PART A

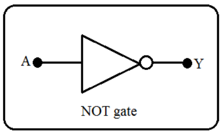
I. Answer any ten of the following questions **10x1=10**

1) **Name the apparatus used to detect electric charge on a body.**
   Gold - Leaf Electroscope.
2) **Define 'electric dipole moment'.**
   The product of magnitude of either of charges and the distance between them is called electric dipole moment.
3) **State ohm's law.**
   The current flowing through the conductor is directly proportional to the potential difference between the ends of the conductor provided temperature and other physical conditions remains the same.
4) **The resistance of a carbon resistor with four coloured rings is $(500 \pm 50)\ \Omega$. Identify the colour of fourth ring.**
   Silver
5) **What is the magnitude of the magnetic force on a charged particle moving anti-parallel to a uniform magnetic field?**
   Zero
6) **Define the magnetic declination at a place on the Earth.**
   The angle between the magnetic meridian and the geographic meridian at a place is known as the declination (D)
7) **Mention the significance of Lenz's law.**
   Conservation of energy
8) **Write the expression for the natural frequency of oscillations in an LC circuit.**
   $$f = \frac{1}{2\pi\sqrt{LC}}$$
9) **Write the relation between the magnitude of the electric and the magnetic fields in an electromagnetic wave.**
   $E = cB$
10) **Name the type of electromagnetic rays lying between ultraviolet and gamma rays.**
   X-rays
11) **What are coherent sources of light?**
   Sources emitting light waves of same frequency with a constant phase difference, are called coherent sources.
12) **How does the resolving power of a telescope change on increasing the diameter of the objective lens?**
   The resolving power of a telescope increases by increasing the diameter of the objective.
13) **What is meant by the ionisation energy of an atom?**
   The minimum energy required to transfer an electron from its orbit to infinite orbit of an isolated atom is called ionization energy.

14) **Give an example for elemental semiconductor.**

Silicon or Germanium

15) **Draw the logic symbol of NOT-gate.**



PART B

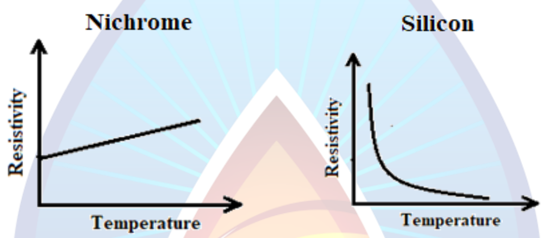
II. Answer any five of the following questions: **5x2=10**

16) **What are polar and non-polar molecules?**

A molecule in which the centre of mass of positive charges (proton) does not coincide with the centre of mass of negative charges (electrons) is called polar molecule.

A molecule in which the centers of mass of positive charges coincide with the centers of mass of negative charges is called a non-polar molecule.

17) **Show with schematic graphs variation of resistivity with absolute temperature for (a)Nichrome and (b) Silicon**



18) **The current in a coil falls from 25 mA to 0 mA in 1ms and induces an emf of 10 V in it. Find the self-inductance of the coil.**

We know that $\in = -L\frac{dI}{dt}$

$$10 = -L\frac{(0 - 25mA)}{1ms}$$

L= 0.4H

19) **Give the working principle of AC generator. Why the current generated by it is called alternating current?**

A.C. generator works on the principle of Faraday's law of electromagnetic induction.

As the coil rotates continuously, the induced potential difference reverses the direction hence induced current constantly changes.

20) **What is displacement current? Write its expression.**

Displacement current is that current which appears in the region in which the electric field and hence the electric flux is changing with time.

It is equal to ϵ_0 times the rate of change of electric flux through a given surface.

$$I_d = \varepsilon_0 \frac{d\phi_E}{dt}$$

21) **Give the reasons for the following statements**

a) **The sun is visible a little before the actual sunrise and until a little after the actual sunset.**

b) **The sky appears blue.**

a) due to refraction of light through the atmosphere.

b) When sun light enters earth's atmosphere, the scattering of different colours takes place due to interaction with large number of very small molecules in the earth's atmosphere. The wavelength of blue colour is much smaller than that of red colour. therefore, intensity of blue light scattered is much more than that of red colour. (i.e., $I \propto \frac{1}{\lambda^4}$). Thus, the blue colour becomes the major colour when the sky is clear. Due to this the sky appears blue

22) Write any two uses of polaroids.

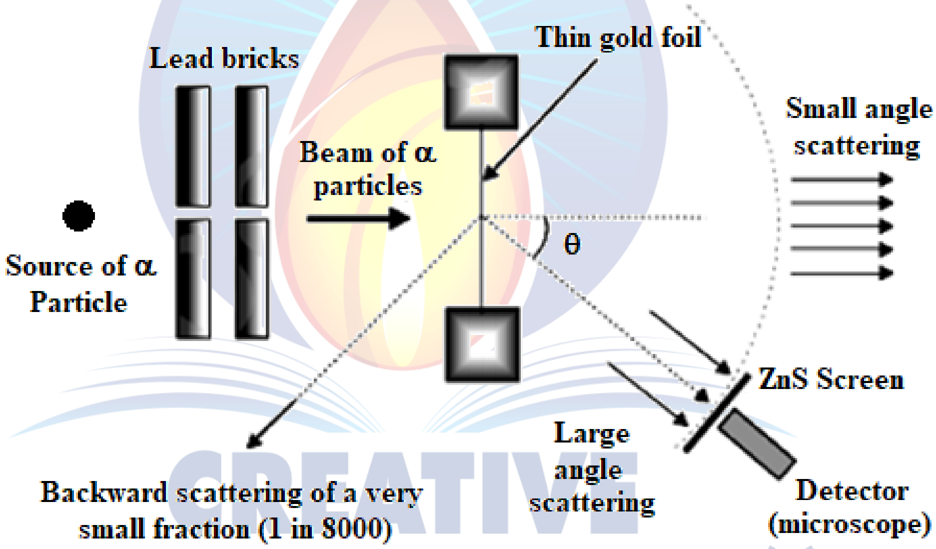
- Polarised are extensively used in polarising sunglasses.
- They are used to produce and detect plane polarised light in the laboratory.
- They are used to view 3-dimensional cinema and images.
- To control the intensity of light entering automobiles, trains and airplanes.

