SRI BHARATHIDASAN

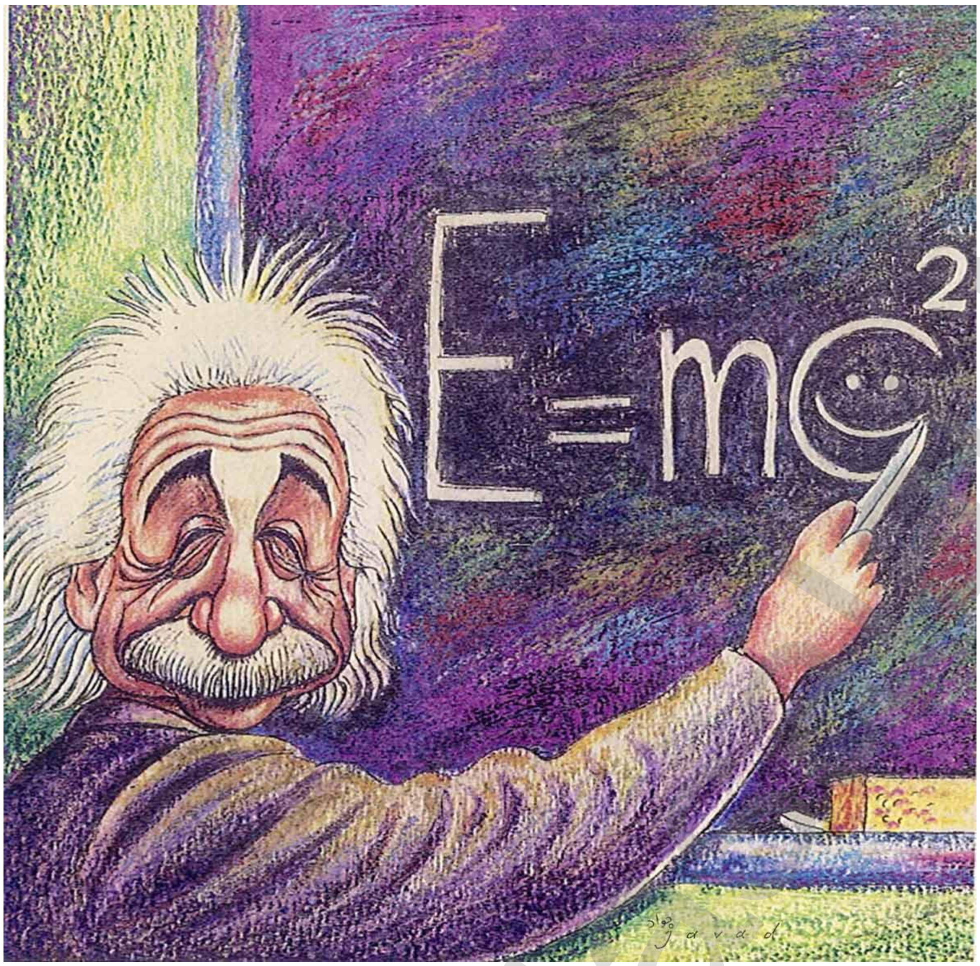
MATRIC HIGHER SECONDARY SCHOOL

(A UNIT OF LAUREL GROUP OF INSTITUTIONS)

MANNARGUDI

PHYSICS

STUDY MATERIAL



One book,

one pen,

one child

and

one teacher

can change the

world.

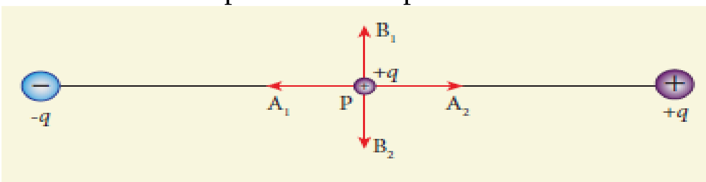
~ **Albert Einstein**

BOOK BACK ONE MARK

QUESTION AND ANSWER

UNIT - I ELECTROSTATICS

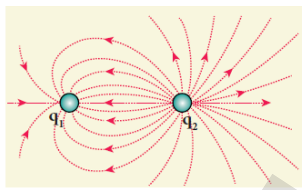
1. Two identical point charges of magnitude –q are fixed as shown in the figure below. A third charge +q is placed midway between the two charges at the point P. Suppose this charge +q is displaced a small distance from the point P in the directions indicated by the arrows, in which direction(s) will +q be stable with respect to the displacement?



(a) A_1 and A_2 (b) B_1 and B_2 (c) both directions (d) No stable

2. Which charge configuration produces a uniform electric field?
(a) point Charge (b) infinite uniform line charge
(c) uniformly charged infinite plane (d) uniformly charged spherical shell

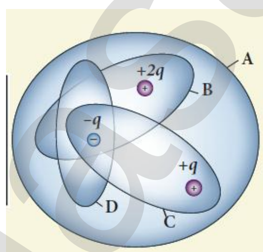
3. What is the ratio of the charges $\left|\frac{q_1}{q_2}\right|$ for the following electric field line pattern?



(a) 1 / 5
(b) 25 / 11
(c) 5
(d) 11 / 25

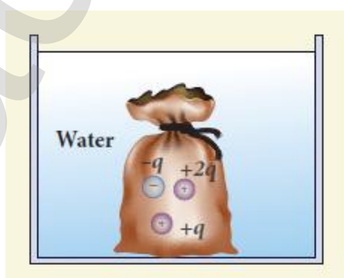
4. An electric dipole is placed at an alignment angle of 30^o with an electric field of 2×10^5 N C^{-1}. It experiences a torque equal to 8 N m. The charge on the dipole if the dipole length is 1 cm is
(a) 4 mC (b) 8 mC (c) 5 mC (d) 7 mC

5. Four Gaussian surfaces are given below with charges inside each Gaussian surface. Rank the electric flux through each Gaussian surface in increasing order.



(a) D < C < B < A
(b) A < B = C < D
(c) C < A = B < D
(d) D > C > B > A

6. The total electric flux for the following closed surface which is kept inside water

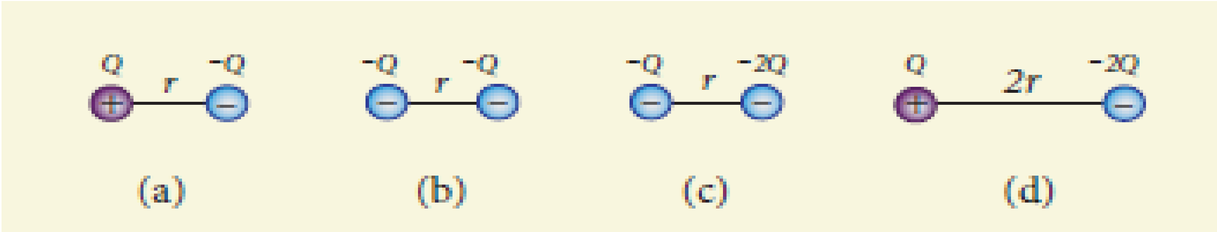


(a) $\frac{80\ q}{\varepsilon_0}$ (b) $\frac{q}{40\ \varepsilon_0}$

(c) $\frac{q}{80\ \varepsilon_0}$ (d) $\frac{q}{160\ \varepsilon_0}$

7. Two identical conducting balls having positive charges q_1 and q_2 are separated by a center to center distance r. If they are made to touch each other and then separated to the same distance, the force between them will be
(a) less than before (b) same as before (c) more than before (d) zero

8. Rank the electrostatic potential energies for the given system of charges in increasing order.

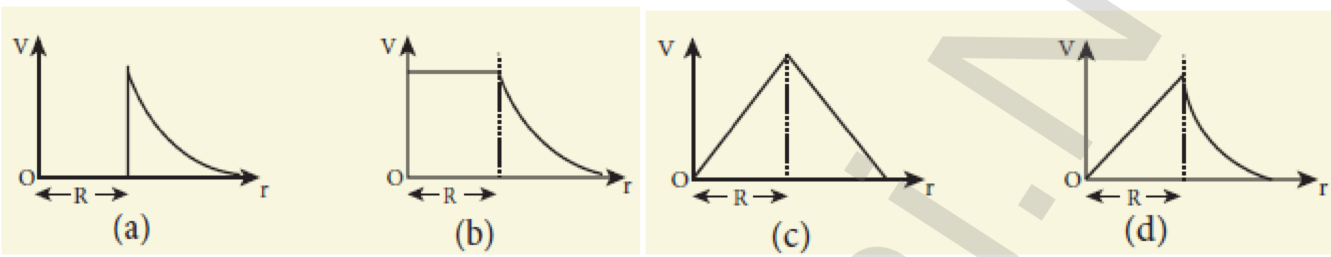


(a) 1 = 4 < 2 < 3 (b) 2 = 4 < 3 < 1 (c) 2 = 3 < 1 < 4 (d) 3 < 1 < 2 < 4

9. An electric field $\vec{E} = 10\,x\hat{i}$ exists in a certain region of space. Then the potential difference $V = V_o - V_A$, where V_o is the potential at the origin and V_A is the potential at x = 2 m is:

(a) 10 V (b) – 20 V (c) +20 V (d) -10 V

10. A thin conducting spherical shell of radius R has a charge Q which is uniformly distributed on its surface. The correct plot for electrostatic potential due to this spherical shell is



11. Two points A and B are maintained at a potential of 7 V and -4 V respectively. The work done in moving 50 electrons from A to B is

(a) 8.80×10^{-17}J (b) -8.80×10^{-17}J (c) 4.40×10^{-17}J (d) 5.80×10^{-17}J

12. If voltage applied on a capacitor is increased from V to 2V, choose the correct conclusion.

(a) Q remains the same, C is doubled (b) Q is doubled, C doubled
(c) C remains same, Q doubled (d) Both Q and C remain same

13. A parallel plate capacitor stores a charge Q at a voltage V. Suppose the area of the parallel plate capacitor and the distance between the plates are each doubled then which is the quantity that will change?

(a) Capacitance (b) Charge (c) Voltage (d)Energy density

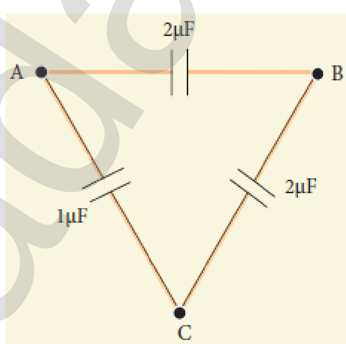
14. Three capacitors are connected in triangle as shown in the figure. The equivalent capacitance between the points A and C is

(a) 1μF

(b) 2 μF

(c) 3 μF

(d) $\frac{1}{4}\mu F$

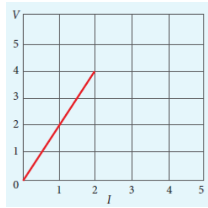


15. Two metallic spheres of radii 1 cm and 3 cm are given charges of -1×10^{-2}C and 5×10^{-2}C respectively. If these are connected by a conducting wire, the final charge on the bigger sphere is

(a) 3×10^{-2}C (b) 4×10^{-2}C (c) 1×10^{-2}C (d) 2×10^{-2}C

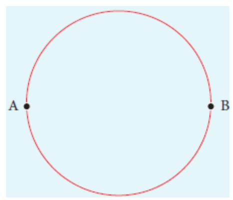
UNIT - II CURRENT ELECTRICITY

1. The following graph shows current versus voltage values of some unknown conductor. What is the resistance of this conductor?



(a) 2 ohm
(b) 4 ohm
(c) 8 ohm
(d) 1 ohm

2. A wire of resistance 2 ohms per meter is bent to form a circle of radius 1m. The equivalent resistance between its two diametrically opposite points, A and B as shown in the figure is



(a) $\pi\ \Omega$
(b) $\frac{\pi}{2}\Omega$
(c) $2\pi\Omega$
(d) $\frac{\pi}{4}\Omega$

3. A toaster operating at 240 V has a resistance of 120 Ω. The power is

(a) 400 W (b) 2 W (c) 480 W (d) 240 W

4. A carbon resistor of (47 ± 4.7) k Ω to be marked with rings of different colours for its identification. The colour code sequence will be
(a) Yellow – Green – Violet – Gold (b) Yellow – Violet – Orange – Silver
(c) Violet – Yellow – Orange – Silver (d) Green – Orange – Violet - Gold

5. What is the value of resistance of the following resistor?

(a)100 k Ω (b)10 k Ω
(c) 1k Ω (d)1000 k Ω

6. Two wires of A and B with circular cross section made up of the same material with equal lengths. Suppose $R_A = 3 R_B$, then what is the ratio of radius of wire A to that of B?

(a) 3 (b) $\sqrt{3}$ (c) $\frac{1}{\sqrt{3}}$ (d) $\frac{1}{3}$

7. A wire connected to a power supply of 230 V has power dissipation P_1. Suppose the wire is cut into two equal pieces and connected parallel to the same power supply. In this case power dissipation is P_2. The ratio $\frac{P_2}{P_1}$ is

(a)1 (b) 2 (c) 3 (d) 4

8. In India electricity is supplied for domestic use at 220 V. It is supplied at 110 V in USA. If the resistance of a 60W bulb for use in India is R, the resistance of a 60W bulb for use in USA will be

(a) R (b) 2R (c) $\frac{R}{4}$ (d) $\frac{R}{2}$

9. In a large building, there are 15 bulbs of 40W, 5 bulbs of 100W, 5 fans of 80W and 1 heater of 1kW are connected. The voltage of electric mains is 220V. The maximum capacity of the main fuse of the building will be

(a) 14 A (b) 8 A (c) 10 A (d) 12 A

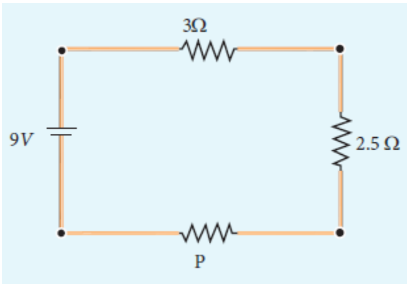
10. There is a current of 1.0 A in the circuit shown below. What is the resistance of P ?

(a) 1.5 Ω

(b) 2.5 Ω

(d) 3.5 Ω

(d) 4.5 Ω



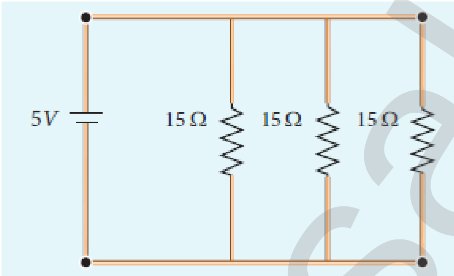
11. What is the current out of the battery?

(a)1A

(b) 2A

(c) 3A

(e) 4A



12. The temperature coefficient of resistance of a wire is 0.00125 per °C. At 20°C, its resistance is 1 Ω. The resistance of the wire will be 2 Ω at

(a) 820°C (b) 720°C (c) 620°C (d) 520°C

13. The internal resistance of a 2.1 V cell which gives a current of 0.2 A through a resistance of 10 Ω is

(a) 0.2 Ω (b) 0.5 Ω (c) 0.8 Ω (d) 1.0 Ω

14. A piece of copper and another of germanium are cooled from room temperature to 80 K. The resistance of

(a) each of them increases

(b) each of them decreases

(c) copper increases and germanium decreases

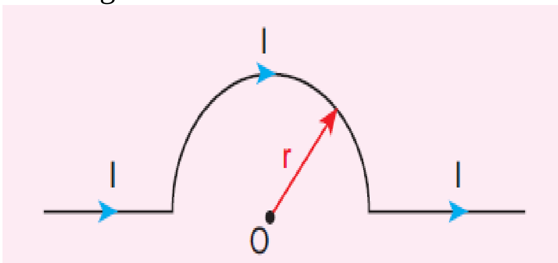
(d)copper decreases and germanium increases

15. In Joule's heating law, when Rand t are constant, if the H is taken along the y axis and I^2 along the x axis, the graph is

(a) straight line (b) parabola (c) circle (d) ellipse

UNIT - III MAGNETISM AND MAGNETIC EFFECTS OF ELECTRIC CURRENT

1. The magnetic field at the center O of the following current loop is



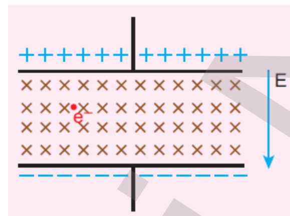
(a) $\frac{\mu_0 I}{4r}\otimes$ (b) $\frac{\mu_0 I}{4r}\odot$

(c) $\frac{\mu_0 I}{2r}\otimes$ (d) $\frac{\mu_0 I}{2r}\odot$

2. An electron moves straight inside a charged parallel plate capacitor of uniform charge density σ. The time taken by the electron to cross the parallel plate capacitor when the plates of the capacitor are kept under constant magnetic field of induction Bis

(a) $\varepsilon_0 \frac{elB}{\sigma}$ • (b) $\varepsilon_0 \frac{lB}{\sigma l}$ • •

(c) $\varepsilon_0 \frac{lB}{e\sigma}$ • • (d) $\varepsilon_0 \frac{lB}{\sigma}$ • •



3. The force experienced by a particle having mass m and charge q accelerated through a potential difference V when it is kept under perpendicular magnetic field B is

(a) $\sqrt{\frac{2q^3BV}{m}}$ (b) $\sqrt{\frac{q^3B^2V}{2m}}$ (c) $\sqrt{\frac{2q^3B^2V}{m}}$ (d) $\sqrt{\frac{2q^3BV}{m^3}}$

4. A circular coil of radius 5 cm and 50 turns carries a current of 3 ampere. Th e magnetic dipole moment of the coil is
(a) 1.0 amp – m^2 (b) 1.2 amp – m^2 (c) 0.5 amp – m^2 (d) 0.8 amp – m^2

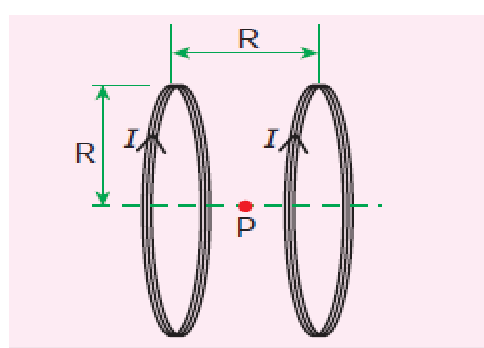
5. A thin insulated wire forms a plane spiral of N = 100 tight turns carrying a current I = 8 m A (milli ampere). The radii of inside and outside turns are a = 50 mm and b = 100 mm respectively. The magnetic induction at the center of the spiral is
(a) 5 μT (b) 7 μT (c) 8 μT (d) 10 μT

6. Three wires of equal lengths are bent in the form of loops. One of the loops is circle, another is a semi-circle and the third one is a square. They are placed in a uniform magnetic field and same electric current is passed through them. Which of the following loop configuration will experience greater torque ?
(a) circle (b) semi-circle (c) square (d) all of them

7. Two identical coils, each with N turns and radius R are placed coaxially at a distance R as shown in the figure. If I is the current passing through the loops in the same direction, then the magnetic field at a point P which is at exactly at $\frac{R}{2}$ distance between two coils is

(a) $\frac{8N\mu_0 I}{\sqrt{5}R}$ (b) $\frac{8N\mu_0 I}{5^{3/2}R}$

(c) $\frac{8N\mu_0 I}{5R}$ (d) $\frac{4N\mu_0 I}{\sqrt{5}R}$



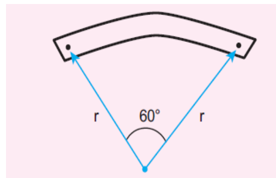
8. A wire of length l carries a current I along the Y direction and magnetic field is given by $\vec{B} = \frac{\beta}{\sqrt{3}}(\hat{i} + \hat{j} + \hat{k})T$. The magnitude of Lorentz force acting on the wire is

(a) $\sqrt{\frac{2}{\sqrt{3}}}\beta Il$ (b) $\sqrt{\frac{1}{\sqrt{3}}}\beta Il$ (c) $\sqrt{2}\beta Il$ (d) $\sqrt{\frac{1}{2}}\beta Il$

9. A bar magnet of length l and magnetic moment M is bent in the form of an arc as shown in figure. The new magnetic dipole moment will be

(a) M (b) $\frac{3}{\pi}M$

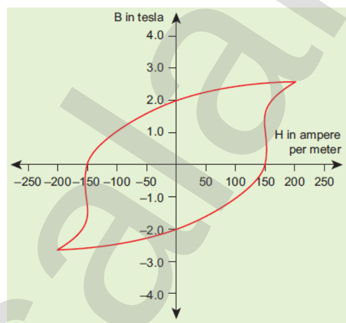
(c) $\frac{2}{\pi}M$ (d) $\frac{1}{2}M$



10. A non-conducting charged ring of charge q, mass m and radius r is rotated with constant angular speed ω. Find the ratio of its magnetic moment with angular momentum is

(a) $\frac{q}{m}$ (b) $\frac{2q}{m}$ (c) $\frac{q}{2m}$ (d) $\frac{q}{4m}$

11. The BH curve for a ferromagnetic material is shown in the figure. The material is placed inside a long solenoid which contains 1000 turns/ cm. The current that should be passed in the solenoid to demagnetize the ferromagnetic completely is



(a) 1.00 m A (milli ampere)

(b) 1.25 mA

(c) 1.50 mA

(d) 1.75 mA

12. Two short bar magnets have magnetic moments 1.20 Am^2 and 1.00 Am^2horizontal table parallel to each other with their north poles pointing towards the south. They have a common magnetic equator and are separated by a distance of 20.0 cm. The value of the resultant horizontal magnetic induction at the mid-point O of the line joining their centers is
(Horizontal components of Earth's magnetic induction is 3.6 X 10^{-5}Wb m^{-2})
(a) 3.60 X 10^{-5}Wb m^{-2} (b) 3.5 X 10^{-5}Wb m^{-2}
(c) 2.56 X 10^{-4}Wb m^{-2} (d) 2.2 X 10^{-4}Wb m^{-2}

13. The vertical component of Earth's magnetic field at a place is equal to the horizontal component. What is the value of angle of dip at this place?
(a) 30^o (b) 45^o (c) 60^o (d) 90^o

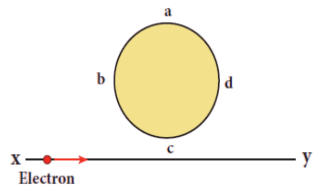
14. A flat dielectric disc of radius R carries an excess charge on its surface. The surface charge density is σ. The disc rotates about an axis perpendicular to its plane passing through the center with angular velocity ω. Find the magnitude of the torque on the disc if it is placed in a uniform magnetic field whose strength is B which is directed perpendicular to the axis of rotation

(a) $\frac{1}{4}\sigma\omega\pi BR$ (b) $\frac{1}{4}\sigma\omega\pi BR^2$ (c) $\frac{1}{4}\sigma\omega\pi BR^3$ (d) $\frac{1}{4}\sigma\omega\pi BR^4$

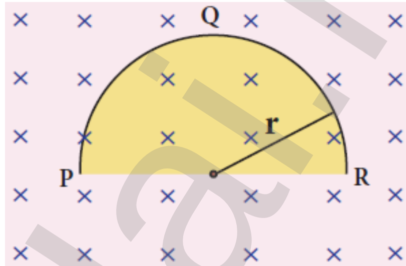
15. The potential energy of magnetic dipole whose dipole moment is $\vec{p}_m = (-0.5\hat{i} + 0.4\hat{j})Am^2$ kept in uniform magnetic field $\vec{B} = 0.2\hat{i}T$
(a) –0.1 J (b) –0.8 J (c) 0.1 J (d) 0.8 J

UNIT - IV ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENT

1. An electron moves on a straight line path XY as shown in the figure. The coil abcdis adjacent to the path of the electron. What will be the direction of current, if any, induced in the coil?
(a) The current will reverse its direction as the electron goes past the coil
(b) No current will be induced
(c) abcd
(d) adcb



2. A thin semi-circular conducting ring (PQR) of radius r is falling with its plane vertical in a horizontal magnetic field B, as shown in the figure.The potential difference developed across the ring when its speed v, is

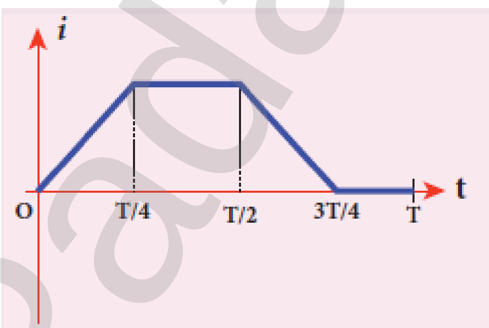


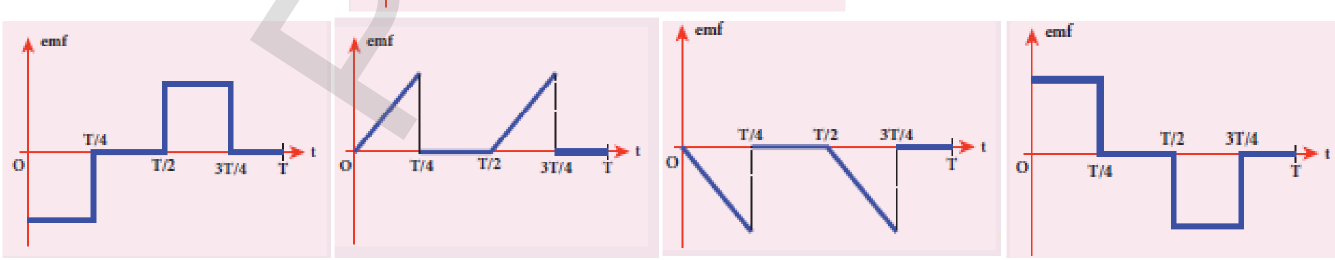
(a) Zero
(b) $\frac{Bv\pi r^2}{2}$ and P is at higher potential
(b) πrBvand R is at higher potential
(d) 2rBvand R is at higher potential

3. The flux linked with a coil at any instant t is given by $\Phi_B = 10t^2 - 50t + 250$. The induced emf at t = 3s is
(a) −190 V (b) −10 V (c) 10 V (d) 190 V

4. When the current changes from +2A to −2A in 0.05 s, an emf of 8 V is induced in a coil. The co-efficient of self-induction of the coil is
(a) 0.2 H (b) 0.4 H (c) 0.8 H (d) 0.1 H

5. The current iflowing in a coil varies with time as shown in the figure. The variation of induced emfwith time would be





(a) (b) (c) (d)

6. A circular coil with a cross-sectional area of 4 cm^2 has 10 turns. It is placed at the centre of a long solenoid that has 15 turns/cm and a cross-sectional area of 10 cm^2. The axis of the coil coincides with the axis of the solenoid. What is their mutual inductance?
(a) 7.54 μH (b) 8.54 μH (c) 9.54 μH (d) 10.54 μH

7. In a transformer, the number of turns in the primary and the secondary are 410 and 1230 respectively. If the current in primary is 6A, then that in the secondary coil is
(a) 2 A (b) 18 A (c) 12 A (d) 1 A

8. A step-down transformer reduces the supply voltage from 220 V to 11 V and increase the current from 6 A to 100 A. Then its efficiency is
(a) 1.2 (b) 0.83 (c) 0.12 (d) 0.9

9. In an electrical circuit, R, L, C and AC voltage source are all connected in series. When L is removed from the circuit, the phase difference between the voltage and current in the circuit is $\pi/3$. Instead, if C is removed from the circuit, the phase difference is again $\pi/3$. The power factor of the circuit is
(a) $1/2$ (b) $1/\sqrt{2}$ (c) 1 (d) $\sqrt{3}/2$

10. In a series RL circuit, the resistance and inductive reactance are the same. Then the phase difference between the voltage and current in the circuit is
(a) $\frac{\pi}{4}$ (b) $\frac{\pi}{2}$ (c) $\frac{\pi}{6}$ (d) zero

