. Use of calculators in not permitted. However, you may use log tables if necessary.
6. You may use the following values of physical constants wherever necessary.
   $c = 3 \times 10^{8}$ ms^{-1}
   $h = 6.626 \times 10^{-34}$ Js
   $e = 1.602 \times 10^{-19}$ C
   $\mu_o = 4\pi \times 10^{-7} TmA^{-1}$
   $\frac{1}{4\pi\varepsilon_o} = 9 \times 10^{-9} Nm^2C^{-2}$
   Mass of electron $m_e = 9.1 \times 10^{-31}$ kg
   Mass of neutron $m_n \cong 1.675 \times 10^{-27}$ kg
   Boltzmann's constant $k = 1.381 \times 10^{-23}$ J K^{-1}
   Avogadro's number $N_A = 6.022 \times 10^{23}$ mol^{-1}
   Radius of earth = 6400 km

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1. What is the direction of the force acting on a charged particle q, moving with a velocity $\vec{v}$ in a uniform magnetic field $\vec{B}$?

2. Name the part of the electromagnetic spectrum of wavelength 10^{-2}m and mention its one application.

3. An electron and alpha particle have the same de-Broglie wavelength associated with them. How are their kinetic energies related to each other?

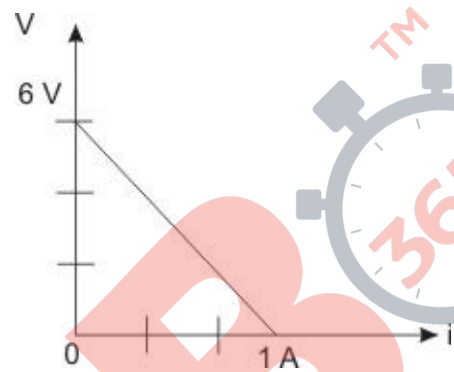
4. A glass lens of refractive index 1.5 is placed in a trough of liquid. What must be the refractive index of the liquid in order to make the lens disappear?

5. A 500 μC charge is at the center of a square of side 10 cm. Find the work done in moving a charge of 10 μC between two diagonally opposite points on the square.

6. State the reason, why heavy water is generally used as a moderator in a nuclear reactor.

7. How does the fringe width of interference fringes change, when the whole apparatus of Young's experiment is kept in a liquid of refractive index 1.3?

8. The plot of the variation of potential difference across a combination of three identical cells in series versus current is as shown below. What is the emf of each cell?



9. Derive the expression for the electric potential at any point along the axial line of an electric dipole?

10. Define magnetic susceptibility of a material. Name two elements, one having positive susceptibility and the other having negative susceptibility. What does negative susceptibility signify?

11. The oscillating magnetic field in a plane electromagnetic wave is given by:

$$B_y = \left(8x10^{-6}\right)\sin(2\times 10^{11}t + 300\pi x)T$$

(i) Calculate the wavelength of the electromagnetic wave.

(ii) Write down the expression for the oscillating electric field.

12. Prove that an ideal capacitor, in an a.c. circuit does not dissipate power.

OR

Derive an expression of the impedance of an ac circuit consisting of an inductor and a resistor.

13. A nucleus $^{23}_{10}Ne$ undergoes β^- decay and becomes $^{23}_{11}Na$. Calculate the maximum kinetic energy of electrons emitted assuming that the daughter nucleus and anti-neutrino carry negligible kinetic energy.

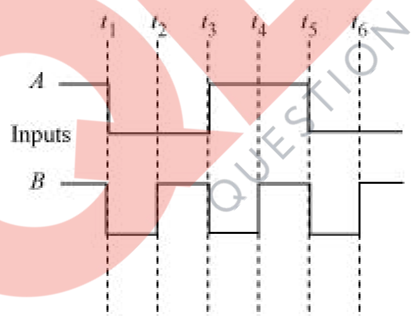
$$\begin{bmatrix} \text{mass of } ^{23}_{10}Ne = 22.994466\,u \\ \text{mass of } ^{23}_{10}Na = 22.989770\,u \\ 1\,u = 931.5\ MeV/c^2 \end{bmatrix}$$

14. Distinguish between an intrinsic semiconductor and p-type semiconductor. Give reason, why, a p-type semiconductor is electrically neutral, although $n_h >> n_e$?

15. Draw a ray diagram of a reflecting type telescope. State two advantages of this telescope over a refracting telescope.

16. A ray of light passing through an equilateral triangular glass prism from air undergoes minimum deviation when angle of incidence is $\frac{3}{4}$th of the angle of prism. Calculate the speed of light in the prism.

17. The given inputs *A*, *B* are fed to a 2-input NAND gate. Draw the output wave form of the gate.

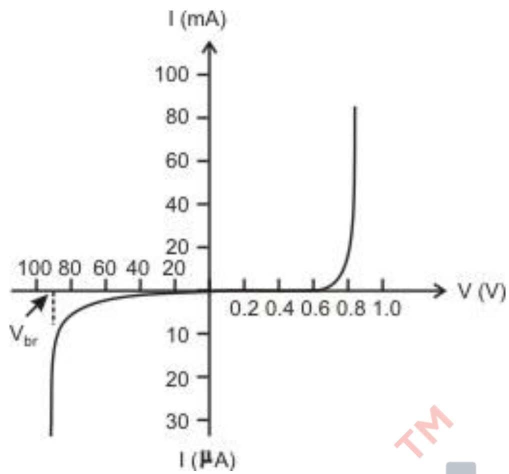


18. A transmitting antenna at the top of a tower has a height of 36m and the height of the receiving antenna is 49m. What is the maximum distance between them, for satisfactory communication in the LOS mode? (Radius of earth =6400km)

19. How is a wavefront defined? Using Huygen's construction draw a figure showing the propagation of a plane wave refracting at a plane surface separating two media. Hence verify Snell's law of refraction.

20. A metallic rod of length *l* is rotated at a constant angular speed ω, normal to a uniform magnetic field *B*. Derive an expression for the current induced in the rod, if the resistance of the rod is *R*.

21. The figure below shows the V-I characteristic of a semiconductor diode.



(i) Identify the semiconductor diode used.

(ii) Draw the circuit diagram to obtain the given characteristic of this device.