23) What are de Broglie waves? Name an experiment which verified the wave nature of electrons.

The wave nature associated with material particles is called matter waves or de Broglie waves.

Davision and Germer experiment.

24) Draw the labeled diagram representing the schematic arrangement of Geiger-Marsden experiment for alpha-particle scattering.



25) Give any two advantages of LEDs over conventional incandescent low power lamps.

- LEDs operate at low voltages and consume less power.
- LEDs have long life and have fast switching capability.
- LEDs have high brightness and intensity.

PART C

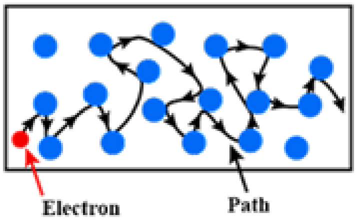
III. Answer any five of the following questions: **5 x 3 = 15**

26) Mention the three factors on which the capacitance of a dielectric parallel plate capacitor depends.

- Area of each plate
- Dielectric medium between the plates
- Distance between the plates

27) Derive the expression for the drift velocity of electrons in a conductor in terms of their relaxation time.

At room temperature, the electrons move randomly within the conductor as they suffer collisions with the fixed ions.



Due to high random motion, the average velocity of electrons is zero. If N number of electrons are present in a conductor, then,

$\frac{1}{N}\sum_{i=1}^{N}\vec{v_i} = 0$

When potential difference is applied across the ends of a metal conductor, the free electrons in the conductor experiences a force in a direction opposite to that of applied field.

$\vec{F} = -e\vec{E}$ …………….(1)

The acceleration of the electrons due to this force is,

$\vec{a} = \frac{\vec{F}}{m} = \frac{-e\vec{E}}{m}$ …………….(2) where m is mass of electron.

If $\vec{v_i}$ is velocity of the electrons just after the collision then $\vec{V_i}$ be the velocity of electrons at any instant of time t_i,

$\vec{V_i} = \vec{v_i} + \vec{a}t_i$

$= \vec{v_i} - \frac{e\vec{E}}{m}t_i$

The average velocity of N electrons is

$\frac{1}{N}\sum_{i=1}^{N}\vec{V_i} = \frac{1}{N}\sum\vec{v}_i - \frac{e\vec{E}}{m}\frac{\sum t_i}{N}$ ………………..(3)

But $\frac{1}{N}\sum\vec{v}_i = 0$

The collision of electrons does not occur at regular intervals. The average time between two successive collisions of electrons in a conductor is called relaxation time. It is denoted by τ . Taking the average value of $\vec{V_i}$ as $\vec{V_d}$, equation (3) becomes

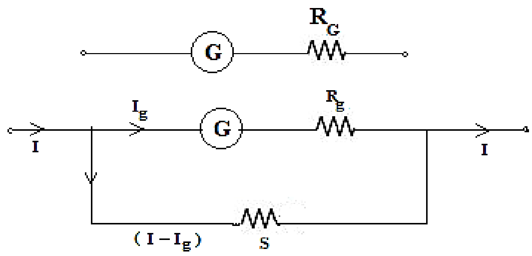
$$\vec{V_d} = 0 - \frac{e\vec{E}}{m}\tau$$

$\vec{V_d} = -\frac{e\vec{E}}{m}\tau$ ………………. (4) τ is called relaxation time.

28) Write the two reasons to show that, 'the galvanometer as such can not be used as an ammeter'. Give the method of converting the galvanometer into an ammeter.

- Galvanometer is a very sensitive device and it shows a full-scale deflection for very small current, hence it may get damaged when high current passes through it.
- Galvanometer has high resistance.

A galvanometer can be converted into an ammeter by connecting a low resistance called shunt resistance 'S' in parallel with the coil of the galvanometer. The shunt resistance reduces the resistance of the galvanometer. Let R_g be the resistance of the galvanometer. It requires a current I_g for full scale deflection.



Let S be the shunt resistance to be connected to convert it into an ammeter of range 0 to I. The value of S should be such that, when a current I enter the instrument, only a small portion I_g flows through galvanometer.

PD across the galvanometer = PD across shunt

$$I_g R_g = (I - I_g) S$$

$$S = \frac{I_g R_g}{I - I_g}$$

This is the expression for shunt required to convert galvanometer into ammeter.

29) List any three properties of ferromagnetic substances.

- A ferromagnetic substance is strongly attracted by a magnet.
- When a ferromagnetic substance is placed in a magnetic field, the magnetic field lines tend to crowed into the substance.
- When a rod of ferromagnetic substance is suspended in a uniform magnetic field, it quickly aligns itself in the direction of the field.
- When placed in a non-uniform magnetic field, a ferromagnetic substance moves from weaker to stronger parts of the magnetic field.
- The relative permeability of a ferromagnetic substance is very large.
- The magnetic susceptibility of a ferromagnetic substance is positive having a very high value.

30) Write any three applications in which advantage of eddy currents are used.