11. In a series resonant RLC circuit, the voltage across 100 Ω resistor is 40 V. The resonant frequency ω is 250 rad/s. If the value of C is 4 μF, then the voltage across L is
(a) 600 V (b) 4000 V (c) 400V (d) 1 V

12. An inductor 20 mH, a capacitor 50 μFand a resistor 40 Ω are connected in series across a source of emf v = 10 sin 340 t. The power loss in AC circuit is
(a) 0.76 W (b) 0.89 W (c) 0.46 W (d) 0.67 W

13. The instantaneous values of alternating current and voltage in a circuit are $i = \frac{1}{\sqrt{2}}\sin(100\pi t)A$ and $v = \frac{1}{\sqrt{2}}\sin(100\pi t + \frac{\pi}{3})V$. The average power in watts consumed in the circuit is
(a) $\frac{1}{4}$ (b) $\frac{\sqrt{3}}{4}$ (c) $\frac{1}{2}$ (d) $\frac{1}{8}$

14. In an oscillating LC circuit, the maximum charge on the capacitor is Q. The charge on the capacitor when the energy is stored equally between the electric and magnetic fields is
(a) $\frac{Q}{2}$ (b) $\frac{Q}{\sqrt{3}}$ (c) $\frac{Q}{\sqrt{2}}$ (d) Q

15. $\frac{20}{\pi^2}H$ inductor is connected to a capacitor of capacitance C. The value of C in order to impart maximum power at 50 Hz is
(a) 50 μF (b) 0.5 μF (c) 500 μF (d) 5 MF

UNIT - V ELECTROMAGNETIC WAVES

1. The dimension of $\frac{1}{\mu_0 \varepsilon_0}$ is (a) $[L T^{-1}]$ (b) $[L^2 T^{-2}]$ (c) $[L^{-1} T]$ (d) $[L^{-2} T^2]$

2. If the amplitude of the magnetic field is 3×10^{-6} T, then amplitude of the electric field for a electromagnetic waves is
(a) 100 V m^{-1} (b) 300 V m^{-1} (c) 600 V m^{-1} (d) 900 V m^{-1}

3. Which of the following electromagnetic radiation is used for viewing objects through fog
(a) microwave (b) gamma rays (c) X- rays (d) infrared

4. Which of the following are false for electromagnetic waves
(a) transverse (b) mechanical waves (c) longitudinal (d) produced by accelerating charges

5. Consider an oscillator which has a charged particle and oscillates about its mean position with a frequency of 300 MHz. The wavelength of electromagnetic waves produced by this oscillator is
(a) 1 m (b) 10 m (c) 100 m (d) 1000 m

6. The electric and the magnetic field, associated with an electromagnetic wave, propagating along X axis can be represented by
(a) $\vec{E} = E_0 \hat{j}$ and $\vec{B} = B_0 \hat{k}$ (b) $\vec{E} = E_0 \hat{k}$ and $\vec{B} = B_0 \hat{j}$
(c) $\vec{E} = E_0 \hat{i}$ and $\vec{B} = B_0 \hat{j}$ (d) $\vec{E} = E_0 \hat{j}$ and $\vec{B} = B_0 \hat{i}$

7. In an electromagnetic wave in free space the rms value of the electric field is 3 V m^{-1}. The peak value of the magnetic field is
(a) 1.414×10^{-8} T (b) 1.0×10^{-8} T (c) 2.828×10^{-8} T (d) 2.0×10^{-8} T

8. An e.m. wave is propagating in a medium with a velocity $\vec{v} = v\hat{i}$. The instantaneous oscillating electric field of this e.m. wave is along +*y*-axis, then the direction of oscillating magnetic field of the e.m. wave will be along:
(a) –*y* direction (b) –*x* direction (c) +*z* direction (d) –*z* direction

9. If the magnetic monopole exists, then which of the Maxwell's equation to be modified?.
(a) $\oint \vec{E}.d\vec{A} = \frac{Q_{enclosed}}{\varepsilon_0}$ (b) $\oint \vec{E}.d\vec{A} = 0$
(c) $\oint \vec{E}.d\vec{A} = \mu_0 I_{enclosed} + \mu_0 \varepsilon_0 \frac{d}{dt} \int \vec{E}.d\vec{A}$ (d) $\oint \vec{E}.d\vec{A} = -\frac{d}{dt}\Phi_B$

10. A radiation of energy E falls normally on a perfectly reflecting surface. The momentum transferred to the surface is
(a) $\frac{E}{c}$ (b) $2\frac{E}{c}$ (c) Ec (d) $\frac{E}{c^2}$

11. Which of the following is an electromagnetic wave?
(a) α – rays (b) β - rays (c) γ – rays (d) all of them

12. Which one of them is used to produce a propagating electromagnetic wave?.
(a) an accelerating charge (b) a charge moving at constant velocity
(c) a stationary charge (d) an uncharged particle

13. Let $E = E_0 \sin[10^6 x - \omega t]$ be the electric field of plane electromagnetic wave, the value of ω is
(a) 0.3×10^{-14} rad s^{-1} (b) 3×10^{-14} rad s^{-1}
(c) 0.3×10^{14} rad s^{-1} (d) 3×10^{14} rad s^{-1}

14. Which of the following is NOT true for electromagnetic waves?.
(a) it transport energy (b) it transport momentum
(c) it transport angular momentum
(d) in vacuum, it travels with different speeds which depend on their frequency

15. The electric and magnetic fields of an electromagnetic wave are
(a) in phase and perpendicular to each other (b) out of phase and not perpendicular to each other
(c) in phase and not perpendicular to each other (d) out of phase and perpendicular to each other

UNIT - VI OPTICS

1. The speed of light in an isotropic medium depends on,

   (a) its intensity (b)its wavelength

   (c) the nature of propagation (d) the motion of the source w.r.to medium

2. A rod of length 10 cm lies along the principal axis of a concave mirror of focal length 10 cm in such a way that its end closer to the pole is 20 cm away from the mirror. The length of the image is,

   (a) 2.5 cm (b) 5cm (c) 10 cm (d) 15cm

3. An object is placed in front of a convex mirror of focal length of f and the maximum and minimum distance of an object from the mirror such that the image formed is real and magnified.

   (a) 2f and c (b) c and ∞ (c) f and O (d) None of these

4. For light incident from air onto a slab of refractive index 2. Maximum possible angle of refraction is,

   (a) 30^o (b) 45^o (c) 60^o (d) 90^o

5. If the velocity and wavelength of light in air is V_a and λ_a and that in water is V_w and λ_w, then the refractive index of water is,

   (a) $\frac{V_w}{V_a}$ (b) $\frac{V_a}{V_w}$ (c) $\frac{\lambda_w}{\lambda_a}$ (d) $\frac{V_a \lambda_a}{V_w \lambda_w}$

6. Stars twinkle due to,

   (a) reflection (b) total internal reflection (c) refraction (d) polarisation

7. When a biconvex lens of glass having refractive index 1.47 is dipped in a liquid, it acts as a plane sheet of glass. This implies that the liquid must have refractive index,

   (a) less than one (b) less than that of glass

   (c) greater than that of glass (d) equal to that of glass

8. The radius of curvature of curved surface at a thin planoconvex lens is 10 cm and the refractive index is 1.5. If the plane surface is silvered, then the focal length will be,

   (a) 5 cm (b) 10 cm (c) 15 cm (d) 20 cm

9. An air bubble in glass slab of refractive index 1.5 (near normal incidence) is 5 cm deep when viewed from one surface and 3 cm deep when viewed from the opposite face. The thickness of the slab is,

   (a) 8 cm (b) 10 cm (c) 12 cm (d) 16 cm

10. A ray of light travelling in a transparent medium of refractive index n falls, on a surface separating the medium from air at an angle of incidents of 45^o. The ray can undergo total internal reflection for the following n,

    (a) n= 1.25 (b) n = 1.33 (c) n = 1.4 (d) n = 1.5

UNIT – VII WAVE OPTICS

1. A plane glass is placed over a various coloured letters (violet, green, yellow, red) The letter which appears to be raised more is,
   (a) red (b) yellow (c) green (d) violet

2. Two point white dots are 1 mm apart on a black paper. They are viewed by eye of pupil diameter 3 mm approximately. The maximum distance at which these dots can be resolved by the eye is, [take wavelength of light, λ = 500 nm]
   (a) 1 m (b) 5 m (c) 3 m (d) 6m

3. In a Young's double-slit experiment, the slit separation is doubled. To maintain the same fringe spacing on the screen, the screen-to-slit distance D must be changed to,
   (a) 2D (b) $\frac{D}{2}$ (c) $\sqrt{2}D$ (d) $\frac{\sqrt{D}}{2}$

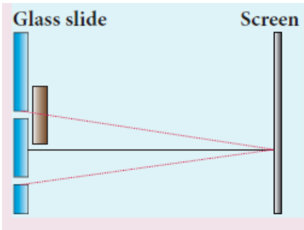
4. Two coherent monochromatic light beams of intensities I and 4I are superposed. The maximum and minimum possible intensities in the resulting beam are
   (a) 5I and I (b) 5I and 3I (c) 9I and I (d) 9I and 3I

5. When light is incident on a soap film of thickness 5×10^{-5} cm, the wavelength of light reflected maximum in the visible region is 5320 Å. Refractive index of the film will be,
   (a) 1.22 (b) 1.33 (c) 1.51 (d) 1.83.

6. First diffraction minimum due to a single slit of width 1.0×10^{-5} cm is at 30^{o}. Then wavelength of light used is,
   (a) 400 Å (b) 500 Å (c) 600 Å (d) 700 Å

7. A ray of light strikes a glass plate at an angle 60^{o}. If the reflected and refracted rays are perpendicular to each other, the refractive index of the glass is,
   (a) $\sqrt{3}$ (b) $\frac{3}{2}$ (c) $\sqrt{\frac{3}{2}}$ (d) 2

8. One of the of Young's double slits is covered with a glass plate as shown in figure. The position of central maximum will,
   (a) get shifted downwards
   (b) get shifted upwards
   (c) will remain the same
   (d) data insufficient to conclude



9. Light transmitted by Nicol prism is,
   (a) partially polarised (b) unpolarised
   (c) plane polarised (d) elliptically polarised

10. The transverse nature of light is shown in,
   (a) interference (b) diffraction (c) scattering (d) polarization

UNIT –VIII DUAL NATURE OF RADIATION AND MATTER

1. The wavelength λ_e of an electron and λ_p of a photon of same energy E are related by

a. $\lambda_p \propto \lambda_e$ b. $\lambda_p \propto \sqrt{\lambda e}$ c. $\lambda_p \propto \frac{1}{\sqrt{\lambda_e}}$ d. $\lambda_p \propto \lambda_e^2$

2. In an electron microscope, the electrons are accelerated by a voltage of 14 kV. If the voltage is changed to 224 kV, then the de Broglie wavelength associated with the electrons would

a.increase by 2 times b. decrease by 2 times c. decrease by 4 times d. increase by 4 times

3. A particle of mass 3×10^{-6}g has the same wavelength as an electron moving with a velocity 6×10^{6}m s^{-1}. The velocity of the particle is

a. 1.82×10^{-18}m s^{-1} b. 9×10^{-2}m s^{-1}

c. 3×10^{-31}m s^{-1} d. 1.82×10^{-15}m s^{-1}

4. When a metallic surface is illuminated with radiation of wavelength λ, the stopping potential is V. If the same surface is illuminated with radiation of wavelength 2λ, the stopping potential is $\frac{V}{4}$.

The threshold wavelength for the metallic surface is

a. 4λ b. 5λ c. $\frac{5}{2}\lambda$ d. 3λ

5. If a light of wavelength 330 nm is incident on a metal with work function 3.55 eV, the electrons are emitted. Then the wavelength of the emitted electron is (Take h = 6.6×10^{-34}Js)

a. $< 2\ 75\times10^{-9}$m b. $\geq 2.75\times10^{-9}$m c. $\leq 2.75\times10^{-9}$m d. $<2.5\times10^{-10}$m

6. A photoelectric surface is illuminated successively by monochromatic light of wavelength λ and $\frac{\lambda}{2}$.

If the maximum kinetic energy of the emitted photoelectrons in the second case is 3 times that in the first case, the work function at the surface of material is

a) $\frac{hc}{\lambda}$ b) $\frac{2hc}{\lambda}$ c) $\frac{hc}{3\lambda}$ d) $\frac{hc}{2\lambda}$

7. In photoelectric emission, a radiation whose frequency is 4 times threshold frequency of a certain metal is incident on the metal. Then the maximum possible velocity of the emitted electron will be

a) $\sqrt{\frac{h\upsilon_0}{m}}$ b) $\sqrt{\frac{6h\upsilon_0}{m}}$ c) $2\sqrt{\frac{h\upsilon_0}{m}}$ d) $\sqrt{\frac{h\upsilon_0}{2m}}$

8. Two radiations with photon energies 0.9 eVand 3.3 eV respectively are falling on a metallic surface successively. If the work function of the metal is 0.6 eV, then the ratio of maximum speeds of emitted electrons will be

a) 1:4 b) 1:3 c) 1:1 d)1:9

9. A light source of wavelength 520 nm emits 1.04×10^{15} photons per second while the second source of 460 nm produces 1.38×10^{15} photons per second. Then the ratio of power of second source to that of first source is

a) 1.00 b) 1.02 c) 1.5 d) 0.98

10. The mean wavelength of light from sun is taken to be 550 nm and its mean power is 3.8×10^{26}W. The number of photons received by the human eye per second on the average from sunlight is of the order of

a) 10^{45} b) 10^{42} c) 10^{54} d) 10^{51}

11. The threshold wavelength for a metal surface whose photoelectric work function is 3.313 eVis

a) 4125Å b) 3750Å c) 6000Å d) 2062.5 Å

12. A light of wavelength 500 nm is incident on a sensitive plate of photoelectric work function 1.235 eV. The kinetic energy of the photo electrons emitted is be (Take $h = 6.6 \times 10^{-34}$Js)

a) 0.58 Ev b) 2.48 eV c) 1.24 eV d) 1.16 eV

13. Photons of wavelength λ are incident on a metal. The most energetic electrons ejected from the metal are bent into a circular arc of radius R by a perpendicular magnetic field having magnitude B. The work function of the metal is

a) $\frac{hc}{\lambda} - m_e + \frac{e^2B^2R^2}{2m_e}$ b) $\frac{hc}{\lambda} + 2m_e\left(\frac{eBR}{2m_e}\right)^2$

c) $\frac{hc}{\lambda} - m_e c^2 \frac{e^2B^2R^2}{2m_e}$ d) $\frac{hc}{\lambda} - 2m_e\left(\frac{eBR}{2m_e}\right)^2$

14. The work functions for metals A, B and C are 1.92 eV, 2.0 eV and 5.0 eV respectively. The metals which will emit photoelectrons for a radiation of wavelength 4100 Å is/are

a. A only b. both A and B c. all these metals d. none

15. Emission of electrons by the absorption of heat energy is called………emission.

a. photoelectric b. field c. thermionic d. secondary

UNIT –IX ATOMIC AND NUCLEAR PHYSICS

1. Suppose an alpha particle accelerated by a potential of V volt is allowed to collide with a nucleus whose atomic number is Z, then the distance of closest approach of alpha particle to the nucleus is

(a) $14.4\frac{Z}{V}$ Å (b) $14.4\frac{V}{Z}$ Å (c) $1.44\frac{Z}{V}$ Å (d) $1.44\frac{V}{Z}$ Å

2. In a hydrogen atom, the electron revolving in the fourth orbit, has angular momentum equal to

(a) h (b) $\frac{h}{\pi}$ (c) $\frac{4h}{\pi}$ (d) $\frac{2h}{\pi}$

3. Atomic number of H-like atom with ionization potential 122.4 V for n = 1 is

(a) 1 (b) 2 (c) 3 (d) 4

4. The ratio between the first three orbits of hydrogen atom is

(a) 1:2:3 (b) 2:4:6 (c) 1:4:9 (d) 1:3:5

5. The charge of cathode rays is

(a) positive (b) negative (c) neutral (d) not defined

6. In J.J. Thomson e/m experiment, a beam of electron is replaced by that of muons (particle with same charge as that of electrons but mass 208 times that of electrons). No deflection condition is achieved only if

(a) B is increased by 208 times (b) B is decreased by 208 times

(c) B is increased by 14.4 times (d) B is decreased by 14.4 times

7. The ratio of the wavelengths for the transition from n =2 to n = 1 in Li^{++}, He^{+} and H is

(a)1: 2: 3 (b) 1: 4: 9 (c) 3:2:1 (d) 4: 9: 36

8. The electric potential between a proton and an electron is given by $V = V_0 \ln\left(\frac{r}{r_0}\right)$, where r_0 is a constant.

Assume that Bohr atom model is applicable to potential, then variation of radius of n^{th} orbit $r_n$with the principal quantum number n is

(a) $r_n \propto \frac{1}{n}$ (b) $r_n \propto n$ (c) $r_n \propto \frac{1}{n^2}$ (d) $r_n \propto n^2$

9. If the nuclear radius of ^{27}Alis 3.6 fermi, the approximate nuclear radius of ^{64}Cu is

(a) 2.4 (b) 1.2 (c) 4.8 (d)3.6

10. The nucleus is approximately spherical in shape. Then the surface area of nucleus having mass number A varies as

(a) $A^{2/3}$ (b) $A^{4/3}$ (c) $A^{1/3}$ (d) $A^{5/3}$

11. The mass of a $^{7}_{3}Li$ nucleus is 0.042 u less than the sum of the masses of all its nucleons. The binding energy per nucleon of $^{7}_{3}Li$ nucleus is nearly

(a) 46 MeV (b) 5.6 MeV (c) 3.9MeV (d)23 MeV

12. $M_p$denotes the mass of the proton and $M_n$denotes mass of a neutron. A given nucleus of binding energy B, contains Z protons and N neutrons. The mass M(N,Z) of the nucleus is given by (where c is the speed of light)

(a) $M(N,Z) = NM_n + ZM_p - Bc^2$ (b) $M(N,Z) = NM_n + ZM_p + Bc^2$

(c) $M(N,Z) = NM_n + ZM_p - B/c^2$ (d) $M(N,Z) = NM_n + ZM_p + B/c^2$

13. A radioactive nucleus (initial mass number A and atomic number Z) emits 2∝and 2 positrons. The ratio of number of neutrons to that of proton in the final nucleus will be

(a) $\frac{A-Z-4}{Z-2}$ (b) $\frac{A-Z-2}{Z-6}$ (c) $\frac{A-Z-4}{Z-6}$ (d) $\frac{A-Z-12}{Z-4}$

14. The half-life period of a radioactive element A is same as the mean life time of another radioactive element B. Initially both have the same number of atoms. Then

(a) A and B have the same decay rate initially (b) A and B decay at the same rate always

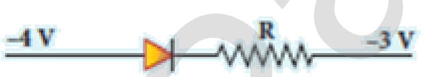
(c) B will decay at faster rate than A (d) A will decay at faster rate than B.

15. A system consists of N_0 nucleus at t=0. The number of nuclei remaining after half of a half-life (that is, at time $t = \frac{1}{2}T_{\frac{1}{2}}$)

(a) $\frac{N_0}{2}$ (b) $\frac{N_0}{\sqrt{2}}$ (c) $\frac{N_0}{4}$ (d) $\frac{N_0}{8}$

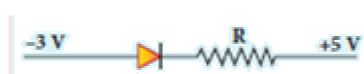
UNIT –X ELECTRONICS AND COMMUNICATION

1. The barrier potential of a silicon diode is approximately,
   a) 0.7 V b) 0.3V c) 2.0 V d) 2.2V
2. If a small amount of antimony (Sb) is added to germanium crystal
   a) it become a p-type semiconductor b) the antimony becomes an acceptor atom
   c) there will be more free electrons than hole in the semiconductor
   d) its resistance is increased
3. In an unbiased *p-n* junction, the majority charge carriers (that is, holes) in the *p*-region diffuse into *n*-region because of
   a) the potential difference across the *p-n* junction
   b) the higher hole concentration in *p*-region than that in n-region
   c) the attraction of free electrons of *n*-region
   d) the higher concentration of electrons in the *n*-region than that in the *p*-region
4. If a positive half –wave rectified voltage is fed to a load resistor, for which part of a cycle there will be current flow through the load?
   a) $0^0–90^0$ b) $90^0–180^0$ c) $0^0–180^0$ d) $0^0–360^0$
5. The zener diode is primarily used as
   a) Rectifier b) Amplifier c) Oscillator d) Voltage regulator
6. The principle based on which a solar cell operates is
   a) Diffusion b) Recombination c) Photovoltaic action d) Carrier flow
7. The light emitted in an LED is due to
   a) Recombination of charge carriers b) Reflection of light due to lens action
   c) Amplification of light falling at the junction d) Large current capacity.
8. The barrier potential of a *p-n* junction depends on i) type of semiconductor material ii) amount of doping iii) temperature. Which one of the following is correct? (NEET)
   a) (i) and (ii) only b) (ii) only c) (ii) and (iii) only d) (i) (ii) and (iii)
9. To obtain sustained oscillation in an oscillator,
   a) Feedback should be positive b) Feedback factor must be unity
   c) Phase shift must be 0 or 2π d) All the above
10. If the input to the NOT gate is A = 1011, its output is
    a) 0100 b) 1000 c) 1100 d) 0011
11. Which one of the following represents forward bias diode?

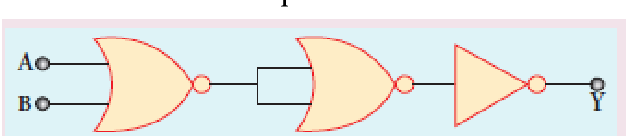
a. 

b. 

c. 

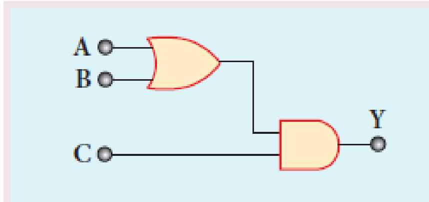
d. 

12. The given electrical network is equivalent to



a) AND gate b) OR gate c) NOR gate d) NOT gate

13. The output of the following circuit is 1 when the input ABC is
    a) 101
    b) 100
    c) 110
    d) 010



14. The variation of frequency of carrier wave with respect to the amplitude of the modulating signal is called
    a) Amplitude modulation b) Frequency modulation
    c) Phase modulation d) Pulse width modulation

15. The frequency range of 3 MHz to 30 MHz is used for
    a) Ground wave propagation b) Space wave propagation
    c) Sky wave propagation d) Satellite communication

UNIT –XI RECENT DEVELOPMENTS IN PHYSICS

1. The particle size of ZnO material is 30 nm. Based on the dimension it is classified as
   (a) Bulk material (b) Nanomaterial
   (c) Soft material (d) Magnetic material
2. Which one of the following is the natural nanomaterial.
   (a) Peacock feather (b) Peacock beak
   (c) Grain of sand (d) Skin of the Whale
3. The blue print for making ultra durable synthetic material is mimicked from
   (a) Lotus leaf (b) Morpho butterfly
   (c) Parrot fish (d) Peacock feather
4. The method of making nanomaterial by assembling the atoms is called
   (a) Top down approach (b) Bottom up approach
   (c) Cross down approach (d) Diagonal approach
5. “Sky wax” is an application of nano product in the field of
   (a) Medicine (b) Textile
   (c) Sports (d) Automotive industry
6. The materials used in Robotics are
   (a) Aluminium and silver (b) Silver and gold
   (c) Copper and gold (d) Steel and aluminum
7. The alloys used for muscle wires in Robots are
   (a) Shape memory alloys (b) Gold copper alloys
   (c) Gold silver alloys (d) Two dimensional alloys
8. The technology used for stopping the brain from processing pain is
   (a) Precision medicine (b) Wireless brain sensor
   (c) Virtual reality (d) Radiology
9. The particle which gives mass to protons and neutrons are
   (a) Higgs particle (b) Einstein particle
   (c) Nanoparticle (d) Bulk particle
10. The gravitational waves were theoretically proposed by
    (a) Conrad Rontgen (b) Marie Curie
    (c) Albert Einstein (d) Edward Purcell

ANSWER KEY

Qn. NO	L - 1	L - 2	L - 3	L - 4	L - 5	L - 6	L - 7	L - 8	L - 9	L - 10	L - 11
1	b	a	a	a	b	b	d	d	c	a	b
2	c	b	d	d	d	b	b	c	d	c	a
3	d	c	c	b	d	d	a	d	c	d	c
4	b	b	b	d	c	a	c	d	c	c	b
5	a	a	b	a	a	b	b	b	b	d	c
6	b	c	a	a	b	c	b	d	c	c	d
7	c	d	b	a	a	d	a	b	d	a	a
8	a	c	a	b	c	b	b	b	b	d	c
9	c	d	b	c	b	c	c	c	c	d	a
10	b	c	c	a	b	d	d	a	a	a	c
11	a	a	b	c	c	-	-	b	b	a	-
12	c	d	c	c	a	-	-	c	c	c	-
13	d	b	b	d	d	-	-	d	b	a	-
14	b	d	d	c	d	-	-	b	c	b	-
15	a	a	c	d	a	-	-	c	b	c	-

"I never see what has been done;

I only see what remains to be done."

~ Marie Curie

TWO MARK

QUESTION AND ANSWER

UNIT-1 ELECTROSTATICS

1. Write down Coulomb's law in vector form and mention what each term represents.

Coulomb's law states that the electrostatic force is directly proportional to the product of the magnitude of the point charges and is inversely proportional to the square of the distance between the two point charges.

The force on the point charge q_2 exerted by another point charge q_1 is

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_o}\frac{q_1 q_2}{r^2_{21}}\hat{r}_{21} \quad \text{(or)} \quad \vec{F}_{21} = \frac{1}{4\pi\varepsilon_o}\frac{q_1 q_2}{r^2_{12}}\hat{r}_{12}$$

Where $\hat{r}_{12}$ is the unit vector directed from charge q_1 to charge q_2

k - is the proportionality constant.

r - distance between the two point charges.

ε_0 - Permittivity of free space

2. What are the differences between Coulomb force and gravitational force?

S.NO	COULOMB FORCE	GRAVITATIONAL FORCE
1.	Depends on the magnitude of charges	Depends on the mass of the object
2.	Force between two charges may be attractive or Repulsive	Force between two masses is always attractive
3.	It depends on the medium	It is independent of the medium
4.	Applicable only for charges at rest	Applicable for masses both at rest air in motion

3. Define 'Electric field'.

The electric field at the point P at a distance r from the point charge q is the force experienced by a unit charge at that point.

$$\vec{E} = \frac{\vec{F}}{q_o} = \frac{kq}{r^2}\hat{r} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$$

Here $\hat{r}$ is the unit vector.

The electric field is a vector quantity. Its SI unit is NC^{-1} or Vm^{-1}.

4. **The electric field lines never intersect. Justify.**

- No, two electric field lines intersect each other.
- If two lines cross at a point, then there will be two different electric field vectors at the same point.
- As a consequence, if some charge is placed in the intersection point then it has to move in two different directions at the same, which is physically impossible. Hence electric field lines do not intersect.

5. **Define 'Electric dipole'**

- Two equal and opposite charges are separated by a small distance constitute an electric dipole.
- Examples: water (H_2O), ammonia (NH_3), HC1 etc.
- The magnitude of electric dipole moment, $|\vec{p}| = 2qa$. Its direction is from - q to +q

6. **What is the general definition of electric dipole moment?**

- The magnitude of the electric dipole moment is equal to the algebraic sum of the Product of the magnitude of a charge and the distance of the charge from the origin.
- The electric dipole moment for a collection of n point charges is given by $\vec{p} = \sum_{i=1}^{n} q_i \vec{r}_i$

7. **Define 'electrostatic potential".**

- The electric potential (or) electrostatic potential at a point P is equal to the work done by an external force to bring a unit positive charge with constant velocity from infinity to the point P in the region of the external electric field $\vec{E}$.
- It is a scalar quantity. Its SI unit is volt (V).

8. **What is an equipotential surface?**

An equipotential surface is a surface on which all the points are at the same potential. For a point charge the equipotential surfaces are concentric spherical surfaces. For a uniform electric field, it form a set of planes normal to the electric field $\vec{E}$.