(iii) Briefly explain how this diode can be used as a voltage regulator.

22. An inductor 200 mH, a capacitor of 500 μF and a resistor of 10 Ω are connected in series to a 100 V, variable frequency a.c. source. Calculate the

(i) frequency at which the power factor of the circuit is unity

(ii) current amplitude at this frequency

(iii) Q-factor

23. Prove that the current density of a metallic conductor is directly proportional to the drift speed of electrons.

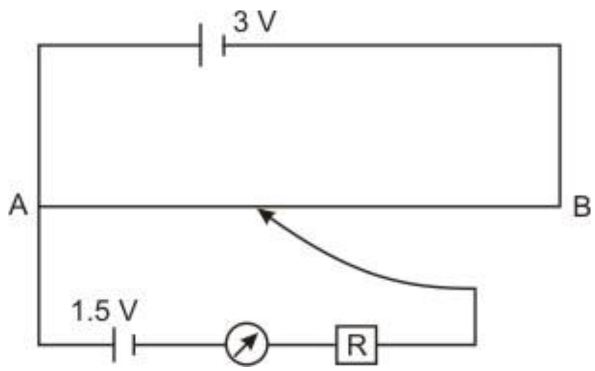
OR

A number of identical cells, n, each of emf E, internal resistance r connected in series are charged by a d.c. source of emf E', using a resistor R.

(i) Draw the circuit arrangement.

(ii) Deduce the expressions for (a) the charging current and (b) the potential difference across the combination of the cells.

24. A potentiometer wire of length 1 m is connected to a driver cell of emf 3 V as shown in the figure. When a cell of 1.5 V emf is used in the secondary circuit, the balance point is found to be 60 cm. On replacing this cell and using a cell of unknown emf, the balance point shifts to 80 cm



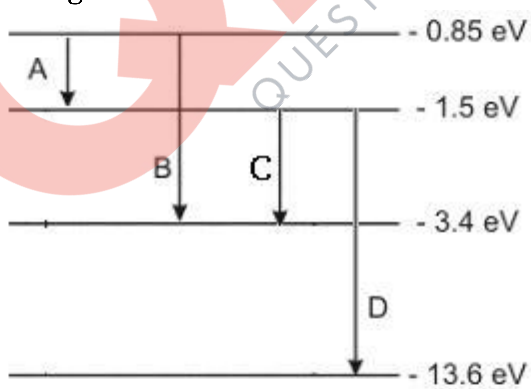
(i) Calculate unknown emf of the cell.

(ii) Explain with reason, whether the circuit works; if the driver cell is replaced with a cell of emf 1 V.

(iii) Does the high resistance R, used in the secondary circuit affect the balance point? Justify your answer.

25. An electromagnetic wave of wavelength λ is incident on a photosensitive surface of negligible work function. If the photo-electrons emitted from this surface have the deBroglie wavelength λ_1, prove that $\lambda = \left(\frac{2mc}{h}\right)\lambda_1^2$

26. The energy level diagram of an element is given below:
Identify, using necessary calculations, the transition, which corresponds to the emission of a spectral line of wavelength 102.7nm.



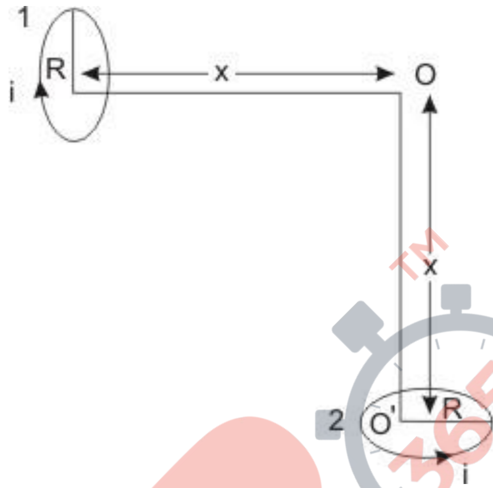
27. Draw a plot of the variation of amplitude with ω for an amplitude modulated wave. Define modulation index. State its importance for effective amplitude modulation.

28. Draw a schematic diagram of a cyclotron. Explain its underlying principle and working, stating clearly the function of the electric and magnetic fields applied on a charged particle. Deduce an expression for the period of revolution and shown that it does not depend on the speed of the charged particle.

OR

(a) Using Biot-Savart's law, derive an expression for the magnetic field at the centre of a circular coil of radius R, number of turns N, carrying current i.

(b) Two small identical circular coils marked 1, 2 carry equal currents and are placed with their geometric axes perpendicular to each other as shown in the figure. Derive an expression for the resultant magnetic field at O.



29.

(a) What is plane polarised light? Two polaroids are placed at 90° to each other and the transmitted intensity is zero. What happens when one more Polaroid is placed between these two, bisecting the angle between them? How will the intensity of transmitted light vary on further rotating the third polaroid?

(b) If a light beam shows no intensity variation when transmitted through a Polaroid which is rotated, does it mean that the light is unpolarised? Explain briefly.

OR

(a) For a ray of light traveling from a denser medium of refractive index n_1 to a rarer medium of refractive index n_2, prove that $\frac{n_2}{n_1} = \sin i_c$, where i_c is the critical angle of incidence for the media.

(b) Explain with the help of a diagram, how the above principle is used for transmission of video signals using optical fibres.

30.

(a) Using Gauss' law, derive an expression for the electric field intensity at any point outside a uniformly charged thin spherical shell of radius R and charge density $\sigma\ C/m^2$. Draw the field lines when the charge density of the sphere is (I) positive, (ii) negative.

(b) A uniformly charged conducting sphere of 2.5 m in diameter has a surface charge density of 100 μC/m². Calculate the

(i) Charge on the sphere

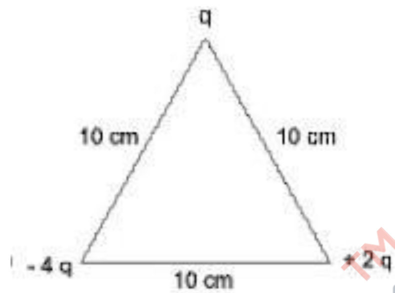
(ii) Total electric flux passing through the sphere.