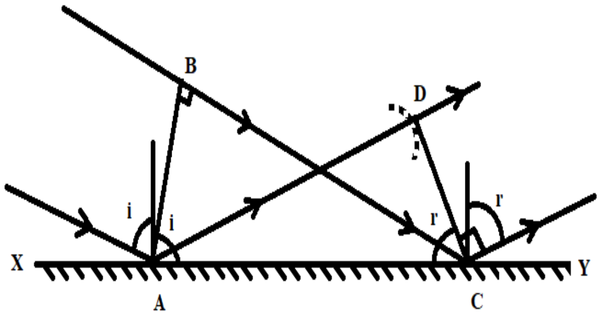
- Induction furnace used to heat the metals to their melting point
- Electromagnetic damping
- Magnetic breaking in trains
- Electric power meters

31) Mention any three sources of energy loss in an actual transformer

- Flux leakage
- Loss in the resistance of winding
- Loss due to Eddy currents
- Hysteresis loss

32) Using Huygen's principle, show that the angle of incidence is equal to the angle of reflection, when a plane wavefront is reflected by a plane surface.

Consider a plane wavefront AB incident at an angle *i* on a reflecting surface XY. If v is the speed of the wave in the medium and if *t* is the time taken by the wavefront to advance from the point B to C then the distance BC = *vt*.



In order to construct the reflected wavefront, we draw an arc at D of radius *vt* with A as centre. The tangent from C touches this arc at D. Hence CD is the reflected wavefront and let *r* be the angle of reflection.

In Δ ABC and Δ ADC, ∠ABC=∠CDA = 90°, AD = BC = *vt* and AC is common. Then triangles ABC and ADC are congruent and therefore, the angles *i* and *r* are equal. This is the law of reflection.

33) Write the three postulates of Bohr model of the hydrogen atom.

- **Postulate 1:** Electrons revolve round the nucleus only in certain stable orbits (called stationary orbits) without the emission of radiant energy.
- **Postulate 2:** Electrons revolve around the nucleus only in those orbits for which the angular momentum of the electron is integral multiple of $\frac{h}{2\pi}$ where, h is Planck's constant.

  i.e., Angular momentum, $mvr = n\frac{h}{2\pi}$ where n = 1, 2, 3 …. ∞ (Bohr's quantization rule) where n is called principal quantum number.
- **Postulate 3:** An electron might make a transition from one of its (specified non-radiating) orbits to another of lower energy. When it does so, a photon is emitted having energy equal to the energy difference between the inner and the outer orbits.

  i.e., $h\nu = E_o - E_i$ (Bohr's frequency condition)

  The frequency of the emitted photon is given by

  $\nu = \frac{E_o - E_i}{h}$ where E_i and E_o are the energies of the electron in inner and outer orbits.

34) Define 'mass defect' and 'binding energy' of a nucleus. Write the relation between them.

The difference between the sum of the masses of the constituent nucleons and the actual mass of the nucleus is called mass defect or missing mass.

The Binding Energy of a nucleus can be defined as the minimum energy required splitting the nucleus into its constituent nucleons. Or it is the minimum energy required to bind the constituent nucleons into a nucleus.

$BE = \Delta mc^2$.

35) **Give any three differences between intrinsic and extrinsic semiconductors.**

Intrinsic semiconductor	Extrinsic semiconductor
Semiconductor in its pure from are called intrinsic semiconductor.	When impurity atoms are added to the pure semiconductor is called extrinsic semiconductor.
Here number of holes is equal to number of electrons above zero kelvin.	Here number of holes and number of electrons are unequal.
The conductivity depends on temperature.	The conductivity depends on temperature and impurity.
Conductivity is due to both electrons and holes.	The conductivity is mainly due to majority charge carriers.

PART D

IV. Answer any two of the following questions: 2 x 5 = 10

36) **What is an electric field line? Write the four general properties of electric field lines.**

Electric field lines are the imaginary lines, the tangent drawn at any point gives the direction of electric lines of force at that point.

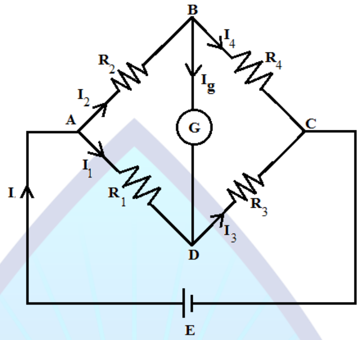
General properties of electric field lines:

- Electric field liens are straight, when they represent the electric field due to an isolated charge, and are curved when they represent the field due to two or more charges placed nearby.
- The electric field lines are directed away from a positive charge and directed towards negative charge.
- Two electric field lines cannot cross each other.
- Electric field lines are closer (crowded) when the electric field is stronger and electric field lines spread out when the field is weaker.
- Electric field lines start form positive charge and end at negative charge. If there is a single charge, they may start or end at infinity.
- The number of electric filed lines leaving the positive charge or terminating at negative charge is proportional to the magnitude of the charge.
- The lines of force do not pass through a conductor as the electric field inside a conductor is always zero.
- Electric lines of force can pass through the nonconductor or dielectric.
- Electric lines of force cannot have sudden makes and breaks. They are continuous and not appear as closed loop.
- Electric lines of force are equidistant and parallel to one another in a uniform electric field.

37) Using Kirchhoff's rules, obtain the expression for the balancing condition of Wheatstone bridge.

Wheatstone's Bridge is a circuit which is used to determine the value of unknown resistance by adjusting three known resistances.

The bridge has four resistors R_1, R_2, R_3 and R_4. Across one pair of diagonally opposite points a source is connected and the other two vertices a galvanometer is connected. Let Ig be the current through the galvanometer.