9. **Define 'electrostatic potential energy'.**

The electric potential at a point at a distance *r* from point charge q_1 is $V = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{r}$. Now if a charge q_2 is brought from infinity to that point, a work must be done against the electric field of q_1. This workdone is stored as the electrostatic potential energy(U) of a system of charges.

$U = q_2 V = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$. Its unit is Joule. It is a scalar quantity.

10. Define electric flux.

- The number of electric field lines crossing a given area kept normal to the electric field lines is called electric flux (ϕ_E).
- It is usually denoted by the Greek letter ϕ_E and its unit is Nm^2C^{-1} or Vm.
- Electric flux is a scalar quantity and it can be positive or negative or zero.

$$\phi_E = \vec{E}.\vec{A} = EA \cos \theta$$

11. Write a short note on 'electrostatic shielding'.

- The process of isolating a certain region of space from external field. It is based on the fact that the electric field inside both hollow and solid conductors is zero.
- Ex: Faraday cage.

12. What is Polarisation?

In the presence of an external electric field, the dipole moment is induced in the dielectric material. This is known as dielectric polarisation.
Polarisation ($\vec{P}$) is defined as the total dipole moment per unit volume of the dielectric.

13. What is dielectric strength?

- When the external electric field applied to a dielectric is very large, it tears the atoms apart so that the bound charges become free charges. Then the dielectric starts to conduct electricity. This is called dielectric breakdown.
- The maximum electric field the dielectric can withstand before it breakdowns is called dielectric strength.
- The dielectric strength of air is 3×10^6 V/m

14. Define 'capacitance'. Give its unit.

The capacitance of a capacitor is defined as the ratio of the magnitude of charge on either of the conductor plates to the potential difference existing between the conductors.C= Q/V
Its SI unit of capacitance is CV^{-1} or farad (F).

15. What is corona discharge?

The leakage of electric charges from the sharp points of a charged conductor is known as action of points or corona discharge.

UNIT - 2 CURRENT ELECTRICITY

1. **Why current is a scalar?**
Though current has a specific direction and magnitude, it does not obey the law of vector addition. So current is a scalar quantity.

2. **Define current density.**
❖ The current density (J) is defined as the current per unit area of cross section of the conductor. J=I/A
❖ The SI unit of current density is A m^{-2} ❖ It is a vector quantity.

3. **Distinguish between drift velocity and mobility.**

S.NO	DRIFT VELOCITY	MOBILITY
1.	Drift velocity is defined as the average velocity acquired by the electrons inside the conductor when external electric field is applied	Mobility is defined as the magnitude of the drift velocity per unit electric field
2.	$\vec{V}_d = -\mu\vec{E}$	$\mu = \frac{\left\|\vec{V}_d\right\|}{\left\|\vec{E}\right\|}$
3.	SI unit is ms^{-1}	SI unit is $m^2V^{-1}\ s^{-1}$

4. **Define electrical resistivity.**
The electrical resistivity of a material is defined as the resistance offered to current flow by a conductor of unit length having unit area of cross section.
The SI unit of ρ is ohm-meter (Ω m).

5. **Define temperature coefficient of resistance.**
The temperature coefficient of resistance is defined as the ratio of increase in resistance per degree rise in temperature to its resistance at T_o. $\alpha = \frac{\Delta R}{R_0 \Delta T}$. Its unit is per °C

6. **What is superconductivity?**
The resistance of certain materials become zero below certain temperature Tc. This temperature is known as critical temperature or transistion temperature. The materials which exhibit this property are known as superconductors. This phenomenon is called super conductivity.

7. What is electric power and electric energy?

❖ The electrical power is the rate at which the electrical energy is consumed.

$$P = \frac{dU}{dt} = V\frac{dQ}{dt}$$

❖ Its unit is watt.

❖ The electrical energy is defined as the ability to do electrical work .
Its unit is watt hour or kWh (or) joule.

8. State Kirchhoff's current rule.

Kirchhoff's current rule states that the algebraic sum of the currents at any junction of a circuit is zero. It is a statement of conservation of electric charge.

9. State Kirchhoff's voltage rule.

Kirchhoff's voltage rule states that in a closed circuit the algebraic sum of the products of the current and resistance of each part of the circuit is equal to the total emf included in the circuit. This rule follows from the law of conservation of energy.

10. State the principle of potentiometer.

The emf of the cell is directly proportional to the balancing length. $\xi = Irl$

11. What do you mean by internal resistance of a cell?

Internal resistance is the resistance which is present within the cell that resists the current flow when connected to a circuit.

12. State Joule's law of heating.

Joule's law of heating is states that the heat developed in an electrical circuit due to the flow of current varies directly as

(i) The square of the current

(ii) The resistance of the circuit and

(iii) The time of flow.

$H = I^2Rt$

13. What is Seebeck effect?

Seebeck discovered that in a closed circuit consisting of two dissimilar metals, when the junctions are maintained at different temperatures an emf (potential difference) is developed. This is called Seebeck effect. This effect is reversible.

14. What is Thomson effect?

Thomson showed that if two points in a conductor are at different temperatures, the density of electrons at these points will differ and as a result the potential difference is created between these points. Thomson effect is also reversible.

5. What is Peltier effect?

When an electric current is passed through a circuit of a thermocouple, heat is evolved at one junction and absorbed at the other junction. This is known as Peltier effect. Peltier effect is reversible.

UNIT-3 MAGNETISM AND MAGNETIC EFFECTS OF ELECTRIC CURRENT

1. What is meant by magnetic induction?

The magnetic induction (total magnetic field) inside the specimen $\vec{B}$ is equal to the sum of the magnetic field $\vec{B}_0$ produced in vacuum due to the magnetizing field and the magnetic field $\vec{B}_m$ due to the induced magnetism of the substance.

$\vec{B} = \vec{B}_0 + \vec{B}_m = \mu_0(\vec{H} + \vec{M})$.

2. Define magnetic flux.

❖ The number of magnetic field lines crossing any area normally is defined as magnetic flux ϕB through the area. $\phi_B = \vec{B}.\vec{A} = BA \cos\theta$

❖ It is a scalar quantity. ❖ Its SI unit is weber.

❖ Its dimension is $[ML^2T^{-2}A^{-1}]$

3. Define magnetic dipole moment.

The magnetic dipole moment is defined as the product of its pole strength and magnetic length. It is a vector quantity, denoted by $\vec{p}_m$. $\vec{p}_m = q_m\vec{d}$

Where $\vec{d}$ is the vector drawn from south pole to north pole and its magnitude $|\vec{d}| = 2l$.

The magnitude of magnetic dipole moment is, $P_m = 2q_m l$.

SI unit is Am^2.

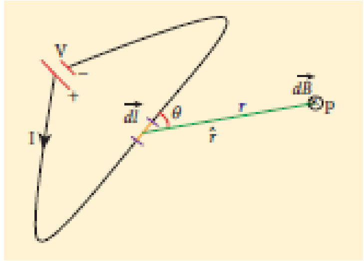
4. State Coulomb's inverse law.

The force of attraction or repulsion between two magnetic poles is directly proportional to the product of their pole strengths and inversely proportional to the square of the distance between them.

$\vec{F} \alpha \frac{q_{m_A} q_{m_B}}{r^2}\hat{r}$

Where q_{m_A} and q_{m_B} are pole strengths of two poles and r is the distance between two magnetic poles.

5. State Biot-Savart's law.



Biot and Savart experimentally observed that the magnitude of magnetic field $d\vec{B}$ at a point P at a distance r from the small elemental length taken on a conductor carrying current varies.

(i) directly as the strength of the current I

(ii) directly as the magnitude of the length element $d\vec{l}$

(iii) directly as the sine of the angle (say, θ) between $d\vec{l}$ and $\hat{r}$.

(iv) inversely as the square of the distance between the point P and length element $d\vec{l}$.

This is expressed as $dB = \frac{\mu_0}{4\pi}\frac{Idl}{r^2}\sin\theta$

6. **State Ampere's circuital law.**

Ampere's law: The line integral of magnetic field over a closed loop is μo times net current enclosed by the loop.

$$\oint \vec{B}.d\vec{l} = \mu_0 I_{enclosed}$$

Where $I_{enclosed}$ is the net current linked by the closed loop.

7. **Define ampere.**

One ampere is defined as that current when it is passed through each of the two infinity long parallel straight conductors kept at a distance of one meter apart in vacuum causes each conductor to experience a force of 2×10^{-7} newton per meter length of conductor.

8. **State Fleming's left hand rule.**

Stretch forefinger, the middle finger and the thumb of the left hand such that they are in mutually perpendicular directions. If we keep the forefinger in the direction of magnetic field, the middle finger in the direction of the electric current, then the thumb points in the direction of the force experienced by the conductors.

9. **Is an ammeter connected in series or parallel in a circuit? Why?**

An ammeter connected in series in a circuit.

In an ammeter a shunt resistance is connected in parallel to galvanometer. Since, the shunt reistance is a very low resistance, the resistance of ammeter is also very small. So, when we connect the ammeter in series, the ammeter will not change appreciably the current in the circuit.

10. **Give the properties of dia, para and ferro magnetic materials?**

S.No	dia magnetic materials	para magnetic materials	ferro materials
1.	Magnetic susceptibility is negative.	Magnetic susceptibility is positive and small.	Magnetic susceptibility is positive and large
2.	Relative permeability is slightly less than unity.	Relative permeability is greater than unity	Relative permeability is large.
3.	When it is placed in magnetic field, it repel (or) expel the magnetic field lines.	When it placed in a magnetic field, it attract the field lines.	When it is placed in magnetic field it strongly attract the field lines.
4.	Susceptibility is nearly temperature independent.	Susceptibility is inversely proportional to temperature.	susceptibility is inversely proportional to temperature.

UNIT - 4
ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENT

1. What is meant by electromagnetic induction?

Whenever the magnetic flux linked with a closed coil changes, an emf (electromotive force) is induced and hence an electric current flows in the circuit. This current is called an induced current and the emf giving rise to such current is called an induced emf. This phenomenon is known as electromagnetic induction.

2. State Faraday's laws of electromagnetic induction.

First law:

Whenever magnetic flux linked with a closed circuit changes, an emf is induced in the circuit.

Second law:

The magnitude of induced emf in a closed circuit is equal to the time rate of change of magnetic flux linked with the circuit.

If the magnetic flux linked with the coil changes by $d\phi_B$ in a time dt, then the induced emf is given by $\varepsilon = \frac{d\phi_B}{dt}$.

3. State Lenz's law.

Lenz's law states that the direction of the induced current is such that it always opposes the cause responsible for its production.

The direction of induced current can be found by Right hand thumb rule. This law is in accordance with the law of conservation of energy.

$$\varepsilon = -\frac{d(N\phi_B)}{dt}$$

4. State Fleming's right hand rule.

The thumb, index finger and middle finger of right hand are stretched out in mutually perpendicular directions. If the index finger points the direction of the magnetic field and the thumb indicates the direction of motion of the conductor, then the middle finger will indicate the direction of the induced current. Fleming's right hand rule is also known as generator rule.

5. Mention the ways of producing induced emf.

Induced emf can be produced by changing magnetic flux in any of the following ways.

(i) By changing the magnetic field (B)

(ii) By changing the area (A) of the coil

(iii) By changing the relative orientation(θ) of the coil with magnetic field.

6. What do you mean by self-induction?

Whenever the magnetic flux linked with a coil changes due to the varying current in that coil, an emf is induced in the same coil. This phenomenon is known as self-induction.

7. What is meant by mutual induction?

When an electric current passing through a coil changes with time, an emf is induced in the neighbouring coil. This phenomenon is known as Mutual induction.

8. List out the advantages of stationary armature-rotating field system of AC generator.

Alternators are generally high current and high voltage machines. The stationary armature-rotating field construction has many advantages.

i) The current is drawn directly from fixed terminals on the stator without the use of brush contacts.

ii) The insulation of stationary armature winding is easier.

iii) The number of sliding contacts (slip rings) is reduced. Moreover, the sliding contacts are used for low-voltage DC Source.

iv) Armature windings can be constructed more rigidly to prevent deformation due to any mechanical stress.

9. What are step-up and step-down transformers?

i) If $N_s>N_p$ (or K>1), $V_s>V_p$ and Is <I_p. This is the case of step-up transformer in which voltage is increased and the corresponding current is decreased.

ii) If $N_s<N_p$ (or K<1), V_s<Vp and $I_s>I_p$ This is step-down transformer where voltage is decreased and the current is increased.

10. Define average value of an alternating current.

The average value of alternating current is defined as the average of all values of current over a positive half-cycle or negative half-cycle.

11. How will you define RMS value of an alternating current?

The root mean square value of an alternating current is defined as the square root of the mean of the squares of all currents over one cycle. It is denoted by I_{RMS}.

12. How will you define Q-factor?

Q-factor is defined as the ratio of voltage across L or C to the applied voltage.

$$Q\text{-factor} = \frac{\text{Voltage across L or C}}{\text{Applied voltage}} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

UNIT – 5 ELECTROMAGNETIC WAVES

1. **What is displacement current?**

The displacement current can be defined as the current which comes into play in the region in which the electric field or the electric flux is changing with time

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

2. **What are electromagnetic waves?**

Electro magnetic waves are non - mechanical waves which move with speed equals to the speed of light (in vacuum). It is a transverse wave.

3. **Give two uses each of (i) IR radiation,(ii) Microwaves and (iii) UV radiation.**

i) Uses of IR radiation: (any Two)

❖ It provides electrical energy to satellites by means of solar cells.
❖ It is used to produce dehydrated fruits.
❖ Heat therapy for muscular pain or sprain.
❖ In TV remote as a signal carrier
❖ To look through haze fog or mist.
❖ In night vision or infrared photography

ii) Uses of Microwaves: (Any Two)

❖ In RADAR system for aircraft navigation.
❖ To find speed of the vehicle.
❖ In microwave oven for cooking.
❖ In very long distance wireless communication through satellites.

iii) Uses of UV radiation: (Any two)

❖ To destroy bacteria in sterilizing the surgical instruments.
❖ In burglar alarm
❖ To detect the invisible writing, finger prints
❖ In the study of atomic structure.

4. **What is meant by Fraunhofer lines? How are they useful in the identification of elements present in theSun?**

When the spectrum obtained from the sun is examined, it consists of large number of dark lines. These dark lines in the solar spectrum are known as Fraunhofer lines.
The absorption spectra for various materials are compared with the Fraunhofer lines in the solar spectrum, which helps in identifying elements present in the sun's atmosphere.

5. Why are electromagnetic waves are called non-mechanical waves?

According to Maxwell, the variation in electric and magnetic fields perpendicular to each other, produces electromagnetic disturbances in space. These disturbances have the properties of a wave ie, electromagnetic waves and propagate through space without any material medium. So electromagnetic wave is a non-mechanical wave.

UNIT – 6 RAY OPTICS

1. State Snell's laws/law of refraction.

(i) The incident ray, refracted ray and normal to the refracting surface are all coplanar.

(ii) The ratio of sine of angle of incident i in the first medium to the sine of angle of refraction r in the second medium is equal to the ratio of refractive index n_2 of the second medium to the refractive index n_1 of the first medium.

$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$ (OR) $n_1 \sin i = n_2 \sin r$

2. Why do stars twinkle?

The stars actually do not twinkle. They appear twinkling because of the movement of the atmospheric layers with varying refractive indices which is clearly seen in the night sky.

3. What is critical angle and total internal reflection?

The angle of incidence in the denser medium for which the angle of refraction is 90° (or) the refracted ray graces the boundary between the two media is called critical angle i_c. For any angle of incidence greater than the critical angle, the entire light is reflected back into the denser medium itself. This phenomenon is called total internal reflection.

4. Explain the reason for glittering of diamond.

Diamond appears glittering because the total internal reflection of light happens inside the diamond. A skilled diamond cutter makes use of this larger range of angle of incidence, to ensure that light entering the diamond is total internally reflected from the many cut faces before getting out. This gives a sparkling effect for diamond.

5. What is power of a lens?

The power of a lens is a measure of the degree of convergence or divergence of light falling on it. The power of a lens P is defined as the reciprocal of its focal length.

$P = 1/f$. The unit of power is diopter (D) (or) m^{-1}.

6. What is dispersion?

Dispersion is splitting of white light into its constituent colours. This band of colours of light is called its spectrum.

7. What is Rayleigh's scattering?

If the scattering of light is by atoms and molecules which have size a very much less than that of the wave length λ of light ($a << \lambda$), then the scattering is called Rayleigh's scattering.

8. Why does sky appear blue?

According to Rayleigh scattering law violet colour which has the shortest wavelength gets more scattered than the other colours. The next scattered colour is blue. As our eyes are more sensitive to blue colour than violet colour, the sky appears blue during day time.

9. What is the reason for reddish appearance of sky during sunset and sunrise?

During sunrise and sunset, the light from sun travels a greater distance through the atmosphere. Hence, According to Rayleigh scattering law the blue light which has shorter wavelength is scattered away and the less-scattered red light of longer wavelength manages to reach our eyes. So the sky appear reddish during sunset and sunrise.

10. Why do clouds appear white?

If light is scattered by large particles like dust and water droplets present in the atmosphere which have size a greater than the wavelength λ of light, $a >> \lambda$, the intensity of scattering is equal for all the colours. It is happening in clouds which contains large amount of dust and water droplets. Thus, in clouds all the colours get equally scattered irrespective of wavelength. This is the reason for the whitish appearance of cloud.

UNIT - 7 WAVE OPTICS

1. **What is a wavefront?**
A wavefront is the locus of points which are in the same state or phase of vibration. When a wave propagates it is treated as the propagation of wavefront. The wavefront is always perpendicular to the direction of the propagation of the wave.

2. **What is Huygens' principle?**
According to Huygens principle, each point on the wavefront behaves as the source of secondary wavelets spreading out in all directions with the speed of the wave. These are called as secondary wavelets.
The envelope to all these wavelets gives the position and shape of the new wavefront at a later time.

3. **What is interference of light?**
The phenomenon of superposition of two light waves which produces increase in intensity at some points and decrease in intensity at some other points is called interference of light.

4. **What are coherent sources?**
Two light sources are said to be coherent if they produce waves which have same phase or constant phase difference, same frequency or wavelength (monochromatic), same waveform and preferably same amplitude.

5. **What is bandwidth of interference pattern?**
The bandwidth (β) is defined as the distance between any two consecutive bright or dark fringes. $\beta = \lambda D/d$

6. **What is diffraction?**
Diffraction is bending of waves around sharp edges into the geometrically shadowed region.

7. **Differentiate between Fresnel and Fraunhofer diffraction.**

S.No	**Fresnel diffraction**	**Fraunhofer diffraction**
1	Spherical or cylindricalwavefront undergoes diffraction	Plane wavefront undergoes diffraction
2	Light wave is from a source at finite distance	Light wave is from a source at infinity
3	convex lenses need not be used in laboratory conditions	convex lenses are to be used in laboratory conditions
4	Difficult to observe and analyse	Easy to observe, and analyse

8. Mention the differences between interference and diffraction.

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

9. What is the difference between resolution and magnification?

S.No	Resolution	Magnification
1.	It is the ability of optical instruments to produce images that are clearer, finer, and sharper	It is the ability of optical instruments to make a bigger image of an object
2.	It allows us to see a object more clearly and with more details	It allows us to see small objects, especially those that are not visible to the naked eye
3.	It can be expressed in arcsec or seconds	It can be expressed by a whole number

10. What is polarisation?

The phenomenon of restricting the vibrations of light to a particular direction perpendicular to the direction of propagation of wave is called polarization of light.

11. Differentiate between polarised and unpolarised light

S.NO	PolarisedLigh	Unpolarised Light
1.	Consists of waves having their electric and magnetic field vibrations in a single plane normal to the direction of ray.	Consists of waves having their electric and magnetic field vibrations in all directions normal to the direction of ray.
2.	Asymmetrical about the ray direction	Symmetrical about the ray direction
3.	It is obtained from unpolarised light with the help of polarisers	Produced by conventional light sources.

12. State Brewster's law.

Brewster's law states that the tangent of the polarising angle for a transparent medium is equal to its refractive index.$\tan i_p = n$

13. What is myopia? What is its remedy?

A person suffering from nearsightedness or myopia cannot see distant objects clearly. This may be due to the short focal length of the eye lens (or) larger diameter of the eyeball than usual. This can be corrected using Concave Lens.

14. What is hypermetropia? What is its remedy?

A person suffering from farsightedness or hypermetropia or hyperopia cannot see closer object clearly. It occurs when the eye lens has long focal length or shortening of the eyeball than usual. It can be corrected using Convex Lens.

15. What is astigmatism? What is its remedy?

Astigmatism is the defect arising due to different curvatures along different planes in the eye lens. Astigmatic person cannot see in all the directions equally well. The defect due to astigmatism is more serious than myopia and hypermetropia. The remedy to astigmatism is using a lens which has different curvatures in different planes i.e. cyclindrical lenses.

16. What is presbyopia?

An aged people cannot strain their eye more to reduce the focal length of the eye lens. For clear vision, they should keep the object inconveniently away from their eye. Thus, reading or viewing smaller things held in the hand is difficult for them.
This kind of farsightedness arising due to aging is called Presbyopia.

UNIT-8 DUAL NATURE OF RADIATION AND MATTER

1. Define work function of a metal. Give its unit.

The minimum energy needed for an electron to escape from the metal surface is called work function of that metal (ϕ_o). Its unit is Joule (or) eV.

2. What is photoelectric effect?

The ejection of electrons from a metal plate when illuminated by light or any other electromagnetic radiation of suitable wavelength (or) frequency is called photoelectric effect.

3. Give the definition of intensity of light and its unit.

According to quantum concept, intensity of light of given wavelength is defined as the number of photons incident per unit area per unit time, with each photon having same energy. Its unit is Wm^{-2}.

4. How will you define threshold frequency?

For a given surface, the emission of photoelectrons takes place only if the frequency of incident light is greater than a certain minimum frequency. The minimum frequency is called threshold frequency.

5. **What is a photo cell? Mention the different types of photocells.**

Photocell is a device which converts light energy into electrical energy. Its Types are

(i) Photo emissive cell (ii) Photo voltaic cell (iii) Photo conductive cell

6. **Define stopping potential?**

Stopping potential is that the value of the negative potential given to the collecting electrode A which is just sufficient to stop the most energetic photoelectrons emitted and make the photocurrent zero.

7. **What is Bremsstrahlung?**

When a fast moving electron penetrates and approaches a target nucleus, the interaction between the electron and the nucleus either accelerates or decelerates it which results in a change of path of the electron. The radiation produced from such decelerating electron is called Bremsstrahlung or braking radiation.

UNIT - 9 ATOMIC AND NUCLEAR PHYSICS

1. **Define the ionization energy and ionization potential.**

❖ The minimum energy required to remove an electron from an atom in the ground state is known as binding energy or ionization energy.

$$E_{ioni} = \frac{13.6}{n^2} Z^2 eV$$

❖ Ionization potential is defined as ionization energy per unit charge

$$V_{ioni} = \frac{1}{e} E_{ioni} = \frac{13.6}{n^2} Z^2 eV$$

2. **What is isotope? Give an example.**

Isotopes are atoms of the same element having same atomic number but different mass number.

Ex : ${}^{1}_{1}H$ - Hydrogen, - ${}^{2}_{1}H$ - Deuterium, ${}^{3}_{1}H$ - Tritium and ${}^{12}_{6}C$, ${}^{12}_{6}C$, ${}^{13}_{6}C$, ${}^{14}_{6}C$

3. **What is isotone? Give an example.**

Isotones are the atoms of the different elements having same number of neutrons.

Ex : ${}^{12}_{5}B$ – Boron, ${}^{13}_{6}C$ – Carbon. Both have 7 neutrons

4. **What is isobar? Give an example.**

Isobars are the atoms of different elements having the same mass number but different atomic number.

Ex: ${}^{40}_{18}Ar$ – Argon, ${}^{40}_{20}Ca$ - Calcium

5. Define atomic mass unit *u*.

One atomic mass unit is defined as the $1/12^{th}$ of the mass of the isotope of carbon $^{12}_{6}C$.

$1\ u = 1.66 \times 10^{-27}$ kg

6. What is mass defect?

The difference in the total mass of the nucleons and the actual mass of the nucleus is known as the mass defect. $\Delta m = (Zm_p + Nm_n) – M$. M - Actual mass of the nucleus

7. What is binding energy of a nucleus? Give its expression.

When the protons and neutrons combine to form a nucleus, the mass that disappears is converted into an equivalent amount of energy. This energy is called the binding energy of the nucleus.

$BE = (Zm_p + Nm_n - M_A)c^2 = \Delta mc^2$

8. Calculate the energy equivalent of 1 atomic mass unit.

$1u = 1.67 \times 10^{-27}\ kg$

Energy equivalent of $1\ u = m \times c^2$

$= 1.66 \times 10^{-27} \times (3 \times 10^8)^2 = 1.66 \times 10^{-27} \times 9 \times 10^{16} = 14.94 \times 10^{-11}\ J$

$= 14.94 \times 10^{-11} / 1.6 \times 10^{-19}\ eV = 931 \times 10^6\ eV = 931\ MeV$

Energy equivalent of 1 u = 931 MeV

9. What is meant by radioactivity?

The phenomenon of spontaneous emission of highly penetrating radiations such as α,β and γ rays by an element is called radioactivity and the substances which emit these radiations are called radioactive elements.

10. What is mean life of radioactive nucleus? Give the expression.

The mean life time of the nucleus is the ratio of sum of life times of all nuclei to the total number of nuclei present initially. $\tau = 1/\lambda = 1.443\ T_{1/2}$

Mean life time is also equal to reciprocal of decay constant.

11. What is half-life of nucleus? Give the expression.

The half life ($T_{1/2}$) is defined as the time required for the number of atoms initially present to reduce to one half of the initial amount. $T_{1/2} = 0.6931/\lambda$

12. Define curie.

One curie is defined as the number of decays per second in lg of radium and it is equal to 3.7×10^{10} decays/s. $1\ Ci = 3.7 \times 10^{10}$ Bq

UNIT - 10 ELECTRONICS AND COMMUNICATION

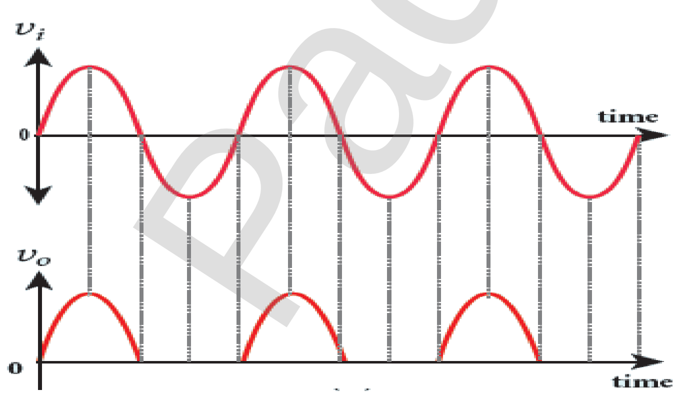
1. What do you mean by doping?

The process of adding impurities to the intrinsic semiconductor is called doping.
It increases the concentration of charge carriers in the semiconductor. So, its electrical conductivity is increases. The impurity atoms are called dopants.

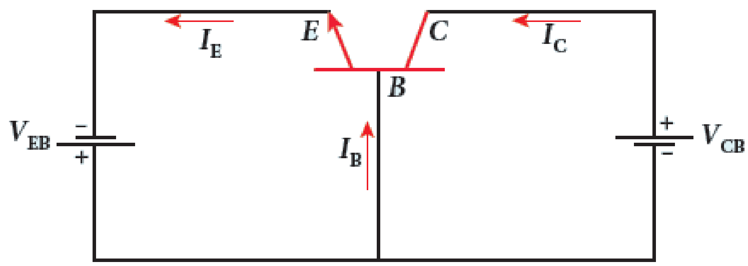
2. Distinguish between intrinsic and extrinsic semiconductors.