OR

(a) Derive an expression or the torque experienced by an electric dipole kept in a uniform electric field.

(b) Calculate the work done to dissociate the system of three charges placed on the vertices of a triangle as shown.

Here, $q = 1.6 \times 10^{-10}$ C



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1. The force is given by $\vec{F} = q(\vec{v} \times \vec{B})$

This force is at right angles to $\vec{v}$ & $\vec{B}$.

2. Microwaves.
It is used in radar & communication purposes.

3. $\lambda = \frac{h}{\sqrt{2mK}}$

Or $K = \frac{h^2}{2m\lambda^2}$

As $\lambda_e = \lambda_\alpha$
$m_e < m_\alpha$
So, $K_e > K_\alpha$

4. The lens will not be visible if no refraction occurs at the liquid–glass interface. This means that the incident ray should go through the glass without any deviation. For this condition to be fulfilled, the refractive index of the liquid must be equal to 1.5.

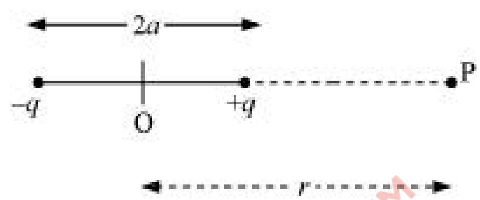
5. The 500 μC charge is at the same distance from all the corners of the square. The opposite corners, say A and C, will have the same potential $V_A = V_C$.
Work done in moving a charge *q* between points A and C is given as:
$W = q(V_C - V_A) = q \times 0 = 0$
Hence, no work is done in moving the charge between two diagonally opposite points on the square.

6. Because heavy water molecules do not absorb fast neutrons but simply them.

7. $\beta = \frac{\lambda D}{d}$
When light enters a denser medium, its wavelength decreases by a factor 1.3 and hence the fringe width also decreases by a factor 1.3.
The fringe width will decrease.

8. When no current is drawn from the cell, V becomes equal to E_{total}.
E = V + ir
i = 0, E = V
From graph, when i = 0, V = 6V
So, emf of each cell = $E_{total}/3 = 6/3 = 2$ V

9.



Let P be an axial point at distance *r* from the centre of the dipole. Electric potential at point P is given as

$$V = V_1 + V_2$$

V_1 and V_2 are the potentials at point P due to charges +q and -q respectively.

$$\therefore V = \frac{1}{4\pi\varepsilon_o}\left(\frac{q}{r-a} + \frac{-q}{r+a}\right) = \frac{q}{4\pi\varepsilon_o}\frac{2a}{r^2 - a^2}$$

$$= \frac{1}{4\pi\varepsilon_o}\left(\frac{p}{r^2 - a^2}\right)$$

10. Magnetic susceptibility: It is the ratio of the intensity of magnetisation (*I*) induced in the material to the magnetization force (*H*) applied on it.
Magnetic susceptibility is represented as:

$$\chi_m = \frac{I}{H}$$

Elements having positive susceptibility: aluminum, sodium.
Elements having negative susceptibility: antimony, copper.
The minus sign (-ve) signifies that the magnetic field is weakened in the presence of the material.

11.

(i) Standard equation of magnetic field is

$$B_y = B_o \sin(\omega t + kx)\,T$$

Comparing this equation with the given equation, we get

(ii) $E_o = B_o c = 8 \times 10^{-6} \times 3 \times 10^8 = 2.4 \times 10^3\,V/m$

According to right hand system of $\vec{E}$, $\vec{B}$, $\vec{K}$, the electric field oscillates along negative z-axis, so equation is

$$E_z = -2.4 \times 10^9 \sin(2 \times 10^{11} t + 300\pi x)\,V/m$$

12. We know average power in an capacitive circuit is given by

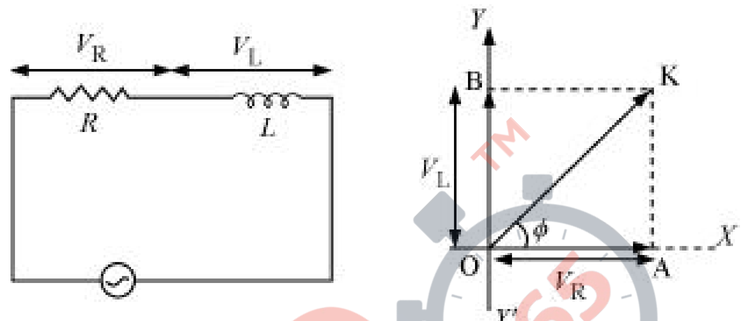
$P = E_v I_v \cos\Phi$

In a pure capacitor $\Phi = 90^0$ and $\cos 90^0 = 0$

So Power consumed in a pure conductor is zero

OR

Let an inductor *L* and resistor *R* be connected in series to a source of alternating *emf* as shown in the following figure.



The maximum voltage across resistor *R* is given as:

$\vec{V}_R = \vec{I}_o R$

In a resistor circuit, voltage $\vec{V}_R$ is in phase with current $\vec{I}_o$. It is represented by $\overrightarrow{OA}$ along OX.

The maximum voltage across inductor *L* is given as:

$\vec{V}_L = \vec{I}_o X_L$

In an inductive circuit, voltage $\vec{V}_L$ across the inductor leads the current $\vec{I}_o$ by 90°. It is represented by $\overrightarrow{OB}$ along OY.

The vector sum of potentials $\vec{V}_R$ and $\vec{V}_L$ is the voltage phasor ($\vec{E}_o$).