Applying Kirchhoff's junction rule the junction B and D

$I_2 = I_4 + I_g$ ------------- (1)

$I_1 + I_g = I_3$ -------------(2)

Applying Kirchhoff's loop rule to ADBA

$-I_1R_1 + I_gG + I_2R_2 = 0$ --------------- (3)

Applying Kirchhoff's loop rule to CBDC

$I_4R_4 - I_gG - I_3R_3 = 0$ ------------------ (4)

The current I_g through the galvanometer can be altered by varying the resistance in the bridge. Let any one or more of the four resistances be changed until current through the galvanometer I_g becomes zero. Under this condition the bridge is said to be balanced.

Then equation (1), (2), (3) and (4) can be rewritten as,

$I_2 = I_4$ -------------- (5)

$I_1 = I_3$ -------------- (6)

$I_1R_1 = I_2R_2$ ---------- (7)

$I_3R_3 = I_4R_4$ ----------(8)

Substitute eqn. (5) and eqn. (6) in eqn. (8) we get,

$I_1R_3 = I_2R_4$ --------------- (9)

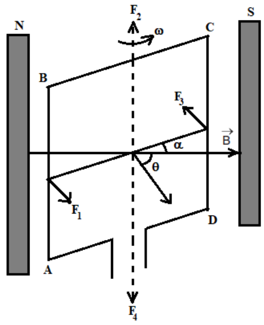
Divide equation. (7) by eqn. (9) we get

$$\frac{R_2}{R_4} = \frac{R_1}{R_3}$$

This is the condition for balance of a Wheatstone's network.

38) With the help of a diagram, derive the expression for the torque on a rectangular loop placed in a uniform magnetic field.

Consider a plane of rectangular loop ABCD makes an angle ∝ with magnetic field. Let θ be the angle between the field and the normal drawn to the plane at the coil.



The force on the arms BC and DA are equal and opposite acts along the axis of coil and hence they cancel with each other. The force on the arm AB and CD are:

$F_1 = F_2 = IbB\sin\theta$

$F_1=F_2 = IbB$ (Since $\theta=90^0$)

But F_1 and F_2 are not collinear. Hence, they produce couple.

Couple makes the body to rotate. Rotational effect produced by the coil is called torque.

$\tau = \text{Force} \times \text{perpendicular distance}$

$= F_1 \times a\cos\propto$

$= IbB\,a\cos\propto$ (Where A = ab)

$= IAB\cos\alpha$

$= mB\cos\propto$

$= nB\cos(90-\theta)$

$\tau = MB\sin\theta$

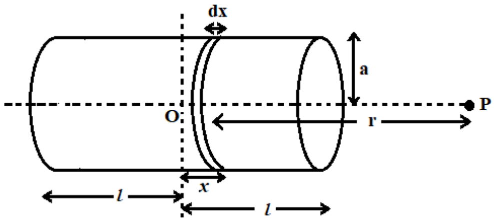
In vector form $\vec{\tau} = \vec{M} \times \vec{B}$, Where M = IA is the magnetic dipole moment.

39) Derive the expression for the magnitude of the magnetic field at a point on the axis of a current carrying solenoid. Hence show that it is equivalent to a bar magnet.

When current is passed through a solenoid, it behaves like a bar magnet. The solenoid can be regarded as a combination of circular loops placed side by side. Each turn of the solenoid behaves as a small magnetic dipole. Therefore, a solenoid becomes an arrangement of small magnetic dipoles placed in line with each other. The number of such magnetic dipoles is equal to the number of turns of the solenoid. The north pole of one magnetic dipole touches the south pole of the adjacent one. Therefore, the opposite poles neutralize each other except at the ends. The result is that we have a single north pole and a single south pole separated by a distance equal to the length of the solenoid. It follows that a current carrying solenoid behaves as a bar magnet.

Consider a solenoid of length $2l$, radius 'a' consists of 'n' turns per unit length.

Let P be a point at a distance r from the center of the solenoid. To calculate axial magnetic field at a point P, consider a circular element of thickness *dx* of solenoid at a distance *x* from its centre. This element consists of 'ndx' turns.



Let I be the current through the solenoid. Now the magnetic field at P, due to circular element is:

$$dB = \frac{\mu_0}{2}\frac{(ndx)Ia^2}{[(r-x)^2+a^2]^{\frac{3}{2}}}$$

Then the total magnetic field is obtained summing over all the elements,

$$B = \frac{\mu_0}{2}\frac{nIa^2}{[(r-x)^2+a^2]^{\frac{3}{2}}}\int_{-l}^{+l} dx$$

$$B = \frac{\mu_0}{2}\frac{nIa^2}{[(r-x)^2+a^2]^{\frac{3}{2}}}(2l)$$

$$B = \frac{\mu_0 nIa^2 l}{2[(r-x)^2+a^2]^{\frac{3}{2}}}$$

If $r >> a$ and r >> l, then

$$B = \frac{2\mu_0 nIa^2 l}{2r^3}$$

multiplying and dividing by 2π

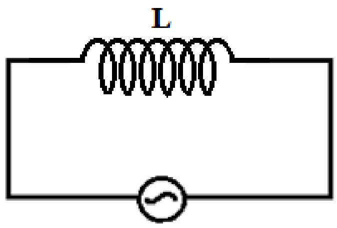
We get, $B = \frac{\mu_0}{4\pi}\frac{2m}{r^3}$

Where $m = n(2l)I\pi a^2$ is called 'magnetic moment'. The above expression is similar to the far axial magnetic field of a bar magnet and the magnetic moment of a bar magnet is equal to the magnetic moment of an equivalent solenoid.