S.No	Intrinsic semiconductor	Extrinsic semiconductor
1.	A semiconductor in its pure form without impurity is called an intrinsic semiconductor	When a small amount of impurity is doped in pure semiconductor it becomes extrinsic semiconductor
2.	The number of free electrons is equal to the number of holes.	The number of free electrons and hole never equal. In n-type majority carriers are electrons. In p-type majority carriers are holes.
3.	In it, electrical conductivity is the function of temperature alone	In it, electrical conductivity is the function of temperature as well as concentration of impurity atoms doped in it.
4.	Fermi energy level lies at the centre of forbidden energy gap.	In n-type Fermi level is just below the conduction band where as in p-type Fermi energy level is just above the valance band.

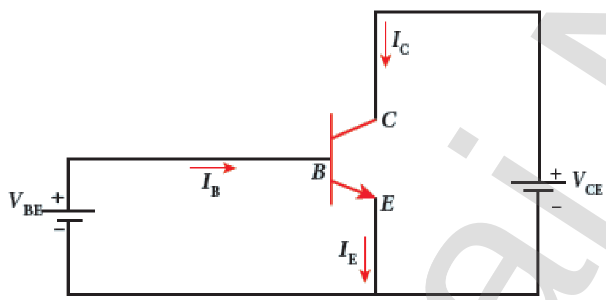
3. Draw the output waveform of a full wave rectifier.



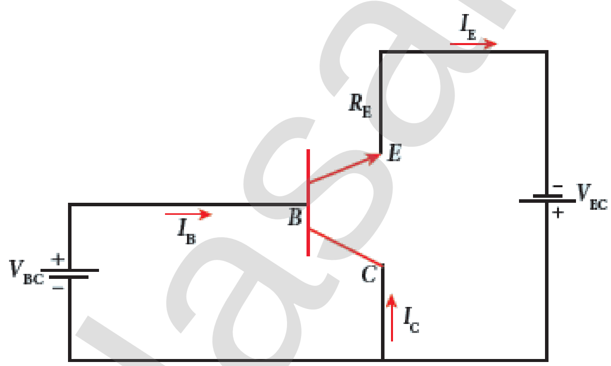
4. Draw the NPN transistor in common base(CB) configuration circuit symbol.



4. Draw the NPN transistor in common emitter(CE) configuration circuit symbol.



5. Draw the NPN transistor in common collector(CC) configuration circuit symbol.



6. Distinguish between avalanche and Zener breakdown

S.No	Avalanche Breakdown	Zener breakdown
1.	When both sides of the PN junction are lightly doped and the depletion layer becomes large.	When both sides of the PN junction heavily doped and the depletion Layer is narrow
2.	The electric field across the depletion layer is not so strong.	A very strong electric field is produced across the thin depletion layer.
3.	Due to the collision, covalent bonds are broken and electron hole pairs are generated.	Due to strong electric field, the covalent bonds breaks and large number of electrons and holes are produced.
4.	Reverse voltage must be greater than 6V	Reverse voltage must be less than 4V

7. What is rectification?

The process in which alternating voltage or alternating current is converted into direct voltage or direct current is known as rectification.

The device used for this process is called as rectifier.

8. List the applications of Light Emitting Diode LED?

a) Indicator lamp
b) Seven segment display
c) Traffic signals, exit signs, emergency vehicle lighting etc...
d) Industrial process control, position encoders, bar graph readers.

9. Give the principle of solar cells.

A solar cell, also known as photovoltaic cell, works on the principle of photovoltaic effect. Accordingly, the p-n junction of the solar cell generates emf when solar radiation falls on it.

10. What is an integrated circuit?

An integrated circuit consists of thousands to millions of transistors, resistors, capacitors integrated on a small flat piece of semiconductor material that is normally silicon. It is also called as an IC or a chip or a microchip.

11. What is modulation?

For long distance transmission, the low frequency baseband signal is superimposed onto a high frequency radio signal by a process called modulation.

12. Define bandwidth of transmission system.

The range of frequencies required to transmit a piece of specified information in a particular channel is called channel bandwidth or the bandwidth of the transmission system.

13. What is meant by skip distance and skip zone?

Skip Distance:

In the sky wave propagation the shortest distance between the point of transmission and the point of reception along the surface is known as the skip distance

Skip Zone / Skip area:

In sky wave propagation, there is a zone where there is no reception of electromagnetic waves neither ground nor sky, called as skip zone (or) skip area.

14. Give applications of RADAR.

i) In military, it is used for locating and detecting the targets.
ii) It is used in navigation systems such as ship borne surface search, air search and missile guidance systems.
iii) Radars are used to measure precipitation rate and wind speed in meteorological observations.
iv) It is employed to locate and rescue people in emergency situations.

UNIT – 11 RECENT DEVELOPMENTS IN PHYSICS

1. Distinguish between Nanoscience and Nanotechnology.

S.No	NANO- SCIENCE	NANO- TECHNOLOGY
1.	Nano science is the study of structures and materials on the scale of nanometers. One nanometer is $10^{-9}m$	Nano technology is a technology involving the design, production, characterization and applications of nano structured materials
2.	When objects go to nano scale in sizes physical laws may not be same as in large scale. Nano science involves finding governing laws of these tiny objects to describe the behaviour of them	Using the knowledge on materials got from nano science, nano technology focuses on properties such as strength, electrical and thermal conductivity etc... to design and manufacture useful things

2. What is the difference between Nano materials and Bulk materials?

S.No	NANO MATERIALS	BULK MATERIALS
1.	Size of the materials is less than 100 nm	Size of the materials is greater than 100 nm
2.	Large surface area per unit mass	Small surface area per unit mass compared to nano materials

3. Why steel is preferred in making Robots?

- Robot bodies are made using sheet, bar, rod and other shapes with steel because the steel is several times stronger than aluminium.

4. What are black holes?

- Black holes are end stage of stars which are highly dense massive objects. Its mass ranges from 20 times to 1 million times mass of the sun.
- It has very strong gravitational force such that any particle or even light cannot escape from it. Every galaxy has black hole at its centre.

"Gravity explains the

motions of the planets,

but it cannot explain

who sets the planets in motion."

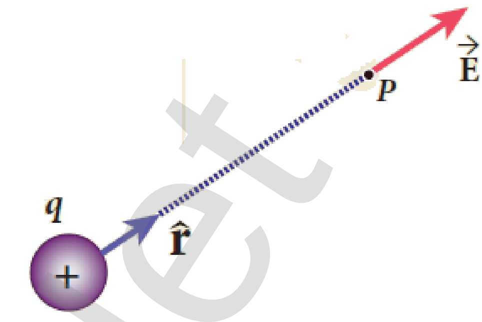
~Isaac Newton

THREE MARK

QUESTION AND ANSWER

UNIT - I ELECTROSTATICS

1. Define 'electric field' and discuss its various aspects.



- Consider a source point charge q located at a point in space.
- Another point charge q_o(test charge) is placed at some point P which is at a distance r from the charge q.
- The electrostatic force experienced by the charge $q_o$due to q is given by Coulomb's law.

$$\vec{F} = k\frac{qq_0}{r^2}\hat{r} = \frac{1}{4\pi\varepsilon_0}\frac{qq_0}{r^2}\hat{r} \qquad \text{where, } k = \frac{1}{4\pi\varepsilon_0}$$

- The electric field at the point P at a distance *r* from the point charge *q* is defined as the force that would be experienced by a unit positive charge placed at that point P and is given by

$$\vec{E} = \frac{\vec{F}}{q_0} = k\frac{q_0}{r^2}\hat{r} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$$

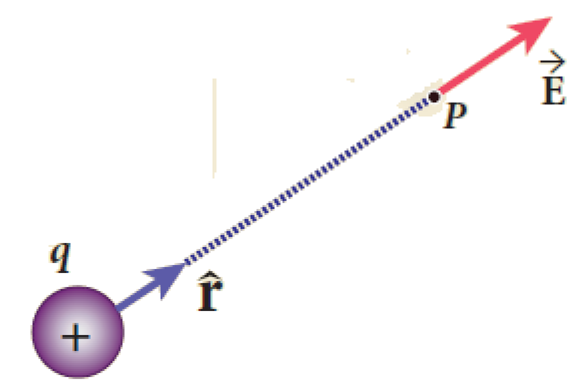
- The electric field is a vector quantity and its SI unit is NC^{-1}.

2. Derive an expression for electrostatic potential due to a point charge.

- Consider a positive charge *q* kept fixed at the origin. Let P be a point at distance r from the charge *q*.
- The electric potential at the point P is

$$V = \int_{\infty}^{r}(-\vec{E}).d\vec{r} = -\int_{\infty}^{r}\vec{E}.d\vec{r}$$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$$



$$V = -\frac{q}{4\pi\varepsilon_0}\int_{\infty}^{r}\frac{1}{r^2}\hat{r}.d\vec{r} \qquad \because d\vec{r} = dr.\hat{r}$$

$$V = \frac{q}{4\pi\varepsilon_0}\int_{\infty}^{r}\frac{1}{r^2}\hat{r}.\hat{r}dr \qquad \because \hat{r}.\hat{r} = 1$$

$$V = -\frac{q}{4\pi\varepsilon_0}\int_{\infty}^{r}\frac{1}{r^2}dr = -\frac{q}{4\pi\varepsilon_0}\left(-\frac{1}{r}\right)_{\infty}^{r} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

3. Obtain Gauss law from Coulomb's law.

A positive point charge Q is surrounded by an imaginary sphere of radius r.

Total electric flux through the closed surface $\phi_E = \oint \vec{E}.d\vec{A} = \oint E.dA\cos\theta$

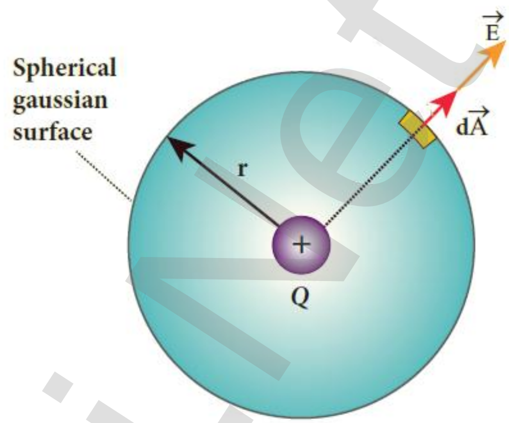
$$\phi_E = \oint E.dA \qquad \sin ce, \cos 0^\circ = 1$$

$$\phi_E = E\oint dA \qquad \oint dA = 4\pi r^2$$

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

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

$$\phi_E = \frac{Q}{\varepsilon_0}$$



The equation is called as Gauss's law.

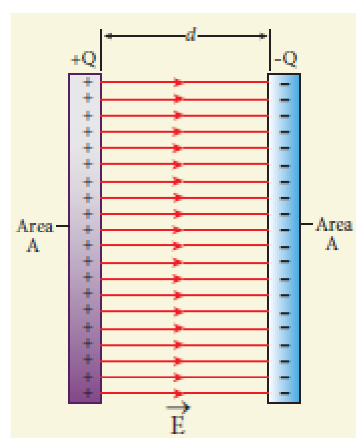
4. Obtain the expression for capacitance for a parallel plate capacitor.

- Consider a capacitor with two parallel plates each of cross-sectional area A and separated by a distance d.
- The electric field between two parallel plates is $E = \frac{\sigma}{\varepsilon_0}$
- where σ is the surface charge density $\sigma = \frac{Q}{A}$.

The electric field between the plates is $E = \frac{Q}{A\varepsilon_0}$

$$V = Ed = \frac{Qd}{A\varepsilon_0}$$

$$C = \frac{Q}{V} = \frac{Q}{\left(\frac{Qd}{A\varepsilon_0}\right)} = \frac{A\varepsilon_0}{d}$$



- capacitance is directly proportional to the area of cross section and is inversely proportional to the distance between the plates.

5. Obtain the expression for energy stored in the parallel plate capacitor.

- Capacitor not only stores the charge but also it stores energy.
- To transfer the charge, work is done by the battery. This work done is stored as electrostatic potential energy in the capacitor.
- The work done is given by $dW = VdQ$

$$dW = \frac{Q}{C}dQ \qquad \because V = \frac{Q}{C}$$

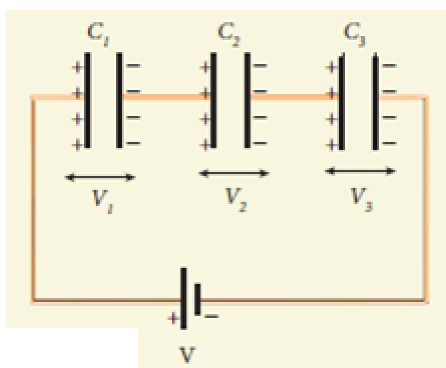
$$W = \int_0^Q \frac{Q}{C}dQ = \frac{Q^2}{2C}$$

$$U_E = \frac{Q^2}{2C} = \frac{1}{2}CV^2 \qquad \because Q = CV$$

- This stored energy is thus directly proportional to the capacitance of the capacitor and the square of the voltage between the plates of the capacitor.

6. Derive the expression for resultant capacitance, when capacitors are connected in series

- Consider three capacitors of capacitance C_1, C_2 and C_3 connected in series with a battery of voltage V.
- voltage across each capacitor is also different and are denoted as V_1, V_2 and V_3 respectively.



$$V = V_1 + V_2 + V_3$$

$$V = \frac{Q}{C_S}; V_1 = \frac{Q}{C_1}; V_2 = \frac{Q}{C_2}; V_3 = \frac{Q}{C_3}$$

$$\frac{Q}{C_S} = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$$

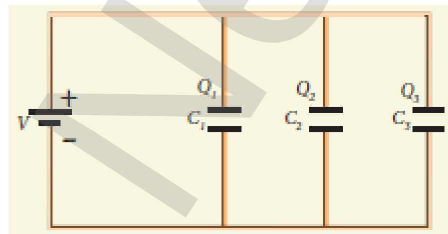
$$\frac{Q}{C_S} = Q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$$

$$\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

The inverse of the equivalent capacitance C_S of three capacitors connected in series is equal to the sum of the inverses of each capacitance.

7. Derive the expression for resultant capacitance, when capacitors are connected in Parallel.

- Consider three capacitors of capacitance C_1, C_2 and C_3 connected in parallel with a battery of voltage V.
- The voltage across each capacitor is equal to the battery's voltage.
- The charge stored in each capacitor is not the same. Let the charge stored in the three capacitors be Q_1, Q_2, and Q_3 respectively.



$$Q = Q_1 + Q_2 + Q_3$$
$$Q = C_P V ; Q_1 = C_1 V ; Q_2 = C_2 V ; Q_3 = C_3 V$$
$$C_P V = C_1 V + C_2 V + C_3 V$$
$$C_P V = V (C_1 + C_2 + C_3)$$
$$C_P = C_1 + C_2 + C_3$$

Thus, the equivalent capacitance of capacitors connected in parallel is equal to the sum of the individual capacitances.

UNIT - II CURRENT ELECTRICITY

1. State Kirchhoff's current rule and voltage rule.

Current rule or Junction rule:
It states that the algebraic sum of the currents at any junction of a circuit is zero.

Voltage rule or Loop rule:
It states that in a closed circuit the algebraic sum of the products of the current and resistance of each part of the circuit is equal to the total emf included in the circuit.

2. State the applications of Seebeck effect.

1. Seebeck effect is used in thermoelectric generators (Seebeck generators).These thermoelectric generators are used in power plants to convert waste heat into electricity
2. This effect is utilized in automobiles as automotive thermoelectric generators for increasing fuel efficiency.
3. Seebeck effect is used in thermocouples and thermopiles to measure the temperature difference between the two objects.

UNIT - III MAGNETISM AND MAGNETIC EFFECTS OF ELECTRIC CURRENT

1. **Discuss the conversion of galvanometer into an ammeter.**

- A galvanometer is converted into an ammeter by connecting a low resistance in parallel with the galvanometer. This low resistance is called shunt resistance *S*.

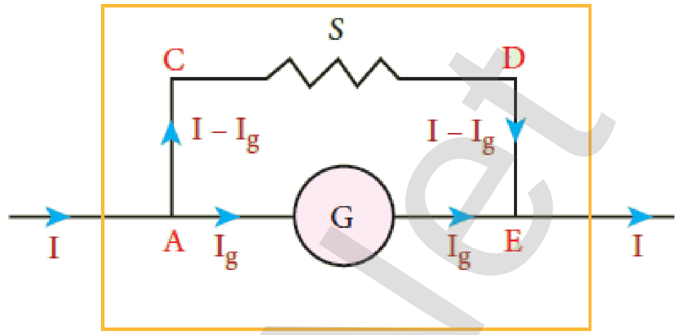
$$V_{galvanometer} = V_{shunt}$$

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

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

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

$$\theta = \frac{1}{G} I_g \Rightarrow \theta \propto I_g \Rightarrow \theta \propto I$$



Ammeter

- The deflection produced in the galvanometer is a measure of the current *I*passing through the circuit.

Resistance of ammeter $\frac{1}{R_{eef}} = \frac{1}{R_g} + \frac{1}{S} \Rightarrow R_{eef} = \frac{R_g S}{R_g + S} = R_a$

- The resistance offered by the ammeter is small. So, when we connect ammeter in series. An ideal ammeter has zero resistance

2. **Discuss the conversion of galvanometer into an ammeter and also a voltmeter.**

- A voltmeter is an instrument used to measure potential difference across any two points in the electrical circuits.
- A galvanometer is converted into a voltmeter by connecting high resistance $R_h$in series with galvanometer

$$I = I_g = \frac{\text{potential difference}}{\text{total resistance}}$$

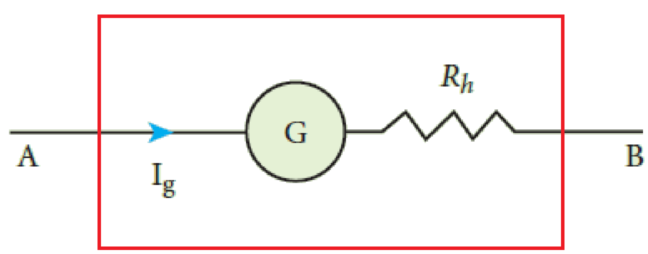
- Since the galvanometer and high resistance are connected in series, the total resistance or effective resistance

$$R_v = R_g + R_h$$

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

$$R_h = \frac{V}{I_g} - R_g$$

$$\theta \propto I_g ; I_g \propto V$$



Voltmeter

- Hence the deflection in the galvanometer is a measure of potential difference.
- Voltmeter must have high resistance and when it is connected in parallel
- An ideal voltmeter is one which has infinite resistance.

3. Give an account of magnetic Lorentz force.

1. $\vec{F}_m$ is directly proportional to the magnetic field $\vec{B}$
2. $\vec{F}_m$ is directly proportional to the velocity $\vec{v}$ of the moving charge
3. $\vec{F}_m$ is directly proportional to sine of the angle between the velocity and magnetic field
4. $\vec{F}_m$ is directly proportional to the magnitude of the charge q
5. The direction of $\vec{F}_m$ is always perpendicular to $\vec{v}$ and $\vec{B}$ as $\vec{F}_m$ is the cross product of $\vec{v}$ and $\vec{B}$
6. The direction of $\vec{F}_m$ on negative charge is opposite to the direction of $\vec{F}_m$ on positive charge provided other factors are identical.
7. If velocity $\vec{v}$ of the charge q is along magnetic field $\vec{B}$ then, $\vec{F}_m$ is zero

$$\vec{F}_m = q\left(\vec{v} \times \vec{B}\right)$$

In magnitude, $F_m = qvB \sin\theta$

4. Compare the properties of soft and hard ferromagnetic materials.

S.No.	Properties	Soft ferromagnetic materials	Hard ferromagnetic materials
1	When external field is removed	Magnetisation disappears	Magnetisation persists
2	Area of the loop	Small	Large
3	Retentivity	Low	High
4	Coercivity	Low	High
5	Susceptibility and magnetic permeability	High	Low
6	Hysteresis loss	Less	More
7	Uses	Solenoid core, transformer core and electromagnets	Permanent magnets
8	Examples	Soft iron, Mumetal, Stalloy etc.	Carbon steel, Alnico, Lodestone etc.

UNIT - IV ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENT

1. An inductor of inductance L carries an electric current i. How much energy is stored while establishing the current in it?

- Whenever a current is established in the circuit, the inductance opposes the growth of the current.
- In order to establish a current in the circuit, work is done against this opposition by some external agency.

$$\varepsilon = -L\frac{di}{dt}$$

$$dW = -\varepsilon dQ$$

$$dW = -\varepsilon idt \qquad \because dQ = idt$$

$$dW = -\left(-L\frac{di}{dt}\right)idt$$

$$dW = Lidt$$

$$W = \int dW = \int_0^t Lidt = L\left[\frac{i^2}{2}\right]_0^t$$

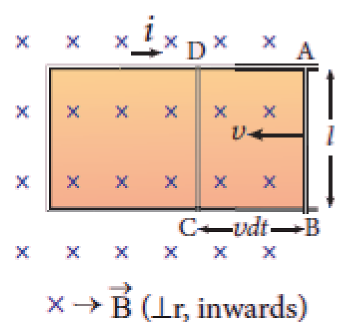
$$W = \frac{1}{2}Li^2$$

- This work done is stored as magnetic potential energy.

$$U_B = \frac{1}{2}Li^2$$

2. How will you induce an emf by changing the area enclosed by the coil?

- Consider a conducting rod of length l moving with a velocity υ towards left on a rectangular fixed metallic framework.
- The whole arrangement is placed in a uniformmagnetic field $\vec{B}$ whose magnetic lines areperpendicularly directed into the plane ofthe paper.
- As the rod moves from AB to DC in a timedt, the area enclosed by the loop and hence the magnetic flux through the loop decreases.
- The change in magnetic fluxis $d\phi_B = B \times \text{Change in area}$



$$d\phi_B = B \times \text{Area ABCD}$$

Since $\text{Area ABCD} = l\,(\text{v dt})$

$$d\phi_B = B \times l\text{vdt}$$

$$\varepsilon = \frac{d\phi_B}{dt} = \frac{Bl\,\text{vdt}}{dt}$$

- As a result of change in flux, an emf is generated in the loop.
- The magnitude of the induced emf is $\varepsilon = Blv$
- This emf is known as **motional emf.**

3. Mention the various energy losses in a transformer.

i) Core loss or Iron loss

- This loss takes place in transformer core. Hysteresis loss and eddy current loss are known as core loss or Iron loss.
- Hysteresis loss is minimized by using steel of high silicon content in making transformer core.
- The energy loss due to the flow of eddy current, called eddy current loss which is minimized by using very thin laminations of transformer core.

ii) Copper loss

- Transformer windings have electrical resistance.
- When an electric current flows through them, some amount of energy is dissipated due to Joule heating.
- This energy loss is called copper loss which is minimized by using wires of larger diameter.

iii) Flux leakage

- Flux leakage happens when the magnetic lines of primary coil are not completely linked with secondary coil.
- Energy loss due to this flux leakage is minimized by winding coils one over the other.

4. Define inductive and capacitive reactance. Give their units.

Inductive reactance

- The resistance offered by the inductor, called inductive reactance (X_L).
- It is measured in ohm.

$$X_L = \omega L$$

$$X_L = 2\pi f L$$

For AC current $X_L \propto L; X_L \propto f$

For DC current , $f = 0$, $X_L = 0$

Thus an ideal inductor offers no resistance to DC current.

Capacitive reactance

- The resistance offered by the capacitor, called capacitive reactance (X_C)
- It is measured in ohm.

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

$$X_C = \frac{1}{2\pi f L}$$

For AC current $X_C \propto \frac{1}{L}; X_C \propto \frac{1}{f}$

For DC current , $f = 0$, $X_C = \infty$

- So that DC cannot flow through the capacitor.

UNIT - V ELECTROMAGNETIC WAVES

1. Write down the integral form of modified Ampere's circuital law.

First equation Gauss's law for electricity $\oint_S \vec{E}.d\vec{A} = \frac{Q_{enclosed}}{\varepsilon_0}$	**Second equation** Gauss's law for magnetism $\oint_S \vec{B}.d\vec{A} = 0$
Third equation Faraday's law $\oint_l \vec{E}.d\vec{l} = \frac{d}{dt}\phi_B$	**Fourth equation** Ampere-Maxwell law $\oint_l \vec{B}.d\vec{l} = \mu_0 i_c + \mu_0 \varepsilon_0 \frac{d}{dt} \oint_s \vec{E}.d\vec{A}$

- These four equations are known as Maxwell's equations in electrodynamics.
- This equation ensures the existence of electromagnetic waves.

2. Write short notes on (a) microwave (b) X-ray (c) radio waves

Microwaves

- It is produced by special vacuum tubes such as klystron, magnetron and gunndiode.
- The frequency range of microwaves is 10^9Hz to 10^{11}Hz.
- These waves undergo reflection and can be polarised.
- It is used in radar system for aircraft navigation, speed of the vehicle, microwave oven for cooking and very long distance wireless communication through satellites.

X-rays

- It is produced when there is sudden stopping of high speed electrons at high-atomic number target, and also by electronic transitions among the innermost orbits of atoms.
- The frequency range of X-rays is from 10^{17}Hz to 10^{19}Hz.
- X-rays have more penetrating power than ultraviolet radiation.
- X-rays are used extensively in studying structures of inner atomic electron shells and crystal structures.
- It is used in detecting fractures, diseased organs, formation of bones and stones, observing the progress of healing bones.
- Further, in a finished metal product, it is used to detect faults, cracks, flaws and holes.

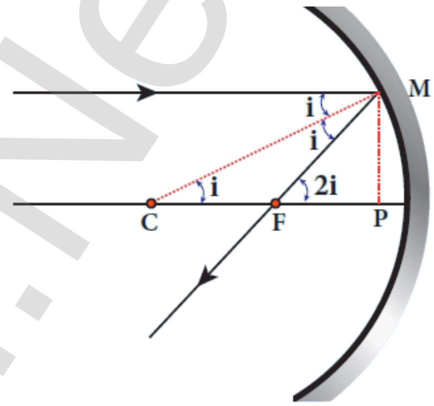
Radio waves

- They are produced by accelerated motion of charges in conducting wires.
- The frequency range is from a few Hz to 10^9Hz.
- They show reflection and diffraction.
- They are used in radio and television communication systems and also in cellular phones to transmit voice communication in the ultra high frequency band.

UNIT - VI RAY OPTICS

1. Derive the relation between f and R for a spherical mirror.

- Let *C* be the centre of curvature of the mirror.
- Consider a ray of light parallel to the principal axis is incident on the mirror at *M*.
- It passes through the principal focus *F* after reflection.
- The line *CM* is the normal to the mirror at *M*. Let *i* be the angle of incidence and the same will be the angle of reflection.
- From right angle triangles Δ*MCP* and Δ*MFP*, we can write,



$$\tan i = \frac{PM}{PC} \text{ and } \tan 2i = \frac{PM}{PF}$$

- As the angles are small, tani = i and tan 2i = 2i,

$$i = \frac{PM}{PC} \text{ and } 2i = \frac{PM}{PF}$$

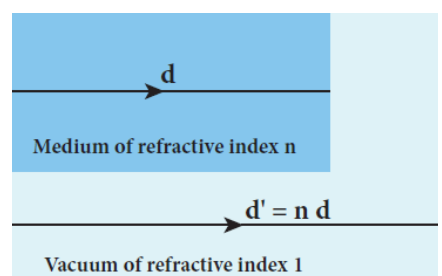
$$2\frac{PM}{PC} = \frac{PM}{PF} \Rightarrow 2\frac{1}{PC} = \frac{1}{PF} \Rightarrow 2PF = PC$$

- *PF* is focal length *f* and *PC* is the radius of curvature *R*.

$2R = f$ (or) $f = \frac{R}{2}$ This is the relation between *f* and *R*.