It is represented by $\overrightarrow{OK}$.

$$E_o = \left|\overrightarrow{OK}\right| = \sqrt{(OA)^2 + (OB)^2 + 2(OA)(OB)\cos 90^\circ}$$

$$= \sqrt{(OA)^2 + (OB)^2} = \sqrt{V_R{}^2 + V_L{}^2} = \sqrt{(I_o R)^2 + (I_o X_L)^2}$$

$$\therefore E_o = I_o\sqrt{R^2 + X_L{}^2}$$

The impendence of the circuit is given by:

$$Z = \frac{E_o}{I_o} = \frac{I_o\sqrt{R^2 + X_L{}^2}}{I_o}$$

$$Z = \sqrt{R^2 + X_L{}^2}$$

13. The reaction can be written as

$$^{23}_{10}Ne \rightarrow {}^{23}_{10}Na + \beta^- + \bar{\nu} + Q$$

where, where, Q = Kinetic energy of the daughter nucleus $^{23}_{11}Na$

Ignoring the rest mass of the anti-neutrino and the mass of the electron, the maximum kinetic energy of the emitted electron is given by,

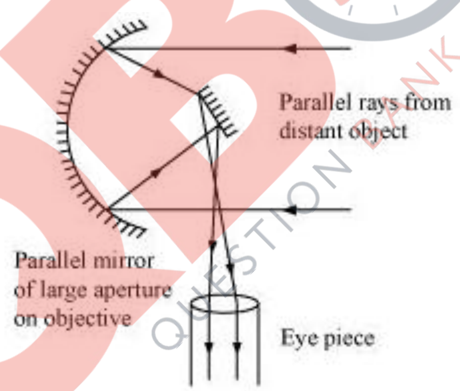
$$Q = [m\,^{23}_{10}Ne - \{m\,^{23}_{11}Na + m_e\}]u \times 931.5MeV$$

$$Q = (22.994466u - 22.989770u) \times 931.5MeV$$

$$Q = 0.004696 \times 931.5 = 4.374324MeV$$

14. An intrinsic semiconductor is a pure semiconductor where as a p-type semiconductor is a semiconductor doped with trivalent impurity atoms like boron or gallium. An intrinsic semiconductor has same number of holes and electrons while in a p-type semiconductor the number of holes is greater than the number of electrons. Each hole is associated with a nearby negative-charged dopant ion, and thus semiconductor remains electrically neutral as a whole.

15. Reflecting type telescope:



Advantages of a reflecting telescope over a refracting telescope:

1. Image formed by a reflecting telescope is brighter than that formed by a refracting telescope.

2. As the objective in a reflecting telescope is a mirror, the image formed by this telescope does not undergo any chromatic aberration.

16. Given: $i = \frac{3}{4}A$

For triangular prism, A=60°

$$\therefore i = \frac{3}{4} \times 60^{\circ} = 45^{\circ}$$

Using the prism formula, we can obtain the relation for the refractive index of the material of the prism as:

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\frac{A}{2}} = \frac{\sin i}{\sin\frac{A}{2}} \qquad \left[\because i = \frac{A+\delta_m}{2}\right]$$

However, $\mu = \frac{c}{v}$

Where,

c = Speed of light = 3×10^8 m/s

v = Speed of light in the prism

$$\therefore \frac{c}{v} = \frac{\sin i}{\sin\frac{A}{2}}$$

$$\frac{3\times10^8}{v} = \frac{\sin 45°}{\sin\frac{60°}{2}} = \frac{\sin 45°}{\sin 30°}$$

$$\therefore v = \frac{3\times10^8\times\sin 30°}{\sin 45°} = \frac{3\times10^8\times\frac{1}{2}}{\frac{1}{\sqrt{2}}} = 2.12\times10^8 \text{ m/s}$$

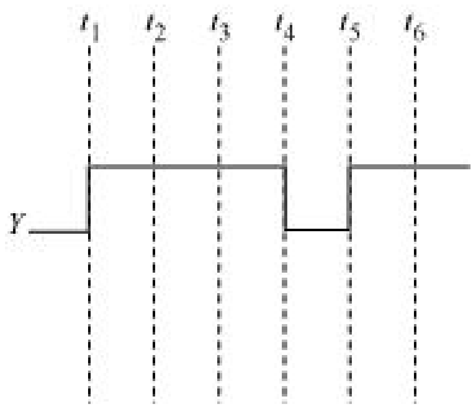
17. For NAND gates, the Boolean expression is written as:

$Y = \overline{A.B} = \overline{A} + \overline{B}$

For the given wave form,

Time interval	Input A	Input B	Output $Y = \overline{A.B} = \overline{A}+\overline{B}$
$t < t_1$	$A = 1$	$B = 1$	$0 + 0 = 0$
$t_1 < t < t_2$	$A = 0$	$B = 0$	$1 + 1 = 1$
$t_2 < t < t_3$	$A = 0$	$B = 1$	$1 + 0 = 1$
$t_3 < t < t_4$	$A = 1$	$B = 0$	$0 + 1 = 1$
$t_4 < t < t_5$	$A = 1$	$B = 1$	$0 + 0 = 0$
$t_5 < t < t_6$	$A = 0$	$B = 0$	$1 + 1 = 1$
$t_6 < t$	$A = 0$	$B = 1$	$1 + 0 = 1$

Thus, the waveform for output Y can be shown as



18. The maximum distance can be given as,

$$d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R}$$

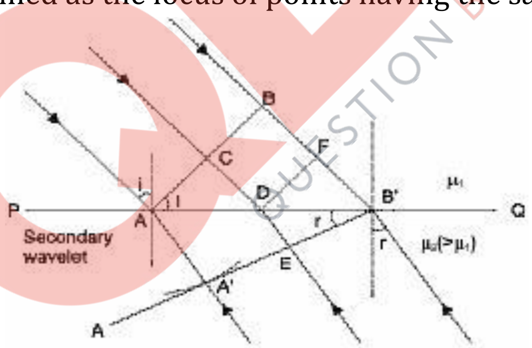
where h_T = height of transmitting antenna

h_R = height of receiving antenna

$$d_M = \sqrt{2 \times 6400 \times 10^3 \times 36} + \sqrt{2 \times 6400 \times 10^3 \times 49}$$

$$= 46510.21\text{m} = 46.51\text{km}$$

19. Wavefront: It is defined as the locus of points having the same phase of oscillation.



Let a plane wavefront AB be incident on a refracting plane surface PQ separating a rarer medium of refractive index μ_1 from a denser medium of refractive index μ_2 ($\mu_2 > \mu_1$). During the time the disturbance from B reaches B', the disturbance from A must have travelled a distance AA' = c_2t, where c_2 is the velocity of light in the rarer medium.

With A as center and AA' as radius, draw a sphere. Draw a sphere. Draw a tangent, to the sphere, from point B'. B'A' will be the refracted wavefront.