V. Answer any two of the following questions: 2x5 =10

40) Show that the current lags the voltage by $\frac{\pi}{2}$ in an AC circuit containing a pure inductor. Draw the phasor diagram for it.

Consider a pure inductor of self-inductance L and negligible AC source as shown below



Let the source supplies a sinusoidal AC voltage to inductor & is given by

$$V = V_m sin\omega t \quad \ldots\ldots\ldots\ldots (1)$$

As the applied voltage varies with time, current through the circuit also varies, consequently a voltage V_L induced across the inductor.

Using Kirchhoff's Loop rule;

$V + V_L = 0$

$V - L\frac{di}{dt} = 0$

Where, $V_L = -L\frac{di}{dt}$ is the voltage across the inductor. L is the self-inductance d the inductor. The negative sign follows from Lenz's Law.

$$V = L\frac{di}{dt}$$

$$\frac{di}{dt} = \frac{V}{L}$$

$$\frac{di}{dt} = \frac{V_m sin\omega t}{L} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

Integrate equation (2) with respect to time:

$$\int \frac{di}{dt}dt = \int \frac{V_m}{L} sin\omega t dt$$

$$i = \frac{V_m}{L}\int sin\omega t dt$$

$$i = -\frac{V_m}{wL} \text{cos wt + constant} \quad \ldots\ldots\ldots\ldots\ldots(3)$$

Where the integration constant is zero. Since the source of emf is sinusoidal or current oscillates symmetrically about zero.

$$\therefore i = -\frac{V_m}{\omega L} cos\omega t$$

$$i = \frac{V_m}{\omega L} sin\left(\omega t - \frac{\pi}{2}\right)$$

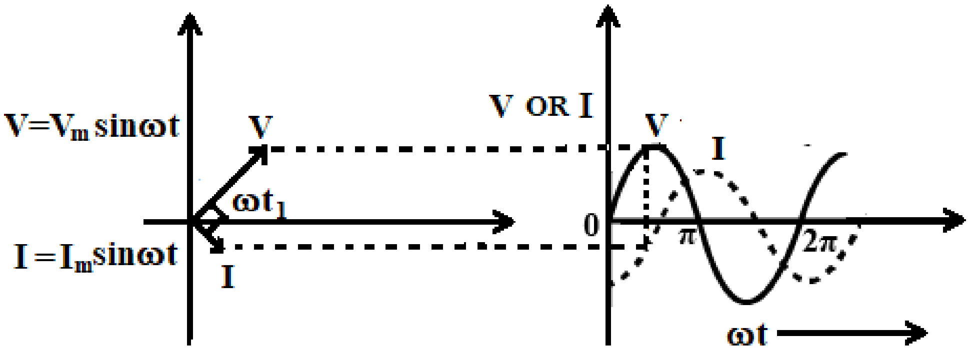
$$i = i_m sin\left(\omega t - {}^{\pi}/{}_{2}\right) \quad \ldots\ldots\ldots\ldots\ldots (4)$$

Where, $i_m = \frac{V_m}{\omega_L}$ is the amplitude of the current. Equation (4) shows that current legs the voltage by an angle ${}^{\pi}/{}_{2}$.

The quantity ω_L in the denominator taken the role of resistance and is called inductive reactance and denoted by X_L.

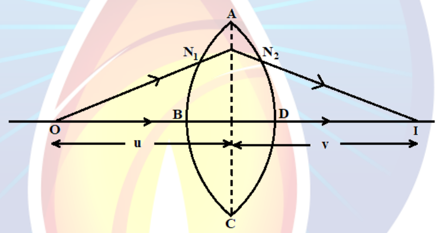
is $X_L = \omega_L = 2\pi\delta L$

Here equation (1) and equation (4) show that the current lags the voltage by ${}^{\pi}/{}_{2}$. The phasor diagram at any instant of time t is as shown below.

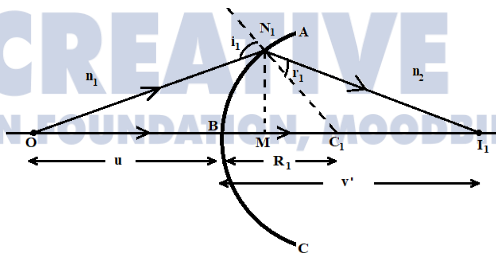


41) Derive lens maker's formula for a convex lens.

Consider a thin lens of focal length f and refractive index n_2 placed in a medium of R.I. n_1 $such$ that $(n_2 > n_1)$. Let R_1 and R_2 be the radii of curvature of the surfaces ABC and ADC of the lens respectively. Let O be the point object placed on the principal axis of the lens at a distance 'u' from the lens. A ray OB incident along the principal axis passes un-deviated. Another ray of light incident on the lens along ON_1 is refracted along N_1N_2. The emergent ray N_2I meets the principal axis at I at a distance 'v' from the lens. So, I is the real image of the object O. The formation of the image can be considered in the following two stages.

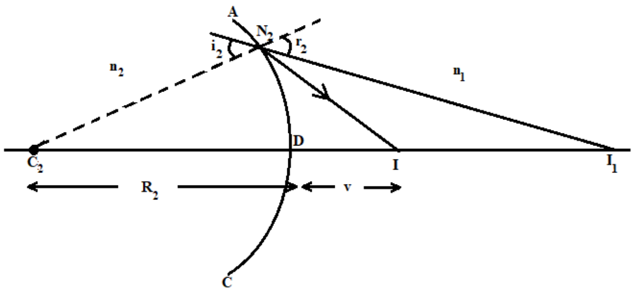


Refraction at the surface ABC: In the absence of the surface ADC, the refracted rays meet at I_1 at a distance v' from the surface ABC. So I_1 is the real image of the object O in the medium of R.I n_2 due to refraction at first surface only.