2. What is optical path? Obtain the equation for optical path.

- Optical path of a medium is defined as the distance d' light travels in vacuum in the same time it travels a distance d in the medium.
- Let us consider a medium of refractive index n and thickness d.
- Light travels with a speed v through the medium in a time t.
- The speed of light through the medium is, $v = \frac{d}{t}$, rewrittenfor as $t = \frac{d}{v}$
- In the same time t, light can cover a longer distance d' in vacuum as it travels with greater speed c in vacuum. $c = \frac{d'}{t}$, rewritten for t as, $t = \frac{d'}{c}$,
- As the time taken in both the cases is the same, we can equate the time t,



$$\frac{d}{v} = \frac{d'}{c}$$

- Optical path d' as, $d' = \frac{c}{v}d$ $\quad \because n = \frac{c}{v}$

$$d' = nd$$

- The value of n is always greater than 1, for a medium. Thus, the optical path d' of a medium is always greater than d.

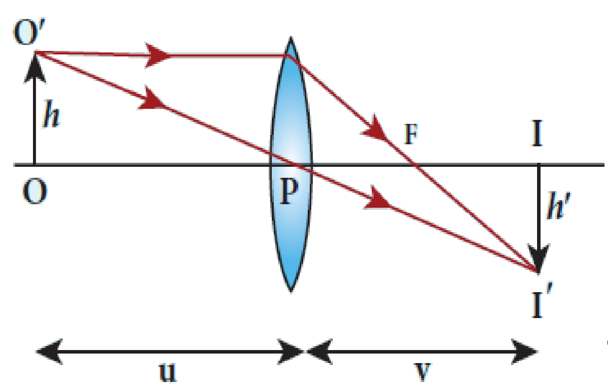
3. What are the Cartesian sign conventions for spherical mirrors?

While tracing the image, we would normally come across the object distance *u*, the image distance *v*, the object height *h*, the image height h', the focal length *f* and the radius of curvature *R*.

(i) The Incident light is taken as if it is travelling from left to right.
(ii) All the distances are measured from the pole of the mirror.
(iii) The distances measured to the right of pole along the principal axis are taken as positive.
(iv) The distances measured to the left of pole along the principal axis are taken as negative.
(v) Heights measured upwards perpendicular to the principal axis are taken as positive.
(vi) Heights measured downwards perpendicular to the principal axis, are taken as negative.

4. Obtain the equation for lateral magnification of thin lens.

- Let us consider an object OO' of height $h_1$placed on the principal axis with its height perpendicular to the principal axis.
- The inverted real image II' is formed which has a height h_2.
- The lateral magnification m is defined as the ratio of the height of the image to height of the object.
- $m = \frac{II'}{OO'}$



From the two similar triangles $\Delta POO'$ and $\Delta PII'$

$$\frac{II'}{OO'} = \frac{PI}{PO}$$

On applying sign convention,

magnification, $m = \frac{-h'}{h} = \frac{v}{-u}$

After rearranging, $m = \frac{h'}{h} = \frac{v}{u}$

- The magnification is negative for real image and positive for virtual image. In the case of a concave lens, the magnification is always positive and less than one.

$$m = \frac{h'}{h} = \frac{f}{f+u} = \frac{f-v}{f}$$

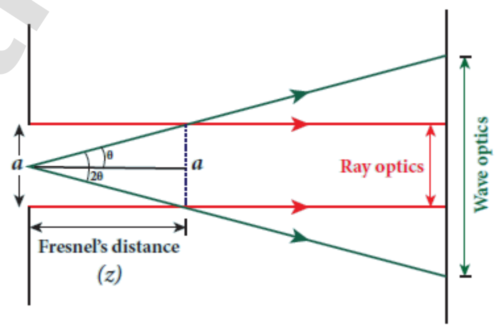
UNIT - VII WAVE OPTICS

1. What is Fresnel's distance? Obtain the equation for Fresnel's distance.

- The rectilinear propagation of light is violated as there is bending of light in diffraction. But, this bending is not seen till the diffracted ray crosses the central maximum at a distance *z* from the slit.
- Fresnel's distance is the distance up to which the ray optics is obeyed and beyond which the ray optics is not obeyed; but, the wave optics becomes significant.
- The diffraction equation for first minimum is, $\sin\theta = \frac{\lambda}{a}$; when θ is small, $\theta = \frac{\lambda}{a}$

From the definition of Fresnel's distance, $2\theta = \frac{a}{z}$ (or)

$\theta = \frac{a}{2z}$



Equating the above two equation for θ gives , $\frac{\lambda}{a} = \frac{a}{2z}$

After rearranging, Fresnel's distance *z* as, $z = \frac{a^2}{2\lambda}$

2. List the uses of polaroids.

1.Polaroids are used in goggles and cameras to avoid glare of light.

2. Polaroids are used to take 3D pictures i.e., holography.

3. Polaroids are used to improve contrast in old oil paintings.

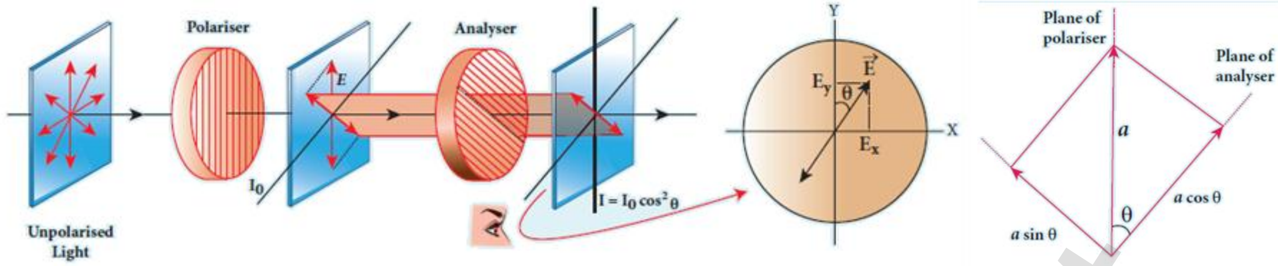
4. Polaroids are used in optical stress analysis.

5. Polaroids are used as window glasses to control the intensity of incoming light.

6. Polarised laser beam acts as needle to read/write in compact discs (CDs).

7. Polarised light is used in liquid crystal display (LCD).

3. State and obtain Malus' law.



Law:

- When a beam of plane polarised light of intensity $I_0$is incident on an analyser, the intensity of light I transmitted from the analyser varies directly as the square of the cosine of the angle θ between the transmission axes of polariser and analyser

$$I = I_0 \cos^2 \theta$$

Proof:

- Let I_0 be the intensity and a be the amplitude of the electric vector transmitted by the polariser.
- The intensity of light transmitted from the analyser is proportional to the square of the component of the amplitude transmitted by the analyser.

$$I \propto (a\cos\theta)^2 \quad I = k(a\cos\theta)^2$$

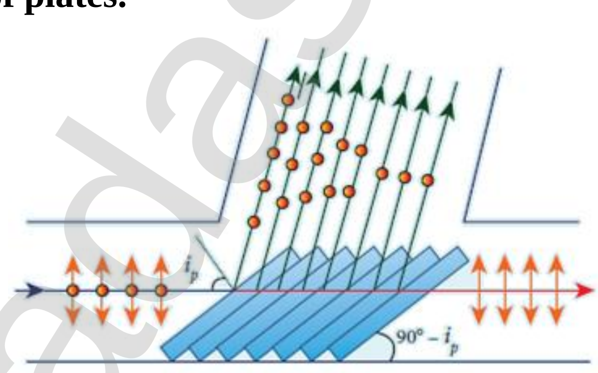
$$I = ka^2 \cos^2\theta$$

$$I = I_0 \cos^2\theta \quad I_0 = ka^2$$

Case (i)When $\theta = 0^o$, $\cos 0^o = 1$, $I = I_0$

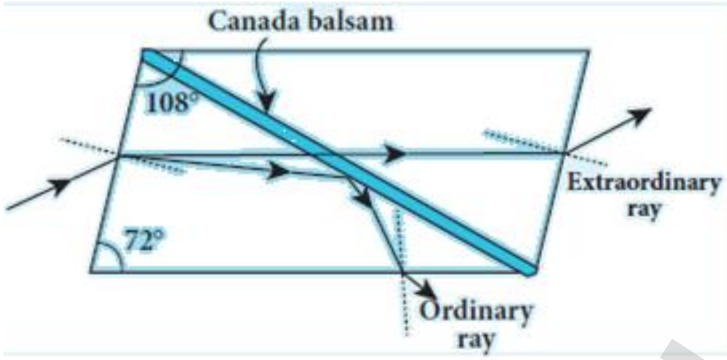
Case (ii)When $\theta = 90^o$, $\cos 90^o = 0$, $I = 0$

4. Discuss about pile of plates.



- Pile of plates makes use of Brewster's law to convert the partially polarised refracted light into plane polarised light.
- It consists of several plates kept one behind the other at an angle (90° – *ip)*with the horizontal surface.
- This arrangement ensures that the parallel light falls on these plates at *ip*.
- When this unpolarised light passes successively through these plates, the few parallel vibrations to the surface which may be present in the refracted light, get a chance for further reflections at the succeeding plates.
- Thus, both the reflected and the refracted lights are found to be plane polarised

5. **Discuss about Nicol prism.**



- Nicol prism is an optical device which forms a part of many optical instruments both for producing plane polarised light and also analysing.
- The construction of a Nicol prism is based on the phenomenon of double refraction.
- Nicol prism is a calcite crystal which has a length three times its breadth and angles $72^o$and 108^o.
- It is cut into two halves along the diagonal as the two halves are pasted together with a layer of a transparent cement.
- Let us consider a ray of unpolarised light from a monochromatic source is incident on the Nicol prism.
- The double refraction takes place and the ray is split into ordinary and extraordinary rays.
- The ordinary ray is total internally reflected at the layer of canada balsam and is prevented from emerging along with extraordinary ray. Where as, the extraordinary ray is transmitted through the crystal which is plane polarised.

UNIT – VIII DUAL NATURE OF RADIATION AND MATTER

1. **List out the laws of photoelectric effect.**

i) For a given metallic surface, the emission of photoelectrons takes place only if the frequency of incident light is greater than a certain minimum frequency called the threshold frequency.
ii) For a given frequency of incident light, the number of photoelectrons emitted is directly proportional to the intensity of the incident light. The saturation current is also directly proportional to the intensity of incident light.
iii) Maximum kinetic energy of the photo electrons is independent of intensity of the incident light.
iv) Maximum kinetic energy of the photo electrons from a given metal is directly proportional to the frequency of incident light.
v) There is no time lag between incidence of light and ejection of photoelectrons.

2. List out the characteristics of photons.

i) The photons of light of frequency ν and wavelength λ will have energy, given by

$$E = h\upsilon = \frac{hc}{\lambda}$$

ii) The energy of a photon is determined by the frequency of the radiation and not by its intensity and the intensity has no relation with the energy of the individual photons in the beam.

iii) The photons travel with the speed of light and its momentum is given by

$$p = \frac{h}{\lambda} = \frac{h\nu}{c}$$

iv) Since photons are electrically neutral, they are unaffected by electric and magnetic fields.

v) When a photon interacts with matter (photon-electron collision), the total energy, total linear momentum and angular momentum are conserved. Since photon may be absorbed or a new photon may be produced in such interactions, the number of photons may not be conserved.

UNIT – IX ATOMIC AND NUCLEAR PHYSICS

1. Write the properties of cathode rays.

(1) Cathode rays possess energy and momentum and travel in a straight line with high speed of the order of 10^7 ms^{-1}. It can be deflected by application of electric and magnetic fields. The direction of deflection indicates that they contain negatively charged particles.

(2) When the cathode rays are allowed to fall on matter, heat is produced. Cathode rays affect the photographic plates and also produce fluorescence when they fall on certain crystals and minerals.

(3) When the cathode rays fall on a material of high atomic weight, x-rays are produced.

(4) Cathode rays ionize the gas through which they pass.

(5) The speed of cathode rays is up to $\left(\frac{1}{10}\right)^{th}$ of the speed of light.

2. Discuss the alpha decay process with example.

- In α decay the atomic number Z decreases by 2 and the mass number decreases by 4.

$${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He$$

- Here *X* is called the parent nucleus and *Y* is called the daughter nucleus.
- Example: ${}^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$

$$\Delta m = m_X - m_Y - m_\alpha$$

Difference in mass (Δm) is released as energy called disintegration energy *Q*.

$$Q = (m_X - m_Y - m_\alpha)c^2$$

3. Discuss the beta decay process with examples.

β^- decay:

- In β^- decay, the atomic number of the nucleus increases by one but its mass number remains the same.

$${}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + e^- + \overline{v}$$

- It implies that the element *X* becomes *Y* by giving out an electron and an antineutrino

$$n \rightarrow p + e^- + \overline{v}$$

Example: ${}^{14}_{6}C \rightarrow {}^{14}_{7}N + e^- + \overline{v}$

β^+ decay:

- In β^+ decay, the atomic number is decreased by one and again its mass number remains the same. This decay is represented by

$${}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + e^+ + v$$

- It implies that the element *X* becomes *Y* by giving out an positron and neutrino(v).

$$n \rightarrow p + e^+ + v$$

Example: ${}^{22}_{11}Na \rightarrow {}^{22}_{10}Ne + e^+ + v$

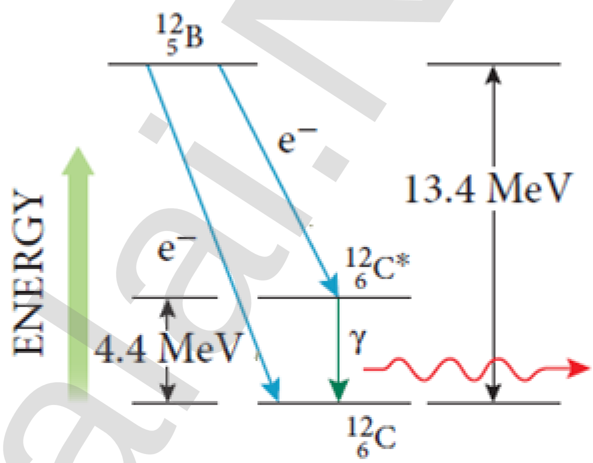
4. Discuss the gamma emission process with example.

- In α and β decay, the daughter nucleus is in the excited state most of the time. The typical life time of excited state is approximately 10^{-11}s.
- So this excited state nucleus immediately returns to the ground state or lower energy state by emitting highly energetic photons called γ rays.
- In fact, when the atom is in the excited state, it returns to the ground state by emitting photons of energy in the order of few eV.
- But when the excited state nucleus returns to its ground state, it emits a highly energetic photon (γ rays) of energy in the order of MeV.

$${}^{A}_{Z}X \rightarrow {}^{A}_{Z}X + \gamma$$

Example: ${}^{12}_{5}B \rightarrow {}^{12}_{6}C + e + \overline{v}$

${}^{12}_{6}C^{*} \rightarrow {}^{12}_{6}C + \gamma$



UNIT – X ELECTRONICS AND COMMUNICATION

1. List out the advantages and limitations of frequency modulation.

Advantages of FM

i) In FM, there is a large decrease in noise. This leads to an increase in signal-noise ratio.

ii) The operating range is quite large.

iii) The transmission efficiency is very high as all the transmitted power is useful.

iv) FM bandwidth covers the entire frequency range which humans can hear. Due to this, FM radio has better quality compared to AM radio.

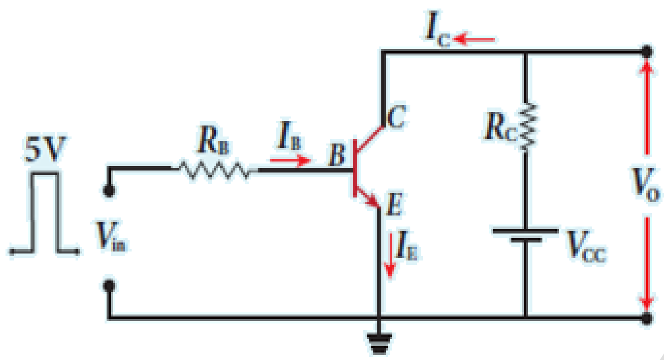
Limitations of FM

i) FM requires a much wider channel.

ii) FM transmitters and receivers are more complex and costly.

iii) In FM reception, less area is covered compared to AM.

2. Transistor functions as a switch. Explain.



- A transistor in saturation region acts as a closed switch while in cut-off region; it acts as an open switch.
- It functions like an electronic switch that helps to turn ON or OFF a given circuit by a small control signal which keeps the transistor either in saturation region or in cut-off region.

When the input is low:

- When the input is low (say 0V), the base current is zero and transistor is not properly forward biased. It is in cut off region.
- As a result, the collector current is zero and correspondingly the voltage drop across R_C also becomes nearly zero. The output voltage is high and is equal to V_{CC}. It means that the no current flows through the transistor and it is said to be switched off. The transistor acts as an open switch.

When the input is high:

- When the input voltage is increased to a certain high value (say +5 V), the base current (I_B) increases and in turn increases the collector current to its maximum.
- The transistor will move into the saturation region. The increase in collector current (I_C) increases the voltage drop across R_C, thereby lowering the output voltage, close to zero (since $V_0 = V_{CC} - I_C R_C$).
- It means that maximum current flows through the transistor and it is said to be switched on. The transistor acts as a closed switch.
- Therefore, a transistor can be used as an inverter (NOT gate) in computer logic circuitry.

UNIT – XI RECENT DEVELOPMENTS IN PHYSICS

1. Mention any two advantages and disadvantages of Robotics.

Advantages

1. Thee robots are much cheaper than humans.
2. Robots never get tired like humans. It can work for 24 x 7. Hence absenteeism in workplace can be reduced.
3. Robots are more precise and error free in performing the task.
4. Stronger and faster than humans.
5. Robots can work in extreme environmental conditions: extreme hot or cold, space or underwater. In dangerous situations like bomb detection and bomb deactivation.
6. In warfare, robots can save human lives.
7. Robots are significantly used in handling materials in chemical industries especially in nuclear plants which can lead to health hazards in humans.

Disadvantages

1. Robots have no sense of emotions or conscience.
2. They lack empathy and hence create an emotionless workplace.
3. If ultimately robots would do all the work, and the humans will just sit and monitor them, health hazards will increase rapidly.
4. Unemployment problem will increase.
5. Robots can perform de.ned tasks and cannot handle unexpected situations
6. The robots are well programmed to do a job and if a small thing goes wrong it ends up in a big loss to the company.
7. If a robot malfunctions, it takes time to identify the problem, rectify it, and even reprogram if necessary. This process requires significant time.
8. Humans cannot be replaced by robots in decision making.
9. Till the robot reaches the level of human intelligence, the humans in work place will exit.

If you want to shine

like a sun,

first burn like a sun

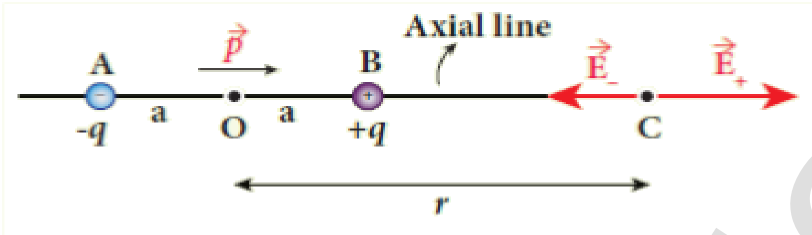
~ **A.P.J Abdul Kalam**

FIVE MARK

QUESTION AND ANSWER

LESSON – 1 ELECTROSTATICS

1. Calculate the electric field due to a dipole on its axial line.



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

- The electric field at a point C due to +*q* is $\vec{E}_+ = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2}\hat{p}$

- The electric field at a point C due to –*q* is $\vec{E}_- = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}(-\hat{p})$

- The total electric field at point C is $\vec{E}_{tot} = \vec{E}_+ + \vec{E}_-$

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

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

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

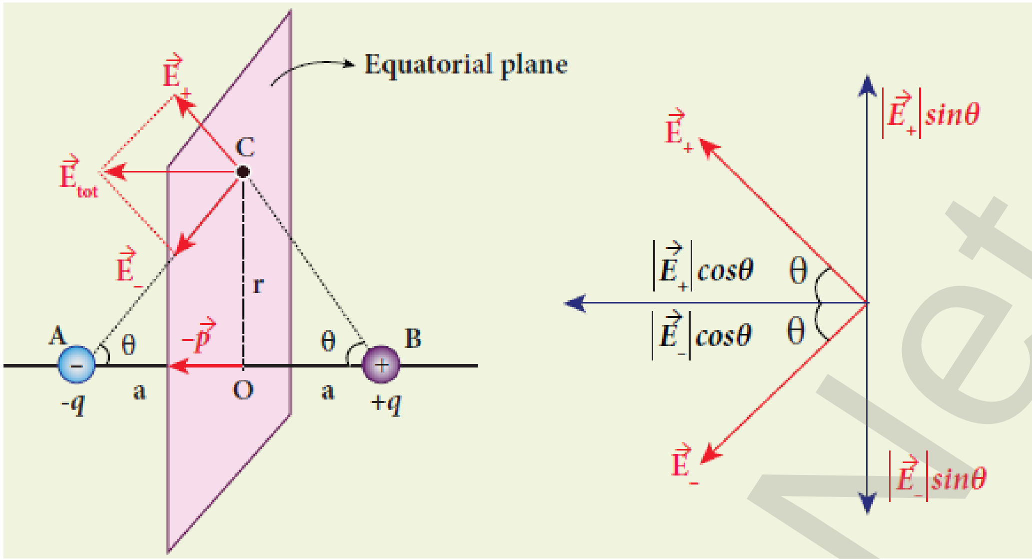
- If the point C is very far away from the dipole (*r* >>*a*). $\therefore (r^2-a^2)^2 \approx r^4$

$$\vec{E}_{tot} = \frac{q}{4\pi\varepsilon_0}\left(\frac{4a}{r^3}\right)\hat{p} \qquad \because \vec{p} = 2qa\,\hat{p}$$

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

- The total electric field is in the direction of $\vec{p}$.

2. Calculate the electric field due to a dipole on its axial line and equatorial plane.



- Consider a point C at a distance r from the midpoint O of the dipole on the equatorial plane.
- Since the point C is equi-distant from $+q$ and $-q$, the magnitude of the electric fields at C due to $+q$ and $-q$ are the same.
- The directionof $\vec{E}_+$ is along BC and the direction of $\vec{E}_-$ is along CA.
- $\vec{E}_+$ and $\vec{E}_-$ can be resolved into two components.
- Since perpendicular components $\vec{E}_+ \sin\theta$ and $\vec{E}_- \sin\theta$ are equal in magnitude and oppositely directed, they cancel each other.
- The magnitude of the total electric field at point C is the sum of the parallel components of $\vec{E}_+$ and $\vec{E}_-$ and its direction is along $-\vec{p}$.
- The total electric field at point C is, $\vec{E}_{tot} = -\left|\vec{E}_+\right|\cos\theta\hat{p} - \left|\vec{E}_-\right|\cos\theta\hat{p}$

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

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

$$\vec{E}_{tot} = -\frac{1}{4\pi\varepsilon_0}\frac{2qa}{(r^2+a^2)^{3/2}}\hat{p} \qquad \because \cos\theta = \frac{a}{\sqrt{r^2+a^2}}$$

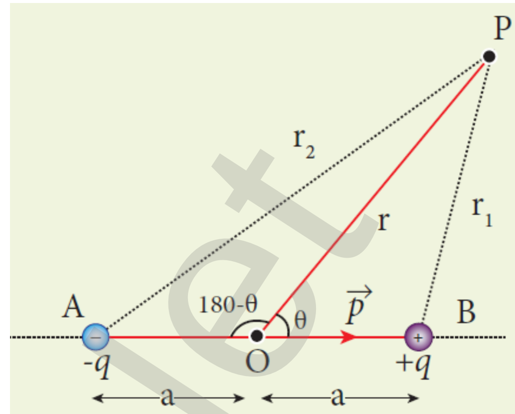
$$\vec{E}_{tot} = -\frac{1}{4\pi\varepsilon_0}\frac{\vec{p}}{(r^2+a^2)^{3/2}} \qquad \because \vec{p} = 2qa\,\hat{p}$$

- If the point C is very far away from the dipole ($r >> a$). $\therefore (r^2+a^2)^{3/2} \approx r^3$

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

- The total electric field is in the direction of $-\vec{p}$.

3. Derive an expression for electrostatic potential due to an electric dipole.



- Consider two equal and opposite charges separated by a small distance 2a.
- The point P is located at a distance r from the midpoint of the dipole.
- Let θ be the angle between the line OP and dipole axis AB.
- Potential at P due to charge +q is, $V_+ = \frac{1}{4\pi\varepsilon_0}\frac{q}{r_1}$
- Potential at P due to charge -q is, $V_- = -\frac{1}{4\pi\varepsilon_0}\frac{q}{r_2}$
- Total potential at the point P is, $V = V_+ + V_- = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$ ....(1)
- By the cosine law for triangle BOP, $\frac{1}{r_1} = \frac{1}{r}\left(1 + \frac{a}{r}\cos\theta\right)$ ....(2)
- Similarly applying the cosine law for triangle AOP, $\frac{1}{r_2} = \frac{1}{r}\left(1 - \frac{a}{r}\cos\theta\right)$ ....(3)
- Substituting equation (2) and (3) in equation (1),

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

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

$$V = \frac{1}{4\pi\varepsilon_0}\frac{2aq}{r^2}\cos\theta \qquad \because p = 2aq$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}\cos\theta$$

Special cases

Case (i) $\theta = 0^o$ **;** $V = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}$

Case (ii) $\theta = 180^o$**;** $V = -\frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}$

Case (iii) $\theta = 90^o$**;** $V = 0$

4. Explain in detail the construction and working of a Van de Graaff generator.

INTRODUCTION

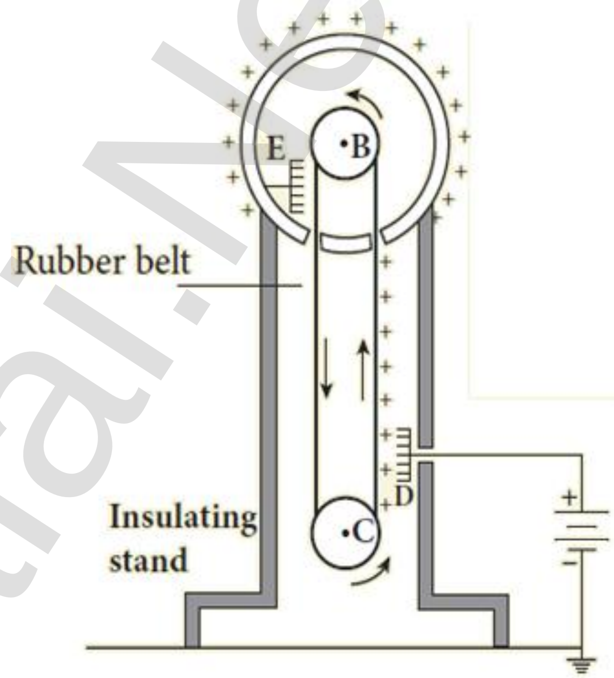
Van de Graaff generator produces a large amount of electrostatic potential up to 10^7 V.

PRINCIPLE

Electrostatic induction and Action at points

CONSTRACTION

- A large hollow spherical conductor is fixed on the insulating stand.
- A pulley B is mounted at the centre of the hollow sphere and another pulley C is fixed at the bottom.
- A belt made up of silk or rubber runs over both pulleys.
- The pulley C is driven continuously by the electric motor.
- Two comb shaped metallic conductors E and D 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.



WORKING

- Due to the high electric field near comb D, air between the belt and comb D gets ionized by the action of points.
- The positive charges are pushed towards the belt and negative charges are attracted towards the comb D.
- The positive charges stick to the belt and move up. When the positive charges on the belt reach the point near the comb E, the comb E acquires negative charge and the sphere acquires positive charge due to electrostatic induction.
- The positive charges are distributed uniformly on the outer surface of the hollow sphere.
- This process continues until the outer surface produces the potential difference of the order of 10^7 V which is the limiting value.
- The leakage of charges can be reduced by enclosing the machine in a gas filled steel chamber at very high pressure.