Let us now confirm the validity of the refracted wavefront. For A'EB' to be the true refracted wavefront, the following should be satisfied.

$$\frac{CD}{c_1}+\frac{DE}{c_2}=\frac{AA'}{c_2}=\frac{BB'}{c_1} \quad ...(1)$$

From D, draw DF parallel to ACB.

Now, $BF + FB' = BB'$

or $$\frac{BF}{c_1}+\frac{FB'}{c_1}=\frac{BB'}{c_1} \quad ...(2)$$

From (1) and (2), $\frac{CD}{c_1}+\frac{DE}{c_2}=\frac{BF}{c_1}+\frac{FB'}{c_1}$

or $$\frac{BF}{c_1}+\frac{DE}{c_2}=\frac{BF}{c_1}+\frac{FB'}{c_1} \quad [\because CD = BF]$$

or $$\frac{DE}{c_2}=\frac{FB'}{c_1}$$

$\Delta s\ ABB'$ and DFB' are similar.

Therefore, $$\frac{B'D}{B'A}=\frac{FB'}{B'B} \quad ...(3)$$

$\Delta s\ AA'B'$ and DEB' are similar.

Therefore, $$\frac{B'D}{B'A}=\frac{DE}{AA'} \quad ...(4)$$

From (4) and (3), $\frac{DE}{AA'}=\frac{FB'}{B'B}$ or $\frac{DE}{c_2 t}=\frac{FB'}{c_1 t}$ or $\frac{DE}{c_2}=\frac{FB'}{c_1}$

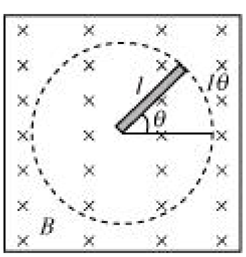
Let us now deduce the laws of refraction.

$$\sin i=\frac{BB'}{AB'} \quad \text{and} \quad \sin r=\frac{AA'}{AB'}$$

$$\therefore \quad \frac{\sin i}{\sin r}=\frac{BB'}{AB'}\times\frac{AB'}{AA'}=\frac{BB'}{AA'}=\frac{c_1 t}{c_2 t}=\frac{c_1}{c_2}=\text{constant}$$

This proves Snell's law of refraction.

20. The given situation can be shown as:



Let θ be the angle traced by the free end of the rod in time *t*. The area swept-out by the rod in time *t* is given as:

$$A=\pi l^2\times\left(\frac{\theta}{2\pi}\right)=\frac{l^2\theta}{2} \quad (1)$$

Since the angle between the area vector and the magnetic field vector is zero, the magnetic flux linked to this area is given as:

$$\phi = B\left(\frac{1}{2}l^2\theta\right)\cos 0^\circ \qquad [\because \text{Flux, } \phi = BA\cos\theta]$$

$$= \frac{1}{2}Bl^2\theta \qquad [\because \cos 0^\circ = 1]$$

According to Faraday's laws of electromagnetic induction, induced *emf* (e) is given as

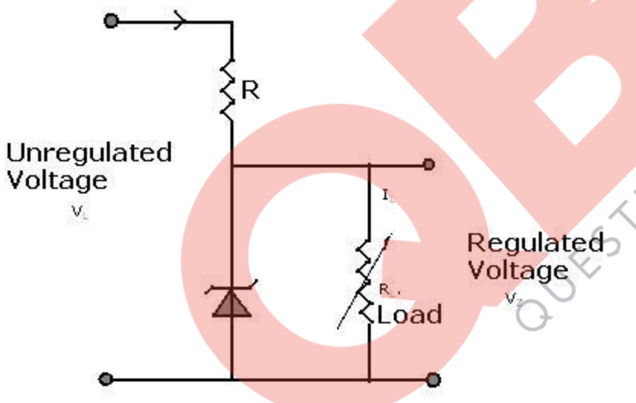
$$e = \frac{d\phi}{dt} = \frac{d}{dt}\left(\frac{1}{2}Bl^2\theta\right) = \frac{1}{2}Bl^2\omega \qquad [\because \omega = \frac{d\theta}{dt}]$$

Hence, the current induced in the rod is given as:

$$I = \frac{e}{R} = \frac{\frac{1}{2}Bl^2\omega}{R} = \frac{Bl^2\omega}{2R}$$

21. (i) Diode used is Zener diode.

(ii) Circuit diagram for Zener diode as a voltage regulator:



(iii) Zener diode as a voltage regulator:

The Zener diode is connected in parallel to external load resistance R_L.

Let the unregulated d.c. input voltage V_i is applied to the Zener diode, whose breakdown voltage is V_Z. if the applied voltage $V_i > V_Z$, the Zener diode is in breakdown condition. As a result, it easily conducts current through it. Thus depending upon the input voltage, the current in the circuit or through the Zener diode may change but voltage across it remains unaffected by change in load resistance. Hence the output voltage across the Zener diode is a regulated voltage.

22. Here L = 200 mH, C = 500 μF, R = 10 Ω, E = 100 V

Power factor of the circuit = 1

So Z = R

i.e. $X_L = X_C$

$$\omega L = \frac{1}{\omega C}$$

$$L = \frac{1}{\omega^2 C}$$

$$\omega^2 = \frac{1}{LC}$$

$$\omega = \frac{1}{\sqrt{LC}}$$

$$2\pi f = \frac{1}{\sqrt{200 \times 10^{-3} \times 500 \times 10^{-6}}}$$

$$2\pi f = \frac{1}{\sqrt{10^{-9} \times 10^{5}}}$$

$$2\pi f = \frac{1}{\sqrt{10^{-4}}}$$

$$2\pi f = 100$$

$$f = \frac{50}{3.14}$$

$$f = 15.92 \text{ Hz}$$

(ii) Current amplitude I_{rms}

$$= \frac{V_{rms}}{R} \quad (\because Z = R)$$

At resonance frequency, Z=R

$$\text{Current amplitude, } I_o = \frac{V_o}{Z} = \frac{V\sqrt{2}}{R} = \frac{100\sqrt{2}}{10} = 10\sqrt{2} \text{ A}$$

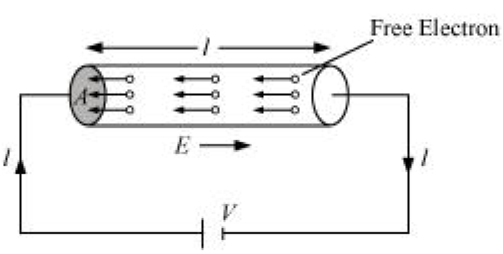
(iii) Q-factor

$$= \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$= \frac{1}{10}\sqrt{\frac{200 \times 10^{-3}}{500 \times 10^{-6}}}$$

$$= \frac{20}{10} = 2$$

23. Consider a conductor of length *l* and area of cross-section *A*, having *n* electrons per unit volume, as shown in the following figure.