Using the relation refraction at spherical surface, $\frac{n_1}{OB} + \frac{n_2}{B\,I1} = \frac{n_2 - n_I}{BC_1}$ …………….(1)

Refraction at surface ADC: In the absence of the surface ABC, the refracted rays meet at I at a distance 'v' from the surface ADC. Since the refracted ray MN is not coming from real object, the image I_1 acts as a virtual object for refraction at the second surface ADC. The final image I is formed in the medium of R.I n_1 and it is real. Hence for refraction at the second spherical surface, object distance is -v' and image distance is v.



Using the relation refraction at spherical surface, $\frac{-n_2}{DI_1} + \frac{n_1}{DI} = \frac{n_2 - n_I}{DC_2}$ ……………(2)

For a thin lens $BI_1 = DI_1$

Adding equation (1) and (2) we get

$\frac{n_1}{OB} + \frac{n_1}{DI} = (n_2 - n_1)[\frac{1}{BC_1} + \frac{1}{DC_2}]$ ……………(3)

Suppose the object is at infinity OB tends to infinity and DI= f

$\frac{n_1}{f} = (n_2 - n_1)[\frac{1}{BC_1} + \frac{1}{DC_2}]$ …………………(4)

Using proper sign convention, $BC_1 = +R_1$ and $DC_2 = -R_2$

$$\frac{1}{f} = (n_{21} - 1)[\frac{1}{R_1} - \frac{1}{R_2}]$$

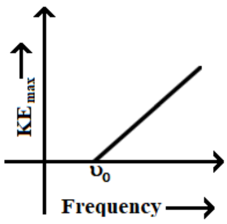
This equation is called Lens maker's formula. It is used to design lenses of desired focal length.

42) Define photoelectric work function. Write the four experimental observations of photoelectric effect.

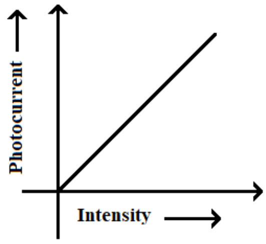
The minimum amount of external energy that must be supplied to a free electron in order that it may be just emitted out of the metal surface is known as work function of that metal.

- The Photoemission is an instantaneous process. The time lag between the instant of light incident and the instant of emission of electrons is so small which is equal to 10^{-9} seconds.
- For every photo emissive material, there is a minimum frequency below which no photo emission takes place. This minimum frequency is called threshold frequency.

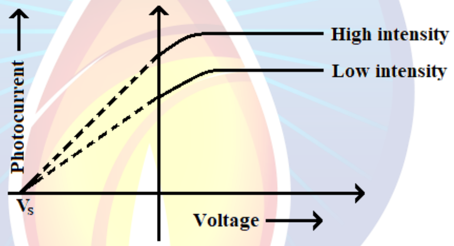
  The maximum wavelength required to emit the electron from the metal is called threshold Wavelength.
- For frequency greater than threshold frequency the maximum kinetic energy of the electron is directly proportional to the frequency of incident radiation.



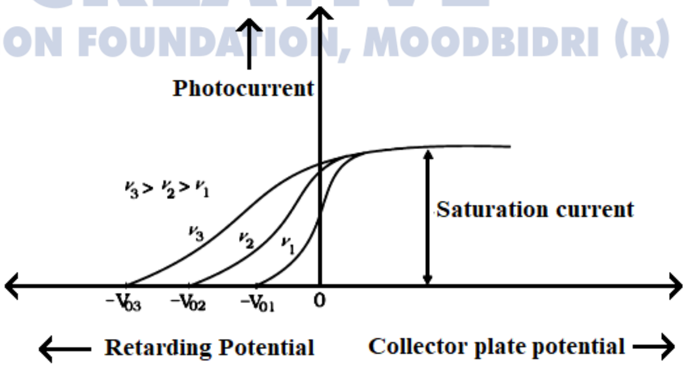
- For frequency greater than threshold frequency the photoelectric current increases linearly with increase in intensity as shown in the fig. The photo current is directly proportional to the number of photoelectrons emitted per second. The number of photoelectrons emitted per second is directly proportional to intensity of incident radiation.



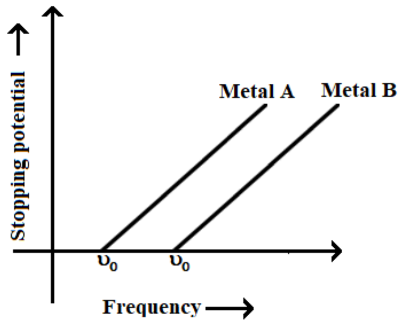
- The minimum negative potential of anode for which the emitted electrons are prevented from reaching the anode is called **Stopping potential (Vs).** It depends on the frequency of incident light and independent on intensity of incident radiation.
- By keeping the frequency and the intensity of incident radiation constant, the positive voltage given to the anode is gradually increased and the corresponding photocurrents are recorded. It can be observed that photocurrent increases with increase in voltage. The current attains some maximum value of $v=v^1$. For value of $v>v^1$ the current does not increase. This maximum value of photoelectric current is called **Saturation current**.



- The energy of emitted electrons depends on the frequency of incident radiations. The stopping potential is more negative for higher frequencies of incident radiations. i.e.., the greater the frequency, KE of the photoelectrons is maximum and we need greater retarding potential to stop them completely.