USES

- The high voltage produced in this Van de Graaff generator is used to accelerate positive ions (protons and deuterons) for nuclear disintegrations and other applications.

LESSON – 2 CURRENT ELECTRICITY

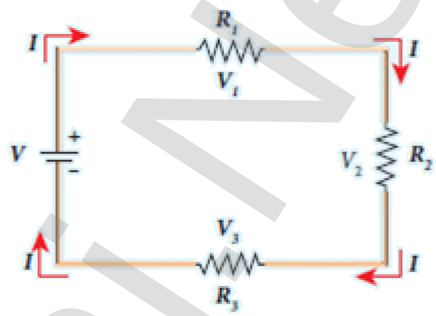
1. Explain the equivalent resistance of a series and parallel resistor network.

Resistor in series network:

- When two or more resistors are connected end to end, they are said to be in series.
- Three resistors R_1, $R_2$and R_3connected in series.
- The current I passing through all the three resistors is the same.
- If V_1, $V_2$and V_3be the voltage across each of the resistors R_1, $R_2$and R_3respectively.
- According to Ohm's law,
  $V_1 = IR_1$, $V_2 = IR_2$and $V_3 = IR_3$, $V = IR_S$

  $V = V_1 + V_2 + V_3$

  $IR_S = IR_1 + IR_2 + IR_3$
  $IR_S = I(R_1 + R_2 + R_3)$
  $R_S = R_1 + R_2 + R_3$



- When several resistors are connected in series, the total resistance is equal to sum of the individual resistances

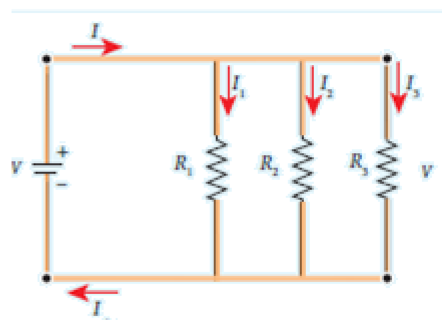
Resistor in parallel network:

- Three resistors R_1, $R_2$and R_3connected in parallel.
- Let I_1, $I_2$and I_3be the current through the resistors R_1, $R_2$and R_3respectively.
- Total current in the circuit I is equal to sum of the currents through each of the three resistors.

  $I = I_1 + I_2 + I_3$

  The voltage across each resistor is the same.

  applying Ohm's law,



$$I = \frac{V}{R_S},\ I_1 = \frac{V}{R_1},\ I_2 = \frac{V}{R_2},\ I_3 = \frac{V}{R_3}$$

$$\frac{V}{R_S} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\frac{V}{R_S} = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$\frac{1}{R_S} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

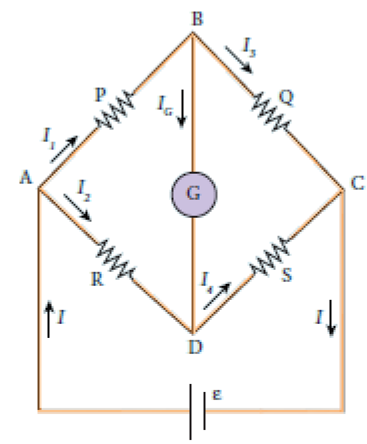
- When a number of resistors are connected in parallel, the sum of the reciprocals of resistance of the individual resistors is equal to the reciprocal of the effective resistance of the combination

2. Obtain the condition for bridge balance in Wheatstone's bridge.

- An important application of Kirchhoff 's rules is the Wheatstone's bridge.
- It is used to compare resistances and in determining the unknown resistance in electrical network.
- The bridge consists of four resistances P, Q, R and S connected as shown in Figure.
- A galvanometer G is connected between the points B and D.
- The battery is connected between the points A and C.
- The current through the galvanometer is I_G and its resistance is G.
- Applying Kirchhoff 's current rule to junction B and D respectively.

  $I_1 - I_G - I_3 = 0$ …………….(1)

  $I_2 + I_G - I_4 = 0$ …………….(2)



- Applying Kirchhoff 's voltage rule to loop ABDA,

  $I_1P + I_GG - I_2R = 0$ …………….(3)

- Applying Kirchhoff 's voltage rule to loop ABCDA,

  $I_1P + I_3Q - I_4S - I_2R = 0$ ………(4)

- When the points B and D are at the same potential, $I_G = 0$. Substituting $I_G = 0$ in equation (1), (2) and (3), we get

  $I_1 = I_3$

  $I_2 = I_4$

  $I_1P = I_2R$ …………….(5)

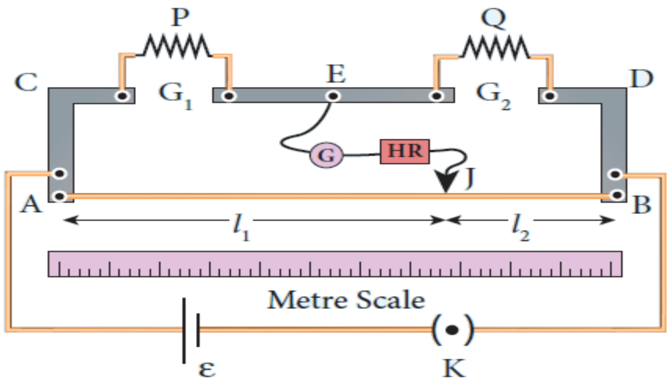
  Using equation (5) in equation (4)

  $I_3Q = I_4S$ …………….(6)

  Dividing equation (5) by equation (6), we get

$$\frac{P}{Q} = \frac{R}{S}$$

3. Explain the determination of unknown resistance using meter bridge.



- The meter bridge is another form of Wheatstone's bridge.
- It consists of a uniform wire of manganin AB of one meter length.
- An unknown resistance P is connected in G_1 and a known resistance Q is connected in G_2.
- A jockey is connected to the terminal E on the central copper strip through a galvanometer (G) and a high resistance (HR).
- A Lechlanche cell and a key (K) are connected between the ends of the bridge wire.
- The position of the jockey on the wire is adjusted so that the galvanometer shows zero deflection.
  Let the position of jockey at the wire be at J.
- The resistances corresponding to AJ and JB of the bridge wire form the resistances R and S of the Wheatstone's bridge.
- Then for the bridge balance $\frac{P}{Q} = \frac{R}{S} = \frac{r.AJ}{r.JB}$, where r is the resistance per unit length of wire.

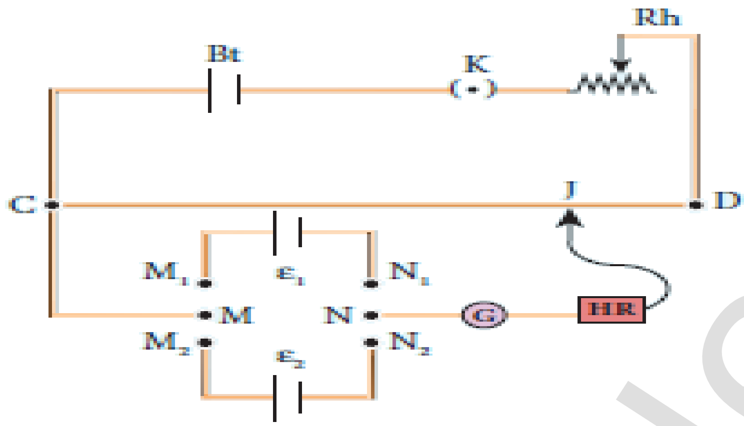
$$\frac{P}{Q} = \frac{AJ}{JB} = \frac{l_1}{l_2}$$

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

ρ =Resistance$\times \frac{A}{l}$.   If P is the unknown resistance

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

4. How the emf of two cells are compared using potentiometer?



- Potentiometer wire CD is connected to a battery *Bt*and a key K in series. This is the primary circuit.

- The end C of the wire is connected to the terminal M of a DPDT switch and the other terminal N is connected to a jockey through a galvanometer G and a high resistance HR.

- The cells whose emf ε1 and ε_2 to be compared are connected to the terminals M_1,$N_1$and M_2,N_2 of the DPDT switch.

- The DPDT switch is pressed towards M_1, N_1 so that cell ε1 is included in the secondary circuit and the balancing length *l*1 is found by adjusting the jockey for zero deflection.

$$\varepsilon_1 = Irl_1 \quad ....(1)$$

- Then the second cell ε_2 is included in the circuit and the balancing length l_2 is determined.

$$\varepsilon_2 = Irl_2 \quad ....(2)$$

Dividing equation (1) by equation (2), we get

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{Irl_1}{Irl_2};$$

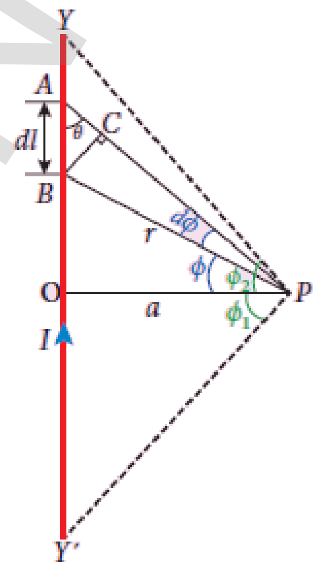
$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2}$$

LESSON – 3 MAGNETISM AND MAGNETIC EFFECTS OF ELECTRIC CURRENT

1. Deduce the relation for the magnetic field at a point due to an infinitely long straight conductor carrying current.

- Let YY' be an infinitely long straightconductor and I be the steady currentthrough the conductor.
- In order to calculate magnetic field ata point P which is at a distance a from thewire, let us consider a small line element dl.
- The magnetic field at a point P due to current element *Idl*can be calculated from

Biot-Savart's law, $d\vec{B} = \frac{\mu_0}{4\pi}\frac{Idl \sin\theta}{r^2}\hat{n}$



In triangle Δ ABC, $\sin\theta = \frac{AC}{AB}$

$AC = AB\sin\theta \because AB = dl$

$AC = dl\sin\theta$

In a triangle Δ APC $\sin d\phi = \frac{AC}{AP}$

Since, $d\phi$ is very small, sin $d\phi \approx d\phi$

$AC = AP\sin d\phi$ But AP = r

$AC = rd\phi$

$AC = dl\sin\theta = rd\phi$

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I}{r^2}(rd\phi)\hat{n} = \frac{\mu_0}{4\pi}\frac{Id\phi}{r}\hat{n}$$

In a ΔOPA, $\cos\phi = \frac{OP}{BP} = \frac{a}{r} \Rightarrow r = \frac{a}{\cos\phi}$

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\phi}{a/\cos\phi}\hat{n} = \frac{\mu_0 I}{4\pi a}\cos\phi d\phi\hat{n}$$

$$\vec{B} = \int_{-\phi_1}^{\phi_2} d\vec{B} = \frac{\mu_0 I}{4\pi a}\int_{-\phi_1}^{\phi_2}\cos\phi d\phi\hat{n}$$

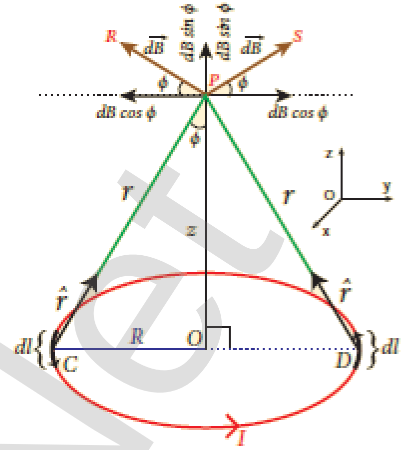
$$\vec{B} = \frac{\mu_0 I}{4\pi a}[\sin\phi]_{-\phi_1}^{\phi_2}$$

$$\vec{B} = \frac{\mu_0 I}{4\pi a}(\sin\phi_1 + \sin\phi_2)\hat{n}$$

For infinitely long conductor, $\phi_1 = \phi_2 = 90°$

$$\vec{B} = \frac{\mu_0 I}{4\pi a}\times 2\hat{n} = \frac{\mu_0 I}{2\pi a}\hat{n}$$

2. Obtain a relation for the magnetic field at a point along the axis of a circular coil carrying current.



- Consider a current carrying circular loop of radius R and let I be the current flowing through the wire.
- The magnetic field at a point P on the axis of the circular coil at a distance z from the centre of the coil O is computed by taking two diametrically opposite line elements of the coil each of length $d\vec{l}$ at C and D.
- Let $\vec{r}$ be the vector joining the current element ($Id\vec{l}$) at C and the point P.
- According to Biot-Savart's law, the magnetic field at P due to the current element at C is, $d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\vec{l} \times \hat{r}}{r^2}$

  The magnitude of $d\vec{B}$

  $$dB = \frac{\mu_0}{4\pi}\frac{Idl \sin\theta}{r^2} = \frac{\mu_0}{4\pi}\frac{Idl}{r^2}$$

  where θ is the angle between $Id\vec{l}$ and $\hat{r}$. Here θ = 90°, sin 90° = 1.
- The magnetic field $d\vec{B}$ due to each current element is resolved into two components; dB cos ϕ along y-direction and dB sin ϕ along z-direction.
- The horizontal components cancel out while the vertical components ($dB \sin\phi\hat{k}$) alone contribute to the net magnetic field $\vec{B}$ at the point P.

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

$$\vec{B} = \frac{\mu_0 I}{4\pi}\int\frac{dl}{r^2}\sin\phi\hat{k} \qquad \because r^2 = (R^2 - z^2)$$

$$\sin\phi = \frac{R}{r} = \frac{R}{(R^2 - z^2)^{1/2}} \qquad \because r = (R^2 - z^2)^{1/2}$$

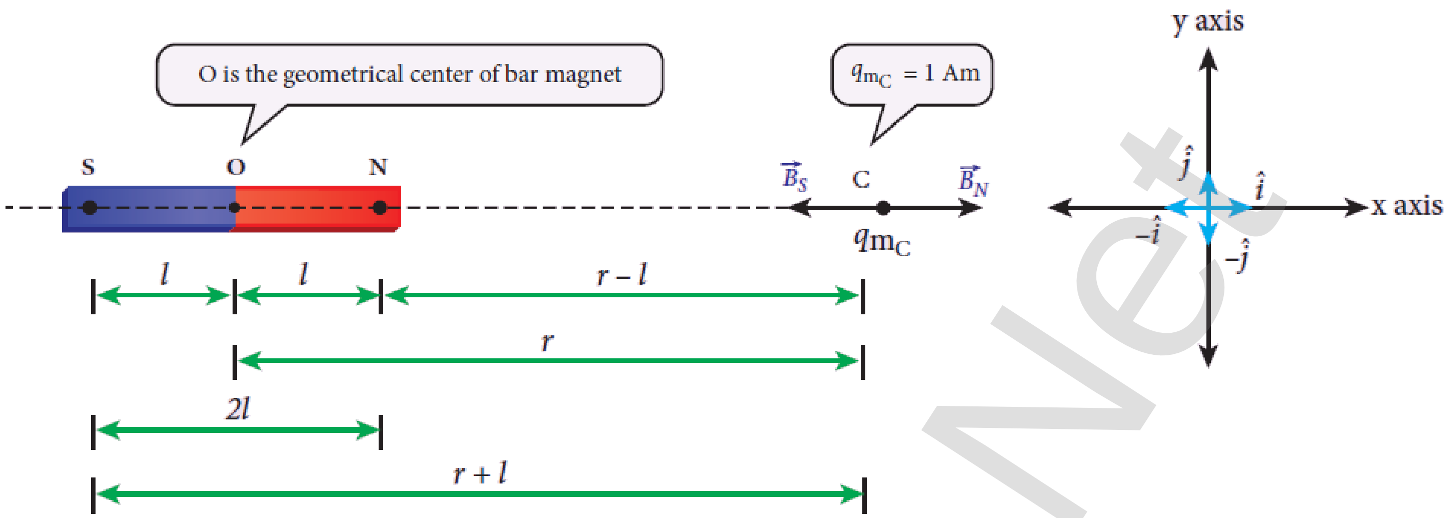
$$\vec{B} = \frac{\mu_0 I}{4\pi}\frac{1}{(R^2 - z^2)}\frac{R}{(R^2 - z^2)^{1/2}}\hat{k}\int_0^{2\pi R} dl$$

$$\vec{B} = \frac{\mu_0 I}{4\pi}\frac{R}{(R^2 - z^2)^{3/2}}(2\pi R)\hat{k}$$

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

The magnetic field at the centre of the coil is $\vec{B} = \frac{\mu_0 I}{2\pi R}\hat{k}$ since $z = 0$

3. Calculate the magnetic field at a point on the axial line of a bar magnet.



Consider a bar magnet NS. Let N be the north pole and S be the south pole of the bar magnet, each of pole strength $q_m$and are separated by a distance of 2l.

The magnetic field at C due to the north pole is $\vec{B}_N = \frac{\mu_0}{4\pi}\frac{q_m}{(r-l)^2}\hat{i}$.

The magnetic field at C due to the south pole is $\vec{B}_S = -\frac{\mu_0}{4\pi}\frac{q_m}{(r+l)^2}\hat{i}$

The net magnetic field due to the magnetic dipole at point C $\vec{B} = \vec{B}_N + \vec{B}_S$

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{q_m}{(r-l)^2}\hat{i} - \frac{\mu_0}{4\pi}\frac{q_m}{(r+l)^2}\hat{i}$$

$$\vec{B} = \frac{\mu_0 q_m}{4\pi}\left[\frac{1}{(r-l)^2} - \frac{1}{(r+l)^2}\right]\hat{i}$$

$$\vec{B} = \frac{\mu_0 q_m}{4\pi}\left[\frac{2(2rl)}{(r^2-l^2)^2}\right]\hat{i}$$

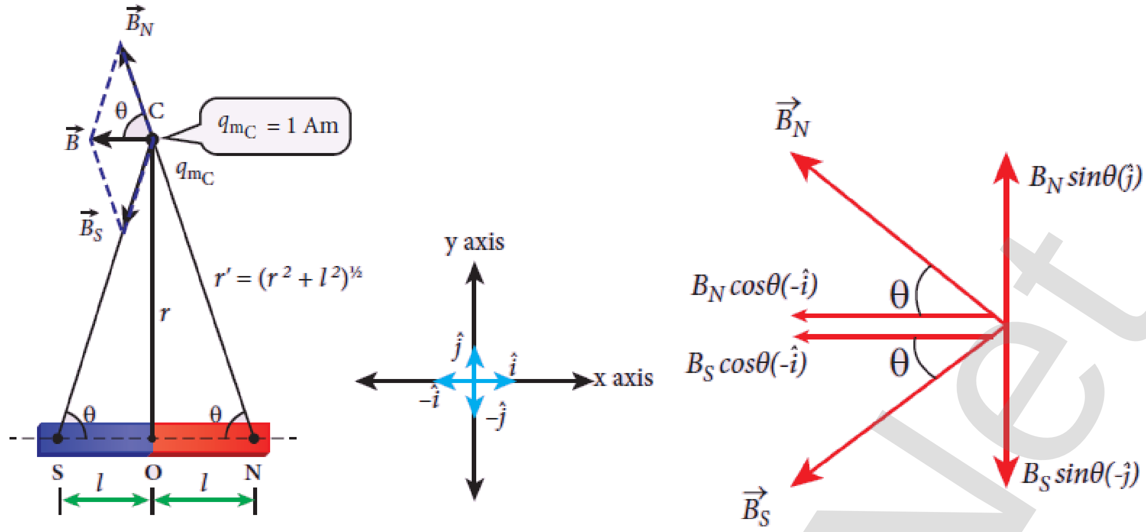
$$\vec{B} = \frac{\mu_0 q_m}{4\pi}\left[\frac{2(2rl)}{(r^2-l^2)^2}\right]\hat{i} \quad (r >> l). \qquad \therefore (r^2-l^2)^2 \approx r^4$$

$$= \frac{\mu_0}{4\pi}\left[\frac{2(2q_m rl)}{r^4}\right]\hat{i}$$

$$= \frac{\mu_0}{4\pi}\left[\frac{2(q_m 2l\hat{i})}{r^3}\right] \qquad \because \vec{p} = q_m 2l\hat{i}$$

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{2\vec{p}_m}{r^3}$$

4. Obtain the magnetic field at a point on the equatorial line of a bar magnet.



- Consider a bar magnet NS.
- Let N be the north pole and S be the south pole of the bar magnet.
- Each with pole strength q_m and separated by a distance of 2*l*.
- The magnetic field at a point C at a distance *r* along the equatorial line of the bar magnet can be computed by keeping unit north pole at C.
- The magnetic field at C due to the north pole is $\vec{B}_N = -B_N \cos\theta\hat{i} + B_N \sin\theta\hat{j}$

$$B_N = \frac{\mu_0}{4\pi}\frac{q_m}{r'^2} \qquad \therefore r' = \left(r^2 + l^2\right)^{1/2}$$

- The magnetic field at C due to the south pole is $\vec{B}_S = -B_S \cos\theta\hat{i} - B_S \sin\theta\hat{j}$

$$B_S = \frac{\mu_0}{4\pi}\frac{q_m}{r'^2}$$

- The net magnetic field at point C due to the dipole is $\vec{B} = \vec{B}_N + \vec{B}_S$

$$\vec{B} = -B_N \cos\theta\hat{i} + B_N \sin\theta\hat{j} - B_S \cos\theta\hat{i} - B_S \sin\theta\hat{j} \qquad \because B_N = B_S$$

$$\vec{B} = -(B_N + B_S)\cos\theta\hat{i} = -2B_N \cos\theta\hat{i}$$

$$\vec{B} = -\frac{2\mu_0}{4\pi}\frac{q_m}{r'^2}\cos\theta\hat{i} \qquad \therefore r'^2 = \left(r^2 + l^2\right)$$

$$\vec{B} = -\frac{2\mu_0}{4\pi}\frac{q_m}{\left(r^2 + l^2\right)}\cos\theta\hat{i}$$

$$\cos\theta = \frac{adjacent}{hypotenuse} = \frac{l}{r'} = \frac{l}{\left(r^2 + l^2\right)^{1/2}}$$

$$\vec{B} = -\frac{2\mu_0}{4\pi}\frac{q_m}{\left(r^2 + l^2\right)}\frac{l}{\left(r^2 + l^2\right)^{1/2}}\hat{i}$$

$$\vec{B} = -\frac{\mu_0}{4\pi}\frac{q_m 2l\hat{i}}{\left(r^2 + l^2\right)^{3/2}} \qquad \because \vec{p} = q_m 2l\hat{i}$$

$$\vec{B} = -\frac{\mu_0}{4\pi}\frac{\vec{p}_m}{r^3} \qquad (r >> l) \qquad \therefore \left(r^2 + l^2\right)^{3/2} \approx r^3$$

5. Discuss the working of cyclotron in detail.

- Cyclotron is a device used to accelerate the charged particles to gain large kinetic energy. It is also called as high energy accelerator.

Principle

- When a charged particle moves perpendicular to the magnetic field, it experiences magnetic Lorentz force.

Construction

- The particles are allowed to move in between two semi-circular metal containers called Dees.
- Dees are enclosed in an evacuated chamber and it is kept in a region with uniform magnetic field controlled by an electromagnet.
- The direction of magnetic field is normal to the plane of the Dees.
- The two Dees are kept separated with a gap and the source S is placed at the centre in the gap between the Dees. Dees are connected to high frequency alternating potential difference.

Working

- Let us assume that the ion ejected from source S is positively charged. As soon as ion is ejected, it is accelerated towards a Dee which has negative potential at that time.
- Since the magnetic field is normal to the plane of the Dees, the ion moves in a circular path.
- After one semi-circular path inside Dee-1, the ion reaches the gap between Dees. 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 on the charged particle q is provided by Lorentz force.

$$\frac{mv^2}{r} = qvB$$

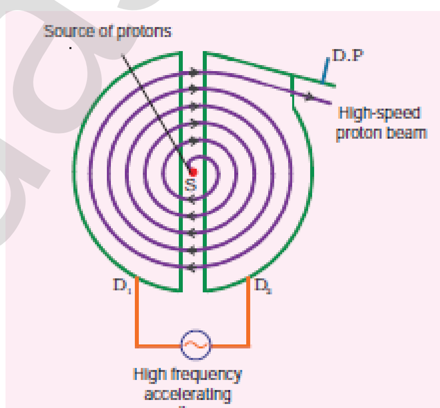
$$r = \frac{m}{qB}v$$

$$r \propto v$$

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

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

$$KE = \frac{1}{2}mv^2 = \frac{q^2B^2r^2}{2m}$$



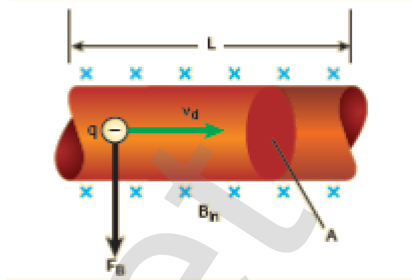
Limitations of cyclotron

(a) the speed of the ion is limited

(b) electron cannot be accelerated

(c) uncharged particles cannot be accelerated

6. Derive the expression for the force on a current-carrying conductor in a magnetic field.



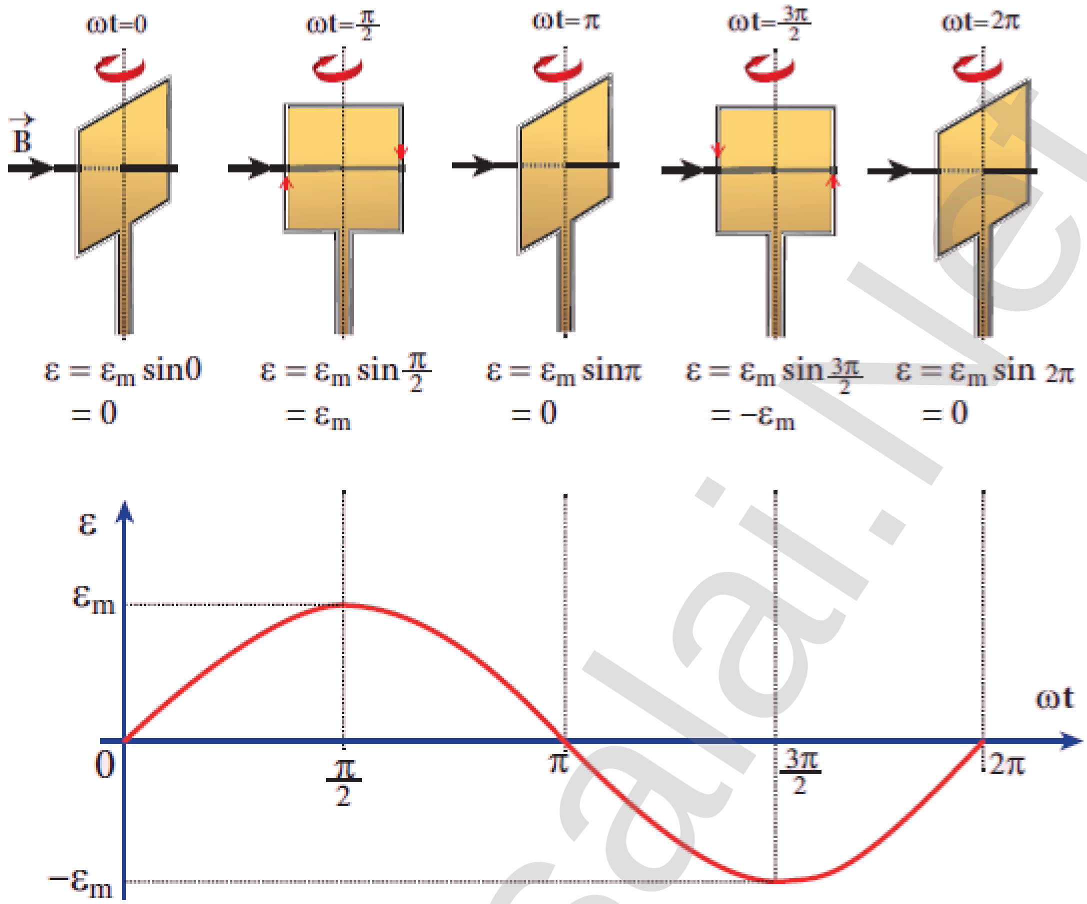
- When a current carrying conductor is placed in a magnetic field, the force experienced by the conductor is equal to the sum of Lorentz forces on the individual charge carriers in the conductor.
- Consider a small segment of conductor of length *dl*, with cross-sectional area *A* and current *I*.
- The free electrons drift opposite to the direction of current. So the relation between current *I* and magnitude of drift velocity v_d
  $$I = neAv_d$$
- If the conductor is kept in a magnetic field $\vec{B}$, then average force experienced by the electron in the conductor is
  $$\vec{f} = -e(\vec{v}_d \times \vec{B})$$
- If *n* is the number of free electrons present in unit volume, then $n = \frac{N}{V}$
  Where *N* is the number of free electrons in the small element of volume $V = A\,dl$.
- Hence Lorentz force on the elementary section of length *dl* is the product of the number of the electrons ($N = nAdl$) and the force acting on each electron.
  $$\vec{F} = -enAdl\ (\vec{v}_d \times \vec{B})$$
- The current element in the conductor is
  $$Id\vec{l} = -enA\,\vec{v}_d\,dl\ .$$
- Therefore the force on the small elemental section of the current- carrying conductor is
  $$d\vec{F} = (Id\vec{l} \times \vec{B})$$
- Thus the force on a straight current carrying conductor of length *l* placed in a uniform magnetic field is
  $$\vec{F} = (I\vec{l} \times \vec{B})$$
- In magnitude, $F = BIl \sin\theta$

(a) If the conductor is placed along the direction of the magnetic field, then $\theta = 0^o$.
Hence, the force experienced by the conductor is zero.