Volume of the conductor = *Al*
Total number of electrons in the conductor = Volume × Electron density = *Aln*
Since *e* is the charge of an electron, the total charge contained in the conductor:

$Q = Alen$

Let a potential difference *V* be applied across the conductor. The resulting electric field in the conductor is given by: E=V/I

Hence, free electrons begin to drift in a direction opposite to that of the electric field *E*. The time taken by the free electrons to cross-over the conductor is given as:

$$t = \frac{l}{v_d}$$

v_d is the drift velocity of free electrons.
Current flowing through the conductor is given by:

$$I = \frac{Q}{t} = \frac{Alen}{\frac{l}{v_d}} = neAv_d$$

Current density, $j = \frac{I}{A} = nev_d$

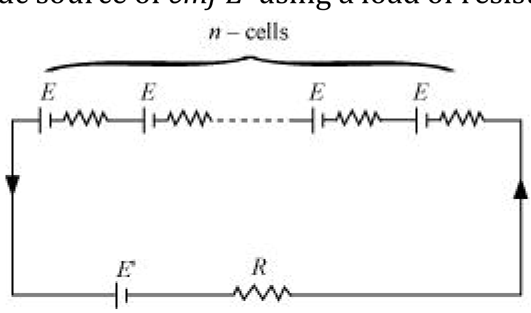
Where, n and e are constants

$\therefore j \propto v_d$

i.e., current density is directly proportional to the drift velocity

OR

(i) The following figure shows a simple circuit diagram that consists of *n* identical cells connected in series, each having an *emf E* and internal resistance *r*. The cells are charged by a dc source of *emf E'* using a load of resistance *R*.



Equivalent *emf* of *n* cells connected in series is given as:
$E' = E + E + \ldots$ up to n terms $= nE$
Equivalent internal resistance of *n* cells connected in series is given as:
$r' = r + r + \ldots$ up to n terms $= nr$
Total resistance of the resistance *R* is given by:
$R' = r' + R = nr + R$

(ii) (a) Current flowing through resistor *R* is given by:

$$I = \frac{E' - nE}{R'} = \frac{E' - nE}{nr + R}$$

(b) Potential difference across the combination of cells is given as:

$$= E' - IR$$
$$= E' - \left(\frac{E' - nE}{nr + R}\right)R$$

24. (i) Here $E_1 = 1.5$ V, $l_1 = 60$ cm, $l_2 = 80$ cm & $E_2 = ?$

By the principle of potentiometer

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

$$E_2 = E_1 \cdot \frac{l_2}{l_1}$$

$$E_2 = 1.5 \times \frac{80}{60}$$

$$E_2 = 2\text{V}$$

(ii) The circuit will not work because there will be little drop of potential across the potentiometer wire in comparison to the *emf* of the unknown cell. Hence, the balance point will not be obtained on the potentiometer wire. Thus, for the functioning of the potentiometer, the *emf* of the driver cell should be greater than the *emf* of the unknown cell.

(iii) The high resistance does not affect the balance point. Because balancing point depends only on emf of potentiometer.

25. Given work function $\Phi_0 = 0$. Using Einstein's photoelectric equation, we have

$$\frac{1}{2}mv^2 = h\upsilon - \Phi_0 = h\upsilon$$

$$\frac{1}{2}mv^2 = \frac{hc}{\lambda} \quad \text{or } mv = \sqrt{\frac{2mhc}{\lambda}}$$

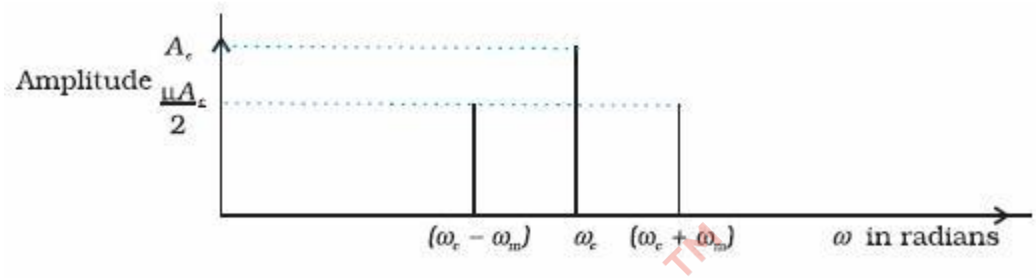
debroglie wavelength of emitted photoelectrons

$$\lambda_1 = \frac{h}{mv} = \frac{h}{\sqrt{2mhc/\lambda}} = \frac{\sqrt{\lambda h}}{\sqrt{2mc}}$$

$$\lambda = \left(\frac{2mc}{h}\right)\lambda_1^2$$

26. The transition will correspond to energy levels from -13.6eV to -1.5eV i.e transition D.
Energy E= E_2-E_1= -1.5 - (-13.6) = 12.1eV.

27. The plot of variation of amplitude w for an amplitude modulated wave is given below:



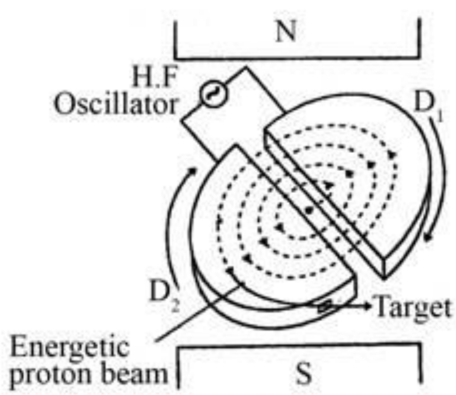
Modulation index:- It is defined as the ratio of amplitude of modulating signal to the amplitude of carrier wave. Mathematically it can be written as

$\mu = \frac{A_m}{A_c}$ where symbols have usual meanings.