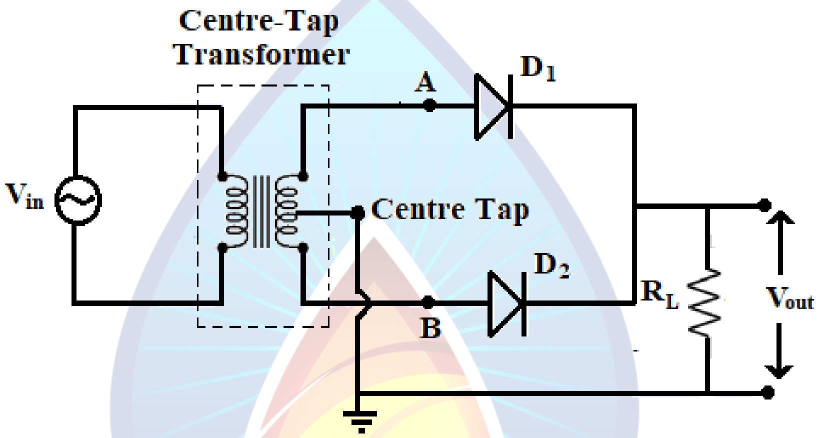


- For a given photosensitive material stopping potential varies linearly with the frequency of incident radiation. Stopping potential is zero at minimum cut off frequency.

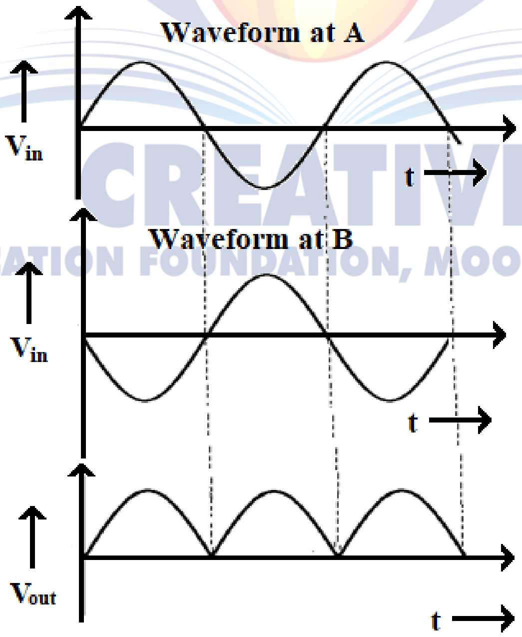


43) What is rectifier? With the suitable circuit diagram, explain the working of p-n junction diode as a full-wave rectifier. Draw the input and the output waveforms.

A rectifier in which current flows over a complete cycle of the input A.C is called a full wave rectifier.



The circuit diagram is as shown in the figure. The diodes D_1 and D_2 with a load resistor R_L are connected across the secondary of the transformer. The R_L is connected to the center tap of the secondary transformer. The A.C voltage to be rectified is applied to the primary of the transformer.



During the positive half cycle of the input voltage i.e.., when potential at A is positive and at B is negative, the diode D_1 is forward biased and D_2 is reverse biased. So D_1 conducts & D_2 does not conduct. During the negative half cycles of the input voltage i.e.., when potential at A is negative and at B is positive the diode D_2 is forward biased and D_1 is reverse biased. So D_2 conducts and D_1 does not conduct. Thus, in each cycle the current flows through the load resistor R_L in the same direction. Hence output obtained is unidirectional (D.C.) and pulsatory.

vi. Answer any three of the following questions: **3 x 5 = 15**

44) Two small charged spheres having charges of 2×10^{-7}C and 3×10^{-7} C are placed 3 cm apart in vacuum. Find the electrostatic force between them. Find the new force, when the distance between them is doubled. Given: $\frac{1}{4\pi\epsilon_0}$= 9×10^{9}Nm^{2}C^{-2}

$$F_{vacuum} = \frac{1}{4\pi\varepsilon_0}.\frac{q_1q_2}{r^2}$$

$$= \frac{(9\times10^9)(2\times10^{-7})(3\times10^{-7})}{(3\times10^{-2})^2}$$

$$= \frac{6\times10^9\times10^{-14}}{10^{-4}}$$

$$= 6\times10^{-1}\text{N} = 0.6\text{N}$$

$$F^1_{vacuum} = \frac{1}{4\pi\varepsilon_0}.\frac{q_1q_2}{(2r)^2}$$

$$= \frac{(9\times10^9)(2\times10^{-7})(3\times10^{-7})}{(2\times3\times10^{-2})^2}$$

$$= \left(\frac{9\times2\times3}{36}\right)\times\frac{10^9\times10^{-14}}{10^{-4}}$$

$$= 1.5\times10^{-1}\text{N} = 0.15\text{N}$$

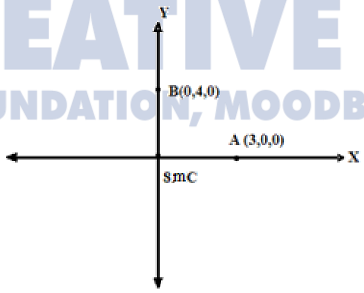
45) A charge of 8mC is located at the origin. Calculate the work done in taking a small charge of -2×10^{-8}C from a point A(3cm, 0,0) to a point B(0,4cm, 0) via a point C (3cm, 4cm, 0)

Electrostatic force is a conservative force. Hence W.D = ΔU

$$= (U_f - U_i)$$

$$= \frac{1}{4\pi\varepsilon_0}.\frac{Q_1Q_2}{r_2} - \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r_1}$$