(b) If the conductor is placed perpendicular to the magnetic field, then the angle $\theta = 90^o$
Hence, the force experienced by the conductor is maximum, which is $F_{total} = BIl$.

LESSON – 4 ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENT

1. Show mathematically that the rotation of a coil in a magnetic field over one rotation induces an alternating emf of one cycle.



- Consider a rectangular coil of N turns kept in a uniform magnetic field $\vec{B}$.
- The coil rotates in anti-clockwise direction with an angular velocity ω about an axis, perpendicular to the field and to the plane of the paper.
- At time t = 0, the plane of the coil is perpendicular to the field and the flux linked with the coil has its maximum value $\Phi_m = NBA$.
- The flux linkage with the coil at in deflected position is

$$N\phi_B = NBA \cos\theta = NBA \cos\omega t$$

- According to Faraday's law, the emf induced at that instant is

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

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

$$\varepsilon = NBA\,\omega \sin\omega t$$

- When the coil is rotated through 90^{o} from initial position, sin ωt = 1.
- Then the maximum value of induced emf is $\varepsilon_m = NBA\,\omega$
- Therefore, the value of induced emf at any instant is then given by

$\varepsilon = \varepsilon_m \sin\omega t$. This is called **alternating emf**.

$i = I_m \sin\omega t$. This is called **alternating current.**

2. Explain the construction and working of transformer.

Transformer is a stationary device used to transform electrical power from one circuit to another without changing its frequency.

Principle

- The principle of transformer is the mutual induction between two coils..

Construction

- In the simple construction of transformers, there are two coils of high mutual inductance wound over the same transformer core.
- The core is generallylaminated and is made up of a good magnetic material like silicon steel.
- Coils are electrically insulated but magnetically linked via transformer core.
- The coil across which alternating voltage is applied is called primary coil *P* and the coil from which output power is drawn out is called secondary coil *S*.
- The assembled core and coils are kept in a container which is filled with suitable medium for better insulation and cooling purpose.

Working

- If the primary coil is connected to a source of alternating voltage, an alternating magnetic flux is set up in the laminated core.
- If there is no magnetic flux leakage, then whole of magnetic flux linked with primary coil is also linked with secondary coil. This means that rate at which magnetic flux changes through each turn is same for both primary and secondary coils.
- The emf induced in the primary coil is given by

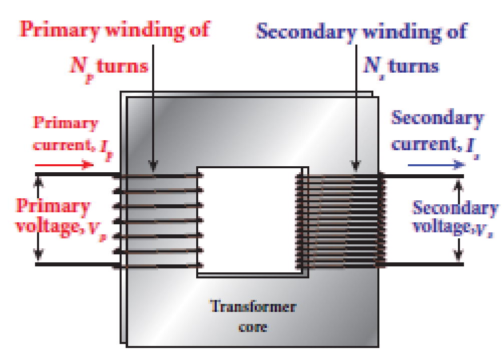
$$\varepsilon_p = -N_p \frac{d\phi_B}{dt} \qquad v_p = -N_p \frac{d\phi_B}{dt} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

- The emf induced in the secondary coil ε is given by

$$\varepsilon_s = -N_s \frac{d\phi_B}{dt} \qquad v_s = -N_s \frac{d\phi_B}{dt} \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Dividing equation (2) by equation (1), we get

$$\frac{v_s}{v_p} = \frac{N_s}{N_p} = K \quad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$



Input power = Output power

$$v_p i_p = v_s i_s$$

$$\frac{v_s}{v_p} = \frac{i_p}{i_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

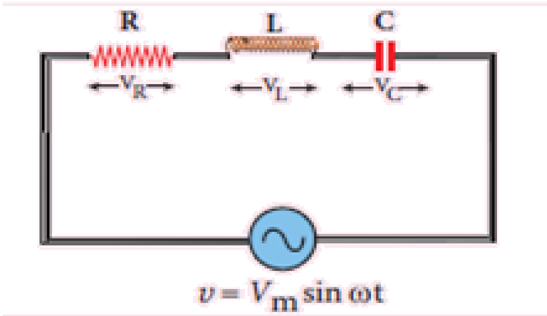
Compare the equations (3) and (4),

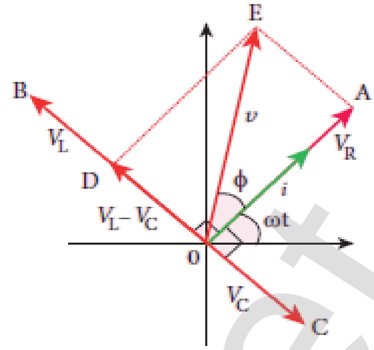
$$\frac{v_s}{v_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s} = K$$

i) In step-up transformer $N_s > N_p, V_s > V_p, I_s < I_p, K > 1$

ii) In step-down transformer $N_s < N_p, V_s < V_p, I_s > I_p, K < 1$

3. Derive an expression for phase angle between the applied voltage and current in a series RLC circuit.





- Consider a circuit containing a resistor of resistance R, an inductor of inductance L and a capacitor of capacitance C connected across an alternating voltage source.
- The instantaneous value of the alternating voltage is given by $v = V_m \sin \omega t$
- Let i be the resulting current in the circuit at that instant.
- As a result, the voltage is developed across R, L and C.
- We know that voltage across R (V_R) is in phase with i,
- voltage across L (V_L) leads i by π/2 and
- voltage across C (V_C) lags behind i by π/2.
- By parallelogram law, $V_m^2 = V_R^2 + (V_L - V_C)^2$

$$V_m = \sqrt{(I_m R)^2 + (I_m X_L - I_m X_C)^2}$$

$$V_m = I_m \sqrt{R^2 + (X_L - X_C)^2}$$

$$\frac{V_m}{I_m} = \sqrt{R^2 + (X_L - X_C)^2}$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} \qquad \because Z = \frac{V_m}{I_m}$$

$$\tan \phi = \frac{V_L - V_C}{V_R} = \frac{X_L - X_C}{X_R}$$

Special cases

(i) If $X_L > X_C$, $(X_L - X_C)$ is positive and phase angle ϕ is also positive.
It means that the applied voltage leads the current by ϕ. The circuit is inductive.

$$v = V_m \sin \omega t; i = I_m \sin(\omega t - \phi)$$

(ii) If $X_L < X_C$, $(X_L - X_C)$ is negative and ϕ is also negative.
Therefore current leads voltage by ϕ and the circuit is capacitive.

$$v = V_m \sin \omega t; i = I_m \sin(\omega t + \phi)$$

(iii) If $X_L = X_C$, ϕ is zero.
Therefore current and voltage are in the same phase and the circuit is resistive.

$$v = V_m \sin \omega t; i = I_m \sin \omega t$$

LESSON – 5 ELECTROMAGNETIC WAVES

1. Write down the properties of electromagnetic waves.

1. Electromagnetic waves are produced by any accelerated charge.
2. Electromagnetic waves do not require any medium for propagation. So electromagnetic wave is a non-mechanical wave.
3. Electromagnetic waves are transverse in nature. The oscillating electric field vector, oscillating magnetic field vector and propagation vector are mutually perpendicular to each other.
4. Electromagnetic waves travel with speed which is equal to the speed of light in vacuum or free space, $C = \frac{1}{\sqrt{\varepsilon_0 \mu_0}} = 3 \times 10^8 \, ms^{-1}$,

   Where ε_0 is the permittivity of free space or vacuum and
   μ_0 is the permeability of free space or vacuum.
5. In a medium with permittivity ε and permeability μ, the speed of electromagnetic wave v is less than that in free space or vacuum ($v < c$).

   In a medium of refractive index, $n = \frac{c}{v} = \frac{1/\sqrt{\varepsilon_0 \mu_0}}{1/\sqrt{\varepsilon \mu}}$

   $$\therefore n = \sqrt{\varepsilon_r \mu_r}$$

   where ε_r is the relative permittivity of the medium and
   μ_r is the relative permeability of the medium.
6. Electromagnetic waves are not deflected by electric field or magnetic field.
7. Electromagnetic waves can exhibit interference, diffraction and polarization.
8. Like other waves, electromagnetic waves also carry energy, linear momentum and angular momentum.
9. If the electromagnetic wave incident on a material surface is completely absorbed, then the energy delivered is U and momentum imparted on the surface is $p = \frac{U}{c}$.
10. If the incident electromagnetic wave of energy U is totally reflected from the surface, then the momentum delivered to the surface is $\Delta p = \frac{U}{c} - \left(-\frac{U}{c}\right) = 2\frac{U}{c}$.

2. Explain the types of emission spectrum.

Continuous spectrum:

- Suppose we allow a beam of white light to pass through the prism.
- It is split into its seven constituent colours which can be viewed on the screen as continuous spectrum.
- This phenomenon is known as dispersion of light and the definite pattern of colours obtained on the screen after dispersion is called as spectrum.

Emission spectra

- When the spectrum of self luminous source is taken, we get emission spectrum.
- Each source has its own characteristic emission spectrum.

The emission spectrum can be divided into three types:

(i) Continuous emission spectrum (or continuous spectrum)

- If the light from filament bulb is allowed to pass through prism, it splits up into seven colours.
- Thus, it consists of wavelengths containing all the visible colours ranging from violet to red.

Examples: spectrum obtained from carbon arc and incandescent solids.

(ii) Line emission spectrum (or line spectrum):

- Suppose light from hot gas is allowed to pass through prism, line spectrum is observed. Line spectra are also known as discontinuous spectra.
- The line spectra consists of sharp lines of definite wavelengths or frequencies.
- These lines are the characteristics of the element and are different for different elements.

Examples: spectra of atomic hydrogen, helium, etc.

(iii) Band emission spectrum (or band spectrum)

- Band spectrum consists of several number of very closely spaced spectral lines which overlap together forming specific bands which are separated by dark spaces.
- This spectrum has a sharp edge at one end and fades out at the other end.
- Band spectrum is the characteristic of the molecule and hence the structure of the molecules can be studied using their band spectra.

Example: spectra of ammonia gas in the discharge tube etc.

3. Explain the types of absorption spectrum.

Continuous spectrum:

- Suppose we allow a beam of white light to pass through the prism.
- It is split into its seven constituent colours which can be viewed on the screen as continuous spectrum.
- This phenomenon is known as dispersion of light and the definite pattern of colours obtained on the screen after dispersion is called as spectrum.

Absorption spectra

- When light is allowed to pass through a medium or an absorbing substance then the spectrum obtained is known as absorption spectrum.
- It is the characteristic of absorbing substance.

Absorption spectrum is classified into three types:

(i) Continuous absorption spectrum

- When we pass white light through a blue glass plate, it absorbs all the colours except blue and gives continuous absorption spectrum.

(ii) Line absorption spectrum

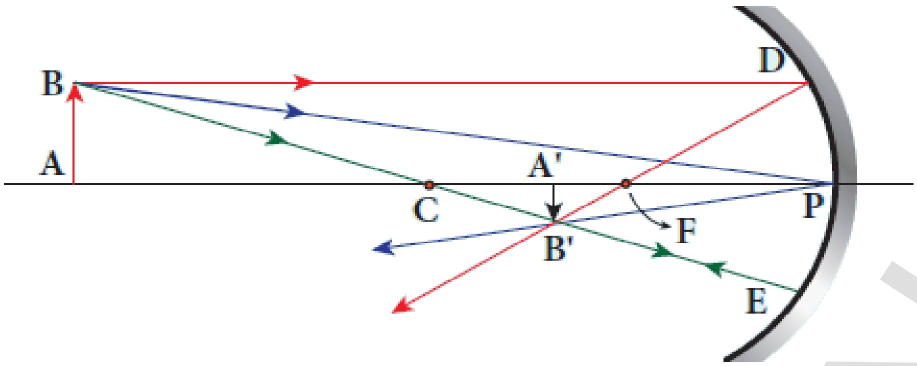
- When light from the incandescent lamp is passed through cold gas, the spectrum obtained through the dispersion due to prism is line absorption spectrum.
- Similarly, if the light from the carbon arc is made to pass through sodium vapour, a continuous spectrum of carbon arc with two dark lines in the yellow region are obtained.

(iii) Band absorption spectrum

- When white light is passed through the iodine vapour, dark bands on continuous bright background is obtained.
- This type of band is also obtained when white light is passed through diluted solution of blood or chlorophyll or through certain solutions of organic and inorganic compounds.

UNIT - VI RAY OPTICS

1. Derive the mirror equation and the equation for lateral magnification.



- The mirror equation establishes a relation among object distance *u*, image distance *v* and focal length *f* for a spherical mirror.
- An object *AB* is considered on the principal axis of a concave mirror beyond the centre of curvature *C*.
- Let us consider three paraxial rays from point *B* on the object. The first paraxial ray *BD* travels parallel to the principal axis. It is incident on the concave mirror at *D*. It is reflected back through the focus *F*.
- The second paraxial ray *BP* is incident at the pole *P*. It is reflected along *PB*´.
- The third paraxial ray *BC* passing through centre of curvature *C*, falls normally on the mirror at *E*. It is reflected back along the same path.
- The three reflected rays intersect at the point B'. A perpendicular drawn as $A'B'$ to the principal axis gives the real, inverted image.
- The triangles Δ *BPA* and Δ $B'PA'$ are similar. Thus, from the rule of similar triangles,

$$\frac{A'B'}{AB} = \frac{PA'}{PA} \text{.......... .(1)}$$

- The other set of similar triangles are, Δ *DPF* and Δ $B'A'P$.

$$\frac{A'B'}{PD} = \frac{A'F}{PF}$$

As, *PD* = *AB* the above equation becomes,

$$\frac{A'B'}{AB} = \frac{A'F}{PF} \text{.........} (2)$$

From equations (1) and (2) we can write,

$$\frac{PA'}{PA} = \frac{A'F}{PF}$$

As, $A'F = PA' - PF$, the above equation becomes,

$$\frac{PA'}{PA} = \frac{PA' - PF}{PF} \text{.........} .(3)$$

Where, PA = -u , PA' = -v , PF = - f

Now, the equation (3) becomes, $\frac{-u}{-v} = \frac{-v-(-f)}{-f}$

On further simplification, $\frac{v}{u} = \frac{v-f}{f}$; $\frac{v}{u} = \frac{v}{f} - 1$

Dividing both sides with v, $\frac{1}{u} = \frac{1}{f} - \frac{1}{v}$

After rearranging, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

This equation is called ***mirror equation***.

Lateral magnification in spherical mirrors

The lateral magnification m is defined as the ratio of the height of the image to the height of the object.

magnification $= \frac{\text{height of the image}}{\text{height of the object}}$; $m = \frac{h'}{h}$

Applying proper sign conventions for equation (1),

$$\frac{A'B'}{AB} = \frac{PA'}{PA}$$

Where, $A'B' = -h', AB = h, PA' = -v, PA = -u$

$$\frac{-h'}{h} = \frac{-v}{-u}$$

Using mirror equation, we can further write the magnification as,

$$m = \frac{h'}{h} = \frac{f-v}{f} = \frac{f}{f-u}$$

2. Describe the Fizeau's method to determine the speed of light.

***Apparatus*:**

- The light from the source S was first allowed to fall on a partially silvered glass plate G kept at an angle of 45^o to the incident light.
- The light then was allowed to pass through a rotating toothed-wheel with N teeth and N cuts of equal widths whose speed of rotation could be varied through an external mechanism.
- The light passing through one cut in the wheel will get reflected by a mirror M kept at a long distance d, about 8 km from the toothed-wheel.
- If the toothed-wheel was not rotating, the light reflected back from the mirror would again pass through the same cut and reach the eyes of the observer who looks through the partially silvered glass plate.

***Working*:**

- The angular speed of rotation of the toothed-wheel was increased from zero to a value ω until the light passing through one cut would completely be blocked by the adjacent tooth. This is ensured by the disappearance of the light while looking through the partially silvered glass plate.

***Expression for speed of light*:**

- The speed v of light in air is equal to the ratio of the distance $2d$, to the time taken t.

$$v = \frac{2d}{t} \quad \text{.......... (1)}$$

- The distance d is a known value from the arrangement. The time t taken for the light to travel the distance $2d$ is calculated from the angular speed ω of the toothed-wheel.
- The angular speed, $\omega = \frac{\theta}{t}$ .... (2)

Here, θ is the angle between one tooth and the next slot which is turned within that time t.

$$\theta = \frac{\text{total angle of the circle in radian}}{\text{number of teeth} + \text{number of cuts}}$$

$$\theta = \frac{2\pi}{2N} = \frac{\pi}{N}$$

Substituting θ in equation (2),

$$\omega = \frac{\pi / N}{t} = \frac{\pi}{Nt}$$

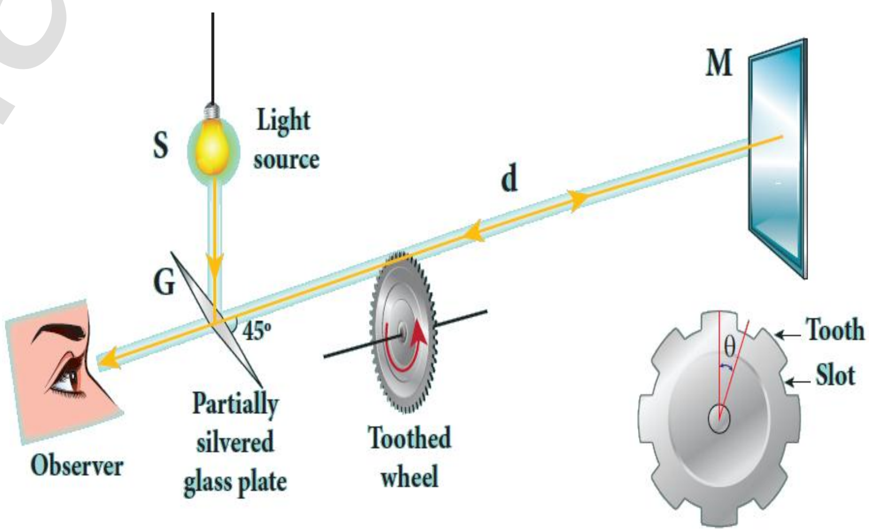
Rewriting the above equation for t,

$$t = \frac{\pi}{N\omega}$$

Substituting this in equation (1),

$$v = \frac{2d}{\pi / N\omega}$$

$$v = \frac{2dN\omega}{\pi}$$



- The speed of light in air was determined as, $v = 2.99792 \times 10^8$ m s^{-1}.

3. Obtain lens maker's formula and mention its significance.

- Let us consider a thin lens made up of a medium of refractive index n_2 placed in a medium of refractive index n_1.
- Let R_1 and R_2 be the radii of curvature of two spherical surfaces ①and ② respectively.
- Consider a point object O on the principal axis. A paraxial ray from O which falls very close to P, after refraction at the surface ① forms image at I'. Before it does so, it is again refracted by the surface ②. Therefore, the final image is formed at I.
- The general equation for the refraction at a single spherical surface is given by the equation

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

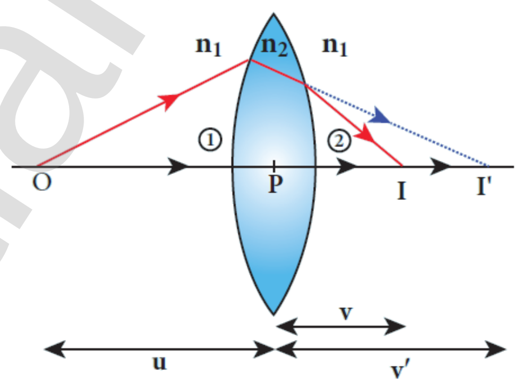
For the refracting surface ①, the light goes from n_1 to n_2.

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

For the refracting surface ②, the light goes from medium n_2 to n_1.

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

Adding the above two equations (1) and (2)



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

On further simplifying and rearranging,

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

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

If the object is at infinity, the image is formed at the focus of the lens.
Thus, for u = ∞ , v = f. Then the equation becomes.

$$\frac{1}{f} - \frac{1}{\infty} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

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

If the lens is kept in air, then we can take $n_1 = 1$ and $n_2 = n$. So the equation (4) becomes,

$$\frac{1}{f} = (n - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

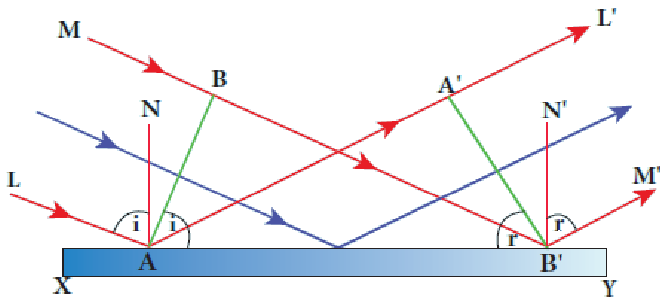
The above formula is called as the **lens maker's formula.**
By comparing the equations (3) and (4) we can write,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

The above equation is known as **lens equation.**

UNIT - VII RAY OPTICS

1. Prove law of reflection using Huygens' principle.



- Let us consider a parallel beam of light is incident on a reflecting plane surface such as a plane mirror *XY*.
- The incident wavefront is *AB* and the reflected wavefront is $A'B'$. These wavefronts are perpendicular to the incident rays *L*, *M* and reflected rays L', M' respectively.
- By the time point *A* of the incident wavefront touches the reflecting surface, the point *B* is yet to travel a distance BB' to touch the reflecting surface at B'. When the point *B* touches the reflecting surface at B', the point *A* would have reached A'.
- As reflection happens in the same medium, the speed of light is same before and after the reflection. The time taken for the light to travel from *B* to B' and *A* to A' are the same.

  Thus, the distance BB' is equal to the distance AA'; $AA' = BB'$

  (i) The incident rays, the reflected rays and the normal are in the same plane.

  (ii) Angle of incidence,

  $$\angle i = \angle NAL = 90^o - \angle NAB = \angle BAB'$$

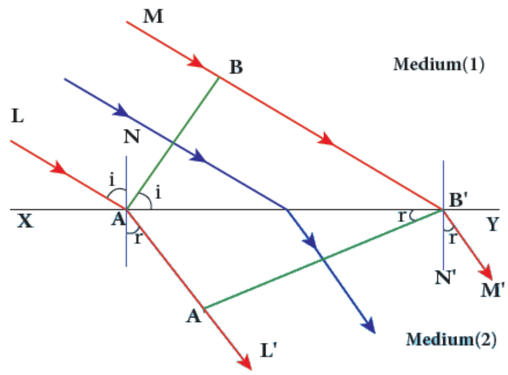
  Angle of reflection,

  $$\angle r = \angle N'B'M' = 90^o - \angle N'B'A' = \angle A'B'A$$

- For the two right angle triangles, $\Delta ABB'$ and $\Delta B'A'A$, $\angle B$ and $\angle A' = 90^o$; $AA' = BB'$;the side AB' is common. Thus, the two triangles are congruent.
- As per the property of congruency, the two angles, $\angle BAB'$ and $\angle A'B'A$ must also be equal.

  $i = r$ Hence, the laws of reflection are proved.

2. Prove law of refraction using Huygens' principle.



- Let us consider a parallel beam of light is incident on a refracting plane surface *XY*.
- The incident wavefront *AB* is in rarer medium (1) and the refracted wavefront $A'B'$ is in denser medium (2).
- These wavefronts are perpendicular to the incident rays *L*, *M* and refracted rays $L'M'$ respectively. By the time the point *A* of the incident wavefront touches the refracting surface, the point *B* is yet to travel a distance BB' to touch the refracting surface at B'. When the point *B* touches the refracting surface at B', the point *A* would have reached A' in the other medium.
- Thus, the refracted wavefront emanates as a plane wavefront. As refraction happens from rarer medium (1) to denser medium (2), the speed of light is v_1 and v_2 before and after refraction and v_1 is greater than v_2.
- But, the time taken *t* for the ray to travel from B to B' is the same as the time taken for the ray to travel from *A* to A'.
- $t = \frac{BB'}{v_1} = \frac{AA'}{v_2} \Rightarrow \frac{BB'}{AA'} = \frac{v_1}{v_2}$

(i) The incident rays, the refracted rays and the normal are in the same plane.
(ii) Angle of incidence,

$$\angle i = \angle NAL = 90^o - \angle NAB = \angle BAB'$$

Angle of reflection,

$$\angle r = \angle N'B'M' = 90^o - \angle N'B'A' = \angle A'B'A$$

For the two right angle triangles $\angle ABB'$ and $\Delta AA'B'$,

$$\frac{\sin i}{\sin r} = \frac{BB'/AB'}{AA'/AB'} = \frac{BB'}{AA'} = \frac{v_1}{v_2} = \frac{c/v_1}{c/v_2}$$

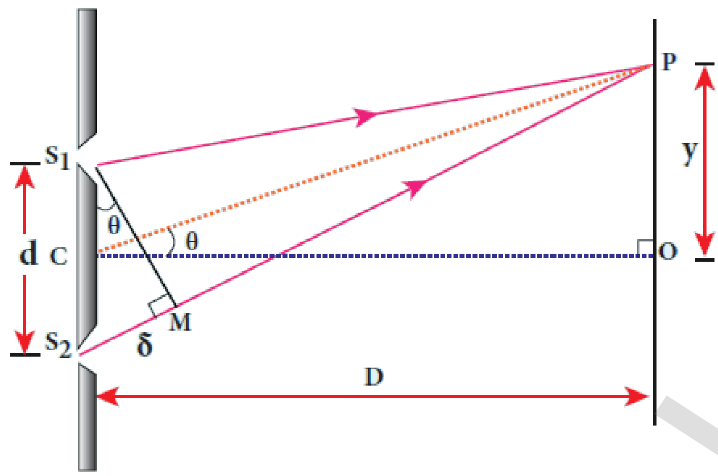
The refractive index of medium (1) is, $c/v_1 = n_1$
The refractive index of medium (2) is, $c/v_2 = n_2$.

In ratio form, $\frac{\sin i}{\sin r} = \frac{n_1}{n_2}$

In product form, $n_1 \sin i = n_2 \sin r$

Hence, the laws of refraction are proved.