The quality of the transmitted signal is determined by the index of modulation (μ).
The variation in the carrier amplitude A_c is small for a small modulation index and vice-versa.
Hence, for effective modulation, the value of μ should be checked and it should be ensured that the modulation index is never greater than unity.

28. **Cyclotron:** Cyclotron is a device by which the positively charged particles like protons, deutrons, etc. can be accelerated.

Principle: Cyclotron works on the principle that a positively charged particle can be accelerated by making it to cross the same electric field repeatedly with the help of a magnetic field.



Construction: The construction of a simple cyclotron is shown in figure above. It consists of two-semi-cylindrical boxes D_1 and D_2, which are called dees. They are enclosed in an evacuated chamber. The chamber is kept between the poles of a powerful magnet so that uniform magnetic field acts perpendicular to the plane of the dees. An alternating voltage is applied in the gap between the two dees by the help of a high frequency oscillator. The electric field is zero inside the dees

Working and theory: At a certain instant, let D_1 be positive and D_2 be negative. A proton from an ion source will be accelerated towards D_2, it describes a semi-circular path with a constant speed and is acted upon only by the magnetic field.

The radius of the circular path is given by, $qvB = \frac{mv^2}{r}$.

From the above equation we get,

$r = \frac{mv}{qB}$ ------ (I)

The period of revolution is given by,

$T = \frac{2\pi r}{v} = \frac{2\pi}{v} \cdot \frac{mv}{qB}$ (From I)

$T = \frac{2\pi m}{qB}$

The frequency of revolution is given by,

$f = \frac{1}{T} = \frac{qB}{2\pi m}$

From the above equation it follows that frequency f is independent of both v and r and is called cyclotron frequency. Also if we make the frequency of applied a.c. equal to f, then every time the proton reaches the gap between the dees, the direction of electric field is reversed and proton receives a push and finally it gains very high kinetic energy. The proton follows a spiral path and finally gets directed towards the target and comes out from it.

OR

(a) Consider a current element AB of a thin curved conductor XY through which a constant current I is maintained. Let dB be the magnitude of the magnetic field $\vec{dB}$ at P due to this current element of length dl. According to Biot-Savart's law which was formulated empirically in 1820,

(i) $dB \propto I$

(ii) $dB \propto dl$

(iii) $dB \propto \sin\theta$,

where θ is the angle between $\vec{r}$ and $\vec{dl}$. $\vec{r}$ is the position vector of the observation point P with respect to the center O of the current element. The direction of $\vec{dl}$ is the direction of flow of current.

(iv) $dB \alpha \frac{1}{r_2}$.

(The field falls off inversely with the square of the diatance between the source of the field and the point at which the field is to be measured. It is also called inverse square law.) where r is the distance of the observation point P from the mid-point O of the current element

Combining all the four factors, we get

$$dB \; \alpha \frac{I \, dl \sin\theta}{r^2} \; or \; dB = k\frac{I \, dl \sin\theta}{r^2}$$

Where k is a constant of proportionality whose value depends on the medium between the observation point and the current element.

(b) **Magnetic field at the center of a circular current-carrying coil-** Consider a circular coil of radius r through which current I is flowing. Let AB be an infinitesimally small element of length dl. According to Biot-Savart's law, the magnetic field dB at the center P of the loop is given by $dB = \frac{\mu_o}{4\pi}\frac{I \, dl \sin\theta}{r^2}$

Where θ is the angle between $\vec{dl}$ and $\vec{r}$.

In the case of a circular loop, θ = 90°.

$$\therefore \quad dB = \frac{\mu_o}{4\pi}\frac{I \, dl \sin 90^\circ}{r^2} = \frac{\mu_o}{4\pi}\frac{I \, dl}{r^2}$$

The net magnetic field at P is given by

$$B = \int dB = \int \frac{\mu_o}{4\pi}\frac{I \, dl}{r^2} = \frac{\mu_o I}{2r \; r^2}\int dl$$

But $\quad \int dl$ = circumference of the circle $= 2\pi r$

$$\therefore \quad B = \frac{\mu_o}{4\pi}\frac{I}{r^2} \times 2\pi r \quad or \quad B = \frac{\mu_o I}{2r}$$

For a coil of N turns, $B = \frac{\mu_o NI}{2r}$

Magnetic field at O due to loop 1

$$B_1 = \frac{\mu_0 i R^2}{2(X^2 + R^2)^{3/2}}$$ acting towards left

Magnetic field at O due to loop 2

$$B_2 = \frac{\mu_0 i R^2}{2(X^2 + R^2)^{3/2}}$$ acting vertically upwards

Here R is the radius of each loop.

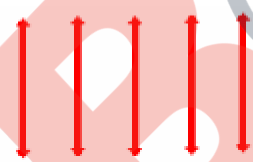
Resultant field at O will be

$$B = \sqrt{B_1^2 + B_2^2} = \sqrt{2} B_1$$

$$= \frac{\mu_0}{\sqrt{2}} \frac{i R^2}{(X^2 + R^2)^{3/2}}$$

This field acts at an angle of 45° with the axis of loop 1.

29. Plane polarized light: In plane polarized light vibrations of electric vectors are taking place in a particular plane only.



Plane polarized light

As the new Polaroid is placed between two crossed Polaroid bisecting the angle between them, it means that it has been placed at an angle 45^0 as compared to first Polaroid. If intensity of light coming out of 1st Polaroid be I, then intensity of light transmitted through second Polaroid is

$I' = I \cos^2 \theta = I \cos^2 45$

$$= I.\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{1}{2}$$

and the light transmitted through the third Polaroid

$I'' = = I' \cos^2 \theta = \cos^2 45$

$$= \frac{I}{2}.\left(\frac{1}{\sqrt{2}}^2\right) = \frac{I}{4}$$

(b) No, consider light which is made up of electric vectors E_x, E_y with a 90^0 phase difference but equal amplitudes. The tip of electric vector executes uniform circular motion at a frequency of light itself. This kind of light said to be circularly polarized. When such light is passes through a Polaroid, which is rotated, the transmitted average intensity remains constant.