Here $r_2 = 4cm; r_1 = 3cm; Q_1 = 8\times10^{-3}C, Q_2 = -2\times10^{-8}C$



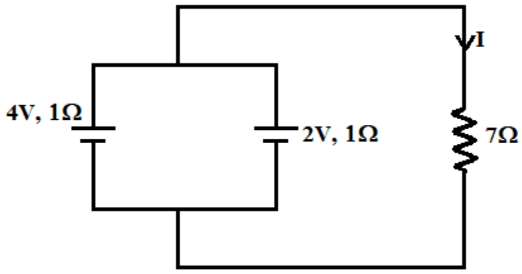
Work done $= \frac{1}{4\pi\varepsilon_0}.Q_1Q_2\left(\frac{1}{r_2}-\frac{1}{r_1}\right) = (8\times10^{-3})(-2\times10^{-8})\times9\times10^9\left(\frac{1}{4\times10^{-2}}-\frac{1}{3\times10^{-2}}\right)$

$$= \frac{-144\times10^{-2}}{10^{-2}}\left(\frac{1}{4}-\frac{1}{3}\right)$$

$$= -144\left(\frac{3-4}{12}\right)$$

= 12 J

46) In the following circuit find the current I



Equivalent Emf $\varepsilon_{eq} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}$

Equivalent resistance $r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$

Here, $\varepsilon_1 = 4V, \varepsilon_2 = 2V$

$r_1 = 1\Omega, r_2 = 1\Omega$

$\varepsilon_{eq} = \frac{(4)(1)+2(1)}{1+1} = 3\text{volts}$

$\text{req} = \frac{(1)(1)}{1+1} = \frac{1}{2}\Omega = 0.5\Omega$

$i = \frac{\varepsilon_{eq}}{R+req} = \frac{3}{7+0.5} = \frac{3}{7.5} = 0.4\text{A}$

47) A circular copper coil of mean radius 6.284cm has 20turns. If a current of 2A is passed through this coil, find the magnitude of the magnet field at the centre. Also find the magnetic dipole moment of this current coil. Given $\mu_0 = 4\pi \times 10^{-7} Hm^{-1}$

$R = 6.284cm, N = 20, i = 2A$

Magnetic field at centre $B = N\left(\frac{\mu_0 i}{2R}\right)$

$= \frac{20 \times 4\pi \times 10^{-7} \times 2}{2(6.284) \times 10^{-2}}$

$= 40 \times 10^{-5} T$

$= 4 \times 10^{-4} T$

Dipole moment $m = NiA = Ni(\pi R^2)$

$= 20(2)(3.14)(6.284 \times 10^{-2})^2$

$= 4959.775 \times 10^{-4}$ A-m^2

= 0.04959 A-m^2

48) A ray of light passes through an equilateral glass prism such that the refracted ray inside the prism is parallel to its base. Calculate the
a) angle of deviation of the ray and b) speed of light ray inside the prism
Given the refractive index of the glass =3/2 and speed of light in vacuum =3x 10^8m/s

Angle of deviation $= i + e - A$

Using Snell's law at left face, $n_1 \sin i = n_2 \sin r$

$\sin i = \frac{3}{2} \sin 30^0$

$\sin i = \frac{3}{4}$

$i = \sin^{-1}\left(\frac{3}{4}\right)$

$i = 48.59^0$

In this case, ray undergoes minimum deviation and $i = e$

$\delta = i + e - A$

$= 2i - A$

$= 2(48.59^0) - 60^0$

$= 37.18^0$.

Refractive index, $n = \frac{c}{v}$

$\frac{3}{2} = \frac{3\times10^8}{v}$

$v = 2 \times 10^8$m/s

49) Two slits separated by 1mm in Young's double slit experiment are eliminated by the violet light of the wavelength 400nm. The interference fringes are obtained on the screen placed at 1m from the slits. Find the fringe width. If the violet light is replaced by the red light of the wavelength 700nm, find the percentage change in fringe width.

Fringe width $\beta = \frac{\lambda D}{d}$

Here, $\lambda = 400nm = 400 \times 10^{-9}m$

$D = 1m$

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

$\beta_{vio} = \frac{\lambda D}{d} = \frac{400\times10^{-9}\times1}{10^{-3}}$

$= 400 \times 10^{-6}m$

$= 4 \times 10^{-4}m$

$\beta_{Re\,d} = \frac{(700 \times 10^{-9}) \times 1}{10^{-3}}$

$= 7 \times 10^{-4}m$

Percentage change in fringe width $= \frac{\beta_{Re\,d}-\beta_v}{\beta_v} \times 100$

$= \frac{7\times10^{-4}-4\times10^{-4}}{4\times10^{-4}} \times 100$

$= \frac{3\times10^{-4}}{4\times10^{-4}} \times 100$

$= 75\%$

50) The normal activity of living carbon (C-14) containing matter is found to be about 15decays per minute per gram of carbon. A specimen found in an archaeological excavation has an activity of 1.5decays per minute per gram of carbon matter. Estimate the age of the specimen. Given the half-life of the carbon (C-14) is 5730years.

$A_0 = \frac{15 \text{ decays}}{\text{Min}} = \frac{1}{4}\frac{\text{decay}}{\text{sec}}$

Activity in specimen, $A = \frac{1.5 \text{ decays}}{\text{Minute}}$

$A = A_0 e^{-\lambda t}$ $\left[Since\ t_{1/2} = \frac{ln(2)}{\lambda}\right]$

$A = A_0 e^{-\frac{ln(2)}{t_{1/2}}t}$

$1.5 = 15.\,e^{\frac{-ln(2)}{5730}(t)}$

$e^{\frac{ln(2)}{5730}t} = \frac{15}{1.5}$

$$e^{\frac{ln(2)}{5730}t} = 10$$

$$\frac{ln(2)}{5730}t = ln(10)$$

$$t = \frac{ln(10)5730}{ln(2)}$$

$$t = 19034\text{years}$$

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