OR

(a) By Snell's law

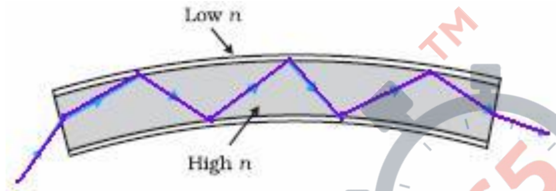
$$\frac{\sin i}{\sin r} = {}_1n_2 = \frac{n_2}{n_1}$$

For i = i_c, r = 90^0

$$\frac{n_2}{n_1} = \frac{\sin i_c}{\sin 90^0} = \sin i_c$$

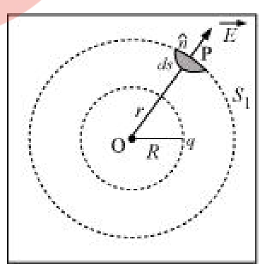
$$\sin i_c = \frac{n_2}{n_1}$$

(b) Optical fibres are used in telephone and other transmitting cables.



Light incident on one end of optical fiber at a small angle passes inside and undergoes repeated total internal reflections inside the fibre. It finally comes out of the other end, even if the fibre is bent or twisted in any form. There is no loss of light through the sides of the fibre. The only condition is that angle of incidence of light must be greater than the critical angle for the fibre material.

30. (a) Electric field intensity at any point outside a uniformly charged spherical shell:
Consider a thin spherical shell of radius *R* and with centre O. Let charge + *q* be uniformly distributed over the surface of the shell.
Let *P* be any point on the Gaussian sphere S_1 with centre O and radius *r*, as shown in the following figure.



According to Gauss's law, we can write the flux through *ds* as:

$$\oint_s \vec{E}.\vec{ds} = \frac{q}{\epsilon_0}$$

$$\oint_s \vec{E}.\hat{n}ds = \frac{q}{\epsilon_0}$$

$$E\oint ds = \frac{q}{\epsilon_0}; \qquad [\because \hat{n}.\hat{n} = 1]$$

$$E.4\pi r^2 = \frac{q}{\epsilon_0}$$

$$\therefore E = \frac{1}{4\pi\epsilon_0}\left(\frac{q}{r^2}\right)$$

At any point on the surface of the shell, r = R

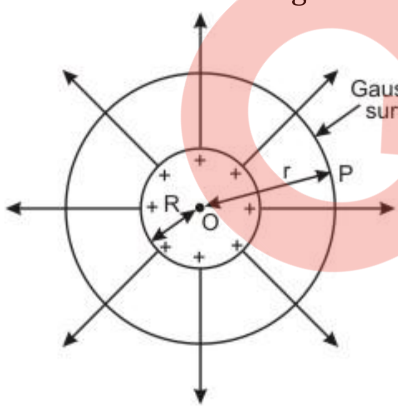
$$\therefore E = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{R^2}$$

For charge density σ, $q = 4\pi R^2\sigma$

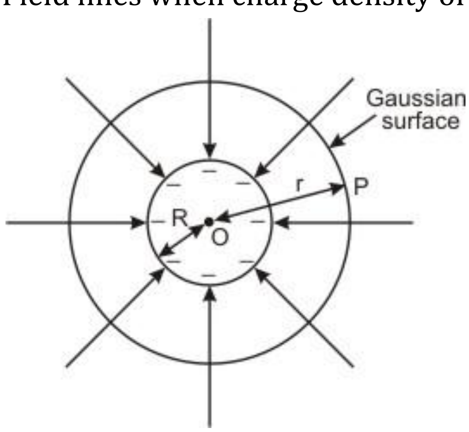
$$\therefore E = \frac{1}{4\pi\epsilon_0}\frac{(4\pi R^2\sigma)}{R^2}$$

$$\text{Hence, } E = \frac{\sigma}{\epsilon_0}$$

Field lines when charge density of the sphere is positive



Field lines when charge density of the sphere is negative



(b) Diameter of the sphere = 2.5 m

Radius of the sphere, $R = \frac{2.5}{2} = 1.25\text{m}$

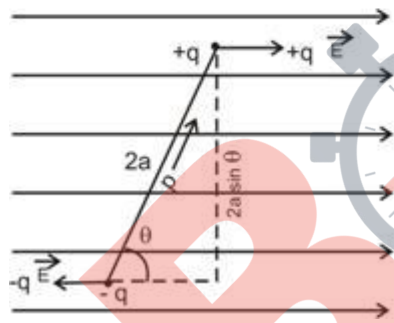
Charge density, $\sigma = 100\mu C/m^2 = 100 \times 10^{-6} = 10^{-4} C/m^2$

(i) Total charge, $q = 4\pi R^2\sigma = 4 \times 3.14 \times (1.25)^2 \times 10^{-4} = 1.96 \times 10^{-3} C$

(ii) Total electric flux, $\phi_E = \frac{q}{\varepsilon_o} = \frac{1.96 \times 10^{-3}}{8.85 \times 10^{-12}} = 2.21 \times 10^8 \, Nm^2C^{-1}$

OR

(a) The figure given below shows an electric dipole of charges +q and –q which are separated by distance 2a.



Expression for the torque: The above arrangement forms a couple. The couple exerts a torque which is given by,

τ =Force x Perpendicular distance between the two forces

τ =qE x 2a.sin θ

τ =pE.sin θ , where p=qx2a=Dipole moment.

Since the direction of torque is perpendicular to $\vec{p}$ and $\vec{E}$ we can rewrite the above equation as,

$\vec{\tau} = \vec{p} \times \vec{E}$

(b) The work done will be equal to the potential energy of the system

$$U = \frac{1}{4\pi\varepsilon_0}\left\{\left(\frac{(q)(-4q)}{0.1}\right) + \left(\frac{(-4q)(2q)}{0.1}\right) + \left(\frac{(q)(2q)}{0.1}\right)\right\}$$

$U = 9 \times 10^9 \times 10(-10q^2)$

$U = -9 \times 10^9 \times 10 \times 10 \times 1.6 \times 10^{-10} \times 1.6 \times 10^{-10}$

$U = -9 \times 1.6 \times 1.6 \times 10^{-9} J$

$U = -23.04 \times 10^{-9} J$