3. Explain the Young's double slit experimental setup and obtain the equation for path difference.



- The Let d be the distance between the double slits S_1 and S_2 which act as coherent sources of wavelength λ.
- A screen is placed parallel to the double slit at a distance D from it.
- The mid-point of S_1 and S_2 is C and the mid-point of the screen O is equidistant from S_1 and S_2 .
- P is any point at a distance y from O. The waves from $S1$ and $S2$ meet at P either in-phase or out-of-phase depending upon the path difference between the two waves.
- The path difference δ between the light waves from $S1$ and $S2$ to the point P is,

$$\delta = S_2P - S_1P \qquad \because S_1P = MP$$

$$\delta = S_2P - MP = S_2M$$

- In right angle triangle ΔS_1S_2M,

$$\sin\theta = \frac{S_2M}{S_1S_2} = \frac{S_2M}{d}$$

$$S_2M = d\sin\theta$$

- The path difference, $\delta = d\sin\theta$

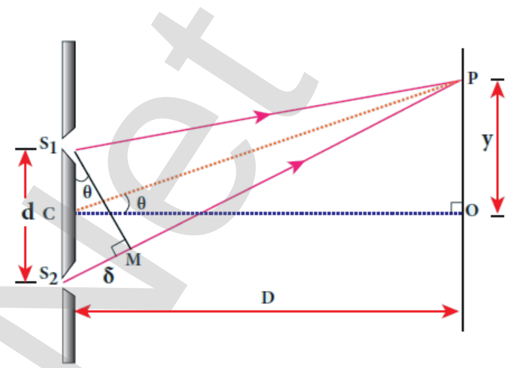
If the angle θ is small, $\sin\theta \approx \tan\theta \approx \theta$

From the right angle triangle ΔOCP, $\tan\theta = \frac{y}{D} \Rightarrow \theta = \frac{y}{D}$

The path difference, $\delta = d\frac{y}{D}$

4. Obtain the equation for bandwidth in Young's double slit experiment.

- The Let d be the distance between the double slits S_1 and S_2 which act as coherent sources of wavelength λ.
- A screen is placed parallel to the double slit at a distance D from it.
- The mid-point of S_1 and S_2 is C and the mid-point of the screen O is equidistant from S_1 and S_2 .



The path difference, $\delta = d\frac{y}{D}$

Condition for bright fringe

The condition for the point P to have a bright fringe is,

Path difference, $\delta = n\lambda$ where, $n = 0, 1, 2, \ldots$

$$d\frac{y}{D} = n\lambda$$

$$y = n\frac{\lambda D}{d} \quad \text{(or)} \quad y_n = n\frac{\lambda D}{d}$$

This is the condition for the point P to have a bright fringe.
The distance y_n is the distance of the n^{th} bright fringe from the point O.

Condition for dark fringe

The condition for the point P to have a dark fringe is,

Path difference, $\delta = (2n-1)\frac{\lambda}{2}$ where, $n = 1, 2, 3 \ldots$

$$d\frac{y}{D} = (2n-1)\frac{\lambda}{2}$$

$$y = \frac{(2n-1)}{2}\frac{\lambda D}{d}$$

This is the condition for the point P to have a dark fringe.
The distance y_n is the distance of the n^{th} dark fringe from the point O.

Equation for bandwidth

The *bandwidth* β is defined as the distance between any two consecutive bright (or) dark fringes.
The distance between $(n+1)^{th}$ and n^{th} consecutive bright fringes from O is given by,

$$\beta = y_{(n+1)} - y_n = \left((n+1)\frac{\lambda D}{d}\right) - \left(n\frac{\lambda D}{d}\right)$$

β for bright, $\beta = \frac{\lambda D}{d}$

Similarly, the distance between $(n+1)^{th}$ and n^{th} consecutive dark fringes from O is given by,

$$\beta = y_{(n+1)} - y_n = \left(\frac{(2(n+1)-1)}{2}\frac{\lambda D}{d}\right) - \left(\frac{(2n-1)}{2}\frac{\lambda D}{d}\right)$$

β for dark, $\beta = \frac{\lambda D}{d}$

UNIT – VIII DUAL NATURE OF RADIATION AND MATTER

1. Obtain Einstein's photoelectric equation with necessary explanation.

- When a photon of energy *hν* is incident on a metal surface, it is completely absorbed by a single electron and the electron is ejected.
- In this process, a part of the photon energy is used in liberate electron from the metal surface and the remaining energy as the kinetic energy of the ejected electron.
- From the law of conservation of energy, $h\nu = \phi_0 + \frac{1}{2}mv^2$ ……………(1)

  where *m* is the mass of the electron and *v* its velocity.

  At some frequency ν_0 of incident radiation, the photo electrons are just ejected with almost zero kinetic energy.
  Then the equation (1) becomes $h\nu_0 = \phi_0$, where ν_0 is the threshold frequency.

  By rewriting the equation (1), we get $h\nu = h\nu_0 + \frac{1}{2}mv^2$ ……………(2)

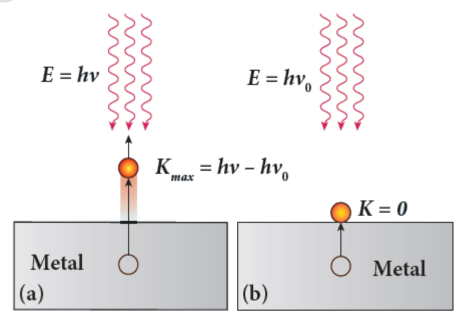
  This equation is known as **Einstein's photoelectric equation**.

  If the electron does not lose energy by internal collisions, then it is emitted with maximum kinetic energy K_{max}.

  Then $K_{max} = \frac{1}{2}mv^2_{max}$

  where v_{max} is the maximum velocity of the electron ejected.

  The equation (1) is rearranged as follows: $K_{max} = h\nu - \phi_0$



Explanation for the photoelectric effect:

i) As each incident photon liberates one electron, then the increase of intensity of the light increases the number of electrons emitted thereby increasing the photocurrent.

ii) From $K_{max} = h\nu - \phi_0$, it is evident that K_{max} is proportional to the frequency of the incident light and is independent of intensity of the light.

iii) As given in equation (2), there must be minimum energy for incident photons to liberate electrons from the metal surface. Below this value of energy, emission of electrons is not possible. Correspondingly, there exists minimum frequency called threshold frequency below which there is no photoelectric emission.

iv) According to quantum concept, there is no time lag between incidence of photons and ejection of electrons.

- Thus, the photoelectric effect is explained on the basis of quantum theory of light.

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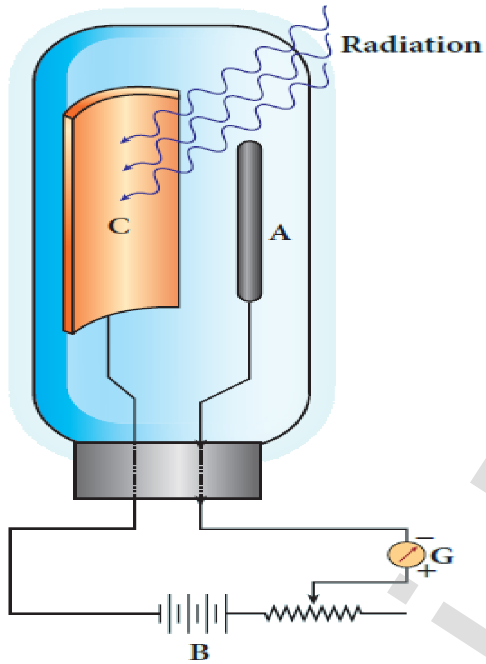
2. Give the construction, working and application of photo emissive cell.



Construction:

- It consists of an evacuated glass or quartz bulb in which two metallic electrodes – that is, a cathode and an anode are fixed.
- The cathode *C* is semi-cylindrical in shape and is coated with a photo sensitive material.
- The anode *A* is a thin rod or wire kept along the axis of the semi-cylindrical cathode.
- A potential difference is applied between the anode and cathode through a galvanometer *G*.

Working:

- When cathode is irradiated with suitable radiation, electrons are emitted from it.
- These electrons are attracted by anode and hence a current is produced which is measured by the galvanometer.
- For a given cathode, the magnitude of the current depends on
  i) the intensity to incident radiation and
  ii) the potential difference between anode and cathode.

Applications of photo cells:

- Photo cells have many applications, especially as switches and sensors.
- Automatic lights that turn on when it gets dark use photocells, and street lights that switch on
  and switch off according to whether it is night or day use photocells.
- Photo cells are used for reproduction of sound in motion pictures and are used as timers to measure the speeds of athletes during a race.
- Photo cells of exposure meters in photography are used to measure the intensity of the given light and to calculate the exact time of exposure.

3. Derive an expression for de Broglie wavelength of electrons.

- Let an electron of mass *m* be accelerated through a potential difference of *V* volt.
- The kinetic energy acquired by the electron is given by, $\frac{1}{2}mv^2 = eV$
- Therefore, the speed v of the electron is $v = \sqrt{\frac{2eV}{m}}$
- Hence, the de Broglie wavelength of the matter waves associated with electron is

$$\lambda = \frac{h}{mv} = \frac{h}{m\sqrt{\frac{2eV}{m}}} = \frac{h}{\sqrt{2emV}}$$

Substituting the known values in the above equation, we get

$$\lambda = \frac{6.626 \times 10^{-24}}{\sqrt{2 \times 1.6 \times 10^{-19} \times 9.11 \times 10^{-31} V}}$$

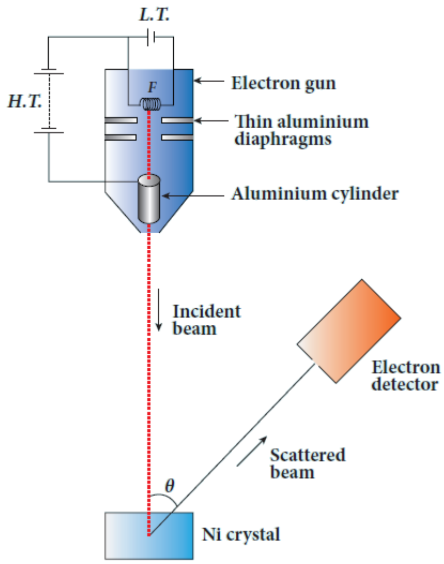
$$\lambda = \frac{12.27 \times 10^{-10}}{\sqrt{V}} = \frac{12.27}{\sqrt{V}} \mathring{A}$$

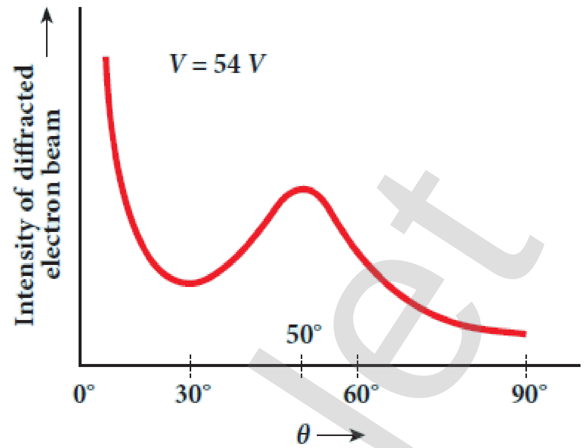
- For example, if an electron is accelerated through a potential difference of 100V, then its de Broglie wavelength is,

$$\lambda = \frac{12.27}{\sqrt{100}} \mathring{A} = 1.227 \mathring{A}$$

- Since the kinetic energy of the electron, $K = eV$,
- Then the de Broglie wavelength associated with electron is, $\lambda = \frac{h}{\sqrt{2mK}}$

4. Describe briefly Davisson – Germer experiment which demonstrated the wave nature of electrons.





- They demonstrated that electron beams are diffracted when they fall on crystalline solids.
- Since crystal can act as a three-dimensional diffraction grating for matter waves.
- The filament *F* is heated by a low tension (L.T.) battery.
- Electrons are emitted from the hot filament by thermionic emission.
- They are then accelerated due to the potential difference between the filament and the anode aluminium cylinder by a high tension (H.T.) battery.
- Electron beam is collimated by using two thin aluminium diaphragms and is allowed to strike a single crystal of Nickel.

- The electrons scattered by Ni atoms in different directions are received by the electron detector which measures the intensity of scattered electron beam.
- The detector is capable of rotation in the plane of the paper so that the angle θ between the incident beam and the scattered beam can be changed at our will.

- From the graph the variation of intensity of the scattered electrons with the angle θ for the accelerating voltage of 54 V. For a given accelerating voltage V, the scattered wave shows a peak or maximum at an angle of 50° to the incident electron beam.

- The wavelength can also be calculated from de Broglie relation for V = 54 V,

$$\lambda = \frac{12.27}{\sqrt{V}} \mathring{A} = \frac{12.27}{\sqrt{54}} \mathring{A}$$

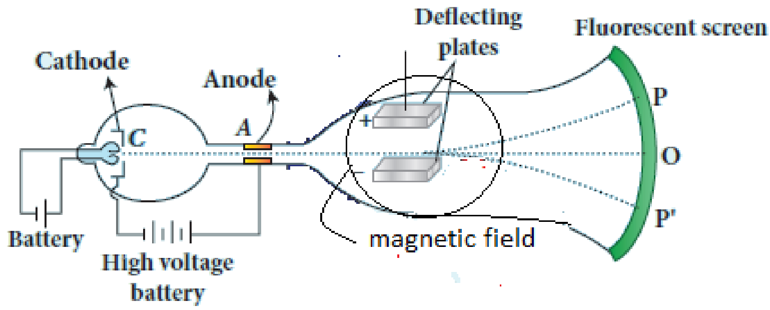
$$\lambda = 1.67 \mathring{A}$$

- This value agrees very well with the experimentally observed wavelength of 1.65Å.
- Thus this experiment directly verifies de Broglie's hypothesis of the wave nature of moving particles.

UNIT – IX ATOMIC AND NUCLEAR PHYSICS

1. Explain the J.J. Thomson experiment to determine the specific charge of electron.

Principle In the presence of electric and magnetic fields, the cathode rays were deflected.

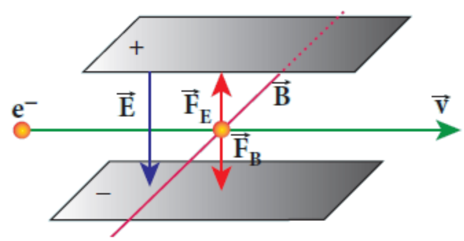


Construction

- A highly evacuated discharge tube is used and cathode rays produced at cathode are attracted towards anode disc A.
- Anode disc is provided with pin hole in order to allow only a narrow beam of cathode rays.
- These cathode rays are now allowed to pass through the parallel metal plates which are maintained at high voltage.
- The gas discharge tube is kept in between pole pieces of magnet such that both electric and magnetic fields are acting perpendicular to each other.
- When the cathode rays strike the screen, they produce scintillation and hence bright spot is observed. This is achieved by coating the screen with zinc sulphide.

(i) Determination of velocity of cathode rays

- For a fixed electric field between the plates, the magnetic field is adjusted such that the cathode rays strike at the original position O. This means that the magnitude of electric force is balanced by the magnitude of force due to magnetic field.



- Force due to electric field is, $F_E = eE$
- Force due to magnetic field is, $F_B = eBv$

$$eE = eBv$$

$$v = \frac{E}{B} \quad ....(1)$$

(ii) Determination of specific charge

- The cathode rays are accelerated from cathode to anode, the potential energy of the electron beam at the cathode is converted into kinetic energy of the electron beam at the anode.
- Let V be the potential difference between anode and cathode, then the potential energy is eV. Then from law of conservation of energy,

$$eV = \frac{1}{2}mv^2$$

$$\frac{e}{m} = \frac{v^2}{2V}$$

Substituting the value of velocity from equation (1), we get $\frac{e}{m} = \frac{1}{2V}\frac{E^2}{B^2}$

Substituting the values of *E*, *B* and *V*, the specific charge can be determined as $\frac{e}{m} = 1.7 \times 10^{11}\ Ckg^{-1}$

2. Discuss the spectral series of hydrogen atom.

- When the hydrogen gas enclosed in a tube is heated up, it emits electromagnetic radiations of certain sharply-defined characteristic wavelength, called hydrogen emission spectrum
- The wave number of these spectral lines, $\bar{\nu} = \frac{1}{\lambda} = R\left(\frac{1}{n^2} - \frac{1}{m^2}\right)$

Spectral series	n	m	Wave number	Region
Lyman series	1	2,3,4…..	$\bar{\nu} = \frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{m^2}\right)$	ultra-violet region
Balmer series	2	3,4,5…..	$\bar{\nu} = \frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{m^2}\right)$	visible region
Paschen series	3	4,5,6…..	$\bar{\nu} = \frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{m^2}\right)$	infra-red region
Brackett series	4	5,6,7…..	$\bar{\nu} = \frac{1}{\lambda} = R\left(\frac{1}{4^2} - \frac{1}{m^2}\right)$	infra-red region
Pfund series	5	6,7,8…..	$\bar{\nu} = \frac{1}{\lambda} = R\left(\frac{1}{5^2} - \frac{1}{m^2}\right)$	infra-red region

3. Obtain the law of radioactivity.

- At any instant t, the number of decays per unit time, called rate of decay $\left(\frac{dN}{dt}\right)$ is proportional to the number of nuclei (N) at the same instant.

$$\frac{dN}{dt} \propto N$$

$$\frac{dN}{dt} = -\lambda N$$

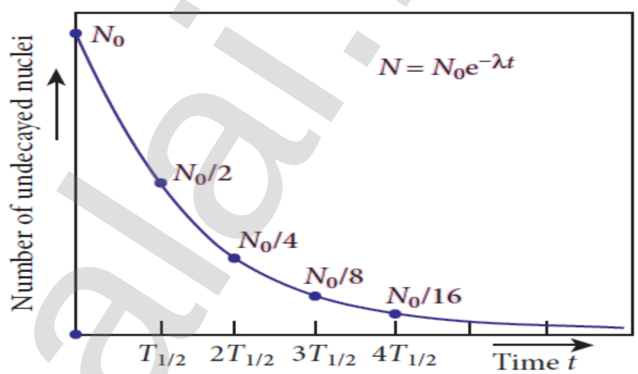
- Here proportionality constant λ is called decay constant which is different for different radioactive sample.
- The negative sign in the equation implies that N is decreasing with time. $dN = -\lambda N dt$
- Here dN represents the number of nuclei decaying in the time interval dt.
- Let us assume that at time t = 0 s, the number of nuclei present in the radioactive sample be N_0. By integrating the equation, we can calculate the number of un decayed nuclei N present at any time t.

$$\frac{dN}{N} = -\lambda dt$$

$$\int_{N_0}^{N} \frac{dN}{N} = -\int_0^t \lambda dt$$

$$[\ln N]_{N_0}^{N} = -\lambda t$$

$$\ln\left[\frac{N}{N_0}\right] = -\lambda t$$



Taking exponentials on both sides, we get

$$\frac{N}{N_0} = e^{-\lambda t}$$

$N = N_0 e^{-\lambda t}$ This is called the law of radioactive decay.

- We can also define another useful quantity called activity (R) or decay rate which is the number of nuclei decayed per second and it is denoted as $R = \left|\frac{dN}{dt}\right|$.

$$R = \left|\frac{dN}{dt}\right| = \lambda N_0 e^{-\lambda t}$$

$$R = R_0 e^{-\lambda t} ; \quad R_0 = \lambda N_0$$

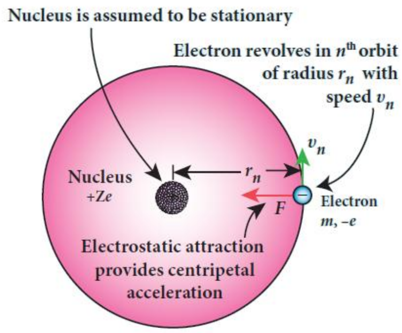
- Here R_0 is the activity of the sample at $t = 0$ and R is the activity of the sample at any time t.

$$R = \lambda N$$

- The SI unit of activity R is Becquerel and one Becquerel (Bq) is equal to one decay per second.
- There is also another standard unit for the activity called Curie(Ci).

1 Curie =1 Ci = 3.7×10^{10} decays per second

4. Derive the energy expression for an electron is the hydrogen atom using Bohr atom model.



- The electrostatic force is a conservative force, the potential energy for the n^{th} orbit is

$$U_n = \frac{1}{4\pi\varepsilon_0}\frac{(+Ze)(-e)}{r_n}$$

$$U_n = -\frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r_n}$$

$$U_n = -\frac{1}{4\varepsilon_0^2}\frac{Z^2me^4}{h^2n^2} \qquad \because r_n = \frac{\varepsilon_0 h^2}{\pi me^2}\frac{n^2}{Z}$$

- The kinetic energy of the electron in n^{th} orbit is

$$KE_n = \frac{1}{2}mv_n^2 = \frac{me^4}{8\varepsilon_0^2h^2}\frac{Z^2}{n^2}$$

- This implies that $U_n = -2\,KE_n$. Total energy of the electron in the n^{th} orbit is

$$E_n = KE_n + U_n = KE_n - 2KE_n = -KE_n$$

$$E_n = -\frac{me^4}{8\varepsilon_0^2h^2}\frac{Z^2}{n^2}$$

For hydrogen atom (Z = 1), $E_n = -\frac{me^4}{8\varepsilon_0^2h^2}\frac{1}{n^2}$

Substituting the known values m, e, ε_0, h in the above equation,

$$E_n = -13.6\frac{1}{n^2}eV$$

For the first orbit (ground state), the total energy of electron is $E_1 = -13.6\ eV$.

For the second orbit (first excited state), the total energy of electron is $E_2 = -3.4\ eV$.

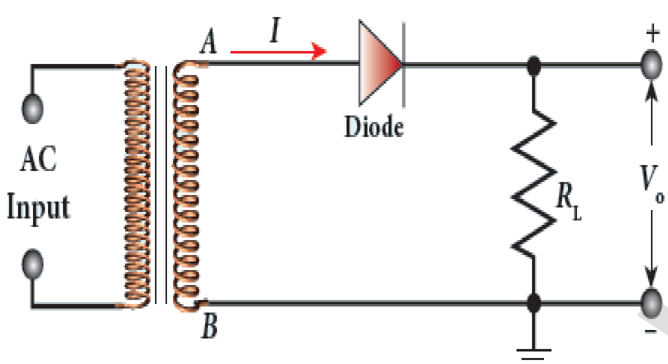
For the third orbit (second excited state), the total energy of electron is $E_3 = -1.51\ eV$ and so on.

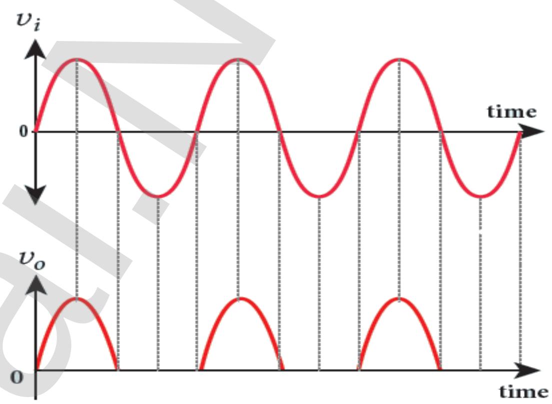
UNIT – X ELECTRONICS AND COMMUNICATION

1. Draw the circuit diagram of a half wave rectifier and explain its working.

Half wave rectifier

- The half wave rectifier circuit consists of a transformer, a *p-n* junction diode and a resistor.
- In a half wave rectifier circuit, either a positive half or the negative half of the AC input is passed through by the diode while the other half is blocked. Only one half of the input wave is rectified. Therefore, it is called half wave rectifier.





During the positive half cycle

- When the positive half cycle of the AC input signal passes through the circuit, terminal *A* becomes positive with respect to terminal *B*.
- The diode is forward biased and hence it conducts.
- The current flows through the load resistor R_L and the AC voltage developed across R_L constitutes the output voltage V_0.

During the negative half cycle

- When the negative half cycle of the AC input signal passes through the circuit, terminal *A* is negative with respect to terminal *B*.
- Now the diode is reverse biased and does not conduct.
- Hence no current passes through *R*L. Since there is no voltage drop across *R*L, the negative half cycle of AC supply is suppressed at the output.

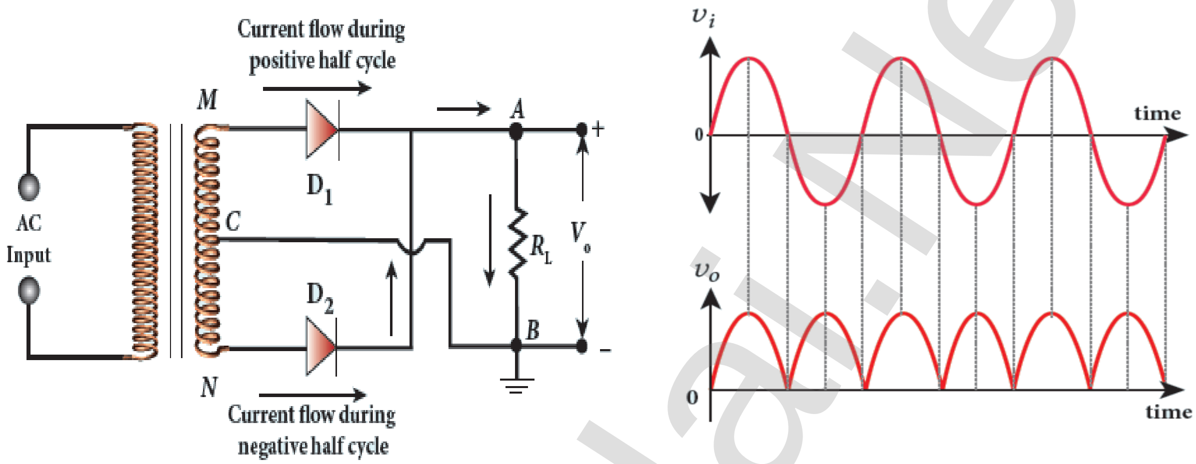
Efficiency (η)

- **It is the ratio of the output DC power to the input AC power supplied to the circuit.**
- Its value for half wave rectifier is 40.6 %.

2. Explain the construction and working of a full wave rectifier.

Full wave rectifier

- The positive and negative half cycles of the AC input signal are rectified in this circuit and hence it is called the full wave rectifier.
- It consists of two *p-n* junction diodes, a centre tap transformer and a load resistor R_L.



During positive half cycle

- When the positive half cycle of the AC input signal passes through the circuit, terminal M is positive, C is at zero potential and N is at negative potential.
- This forward biases diode D_1 and reverse biases diode D_2. Hence, being forward biased, diode D1conducts and current flows along the path MDABC$_1$.

During negative half cycle

- When the negative half cycle of the AC input signal passes through the circuit, terminal *N* becomes positive, *C* is at zero potential and *M* is at negative potential.
- This forward biases diode D2 and reverse biases diode D_1. Hence, being forward biased, diode D_2 conducts and current flows along the pathNDABC$_2$.
- During both positive and negative half cycles of the input signal, the current flows through the load in the same direction.
- Though both half cycles of AC input are rectified, the output is still pulsating in nature.
- **The efficiency (η)** of full wave rectifier is 81.2 %.

3. State and prove De Morgan's first and second theorem.

De Morgan's First Theorem

Statement

The first theorem states that the complement of the sum of two logical inputs is equal to the product of its complements.

Proof

The Boolean equation for NOR gate is $Y = \overline{A + B}$

The Boolean equation for a bubbled AND gate is $Y = \overline{A}.\overline{B}$

A	B	A+B	$\overline{A + B}$	$\overline{A}$	$\overline{B}$	$\overline{A}.\overline{B}$
0	0	0	1	1	1	1
0	1	1	0	1	0	0
1	0	1	0	0	1	0
1	1	1	0	0	0	0

From the above truth table, we can conclude $\overline{A + B} = \overline{A}.\overline{B}$

Thus De Morgan's first theorem is proved.

Hence, a NOR gate is equal to a bubbled AND gate.

De Morgan's Second Theorem

Statement

The second theorem states that the complement of the product of two inputs is equal to the sum of its complements.

Proof

The Boolean equation for NAND gate is $Y = \overline{A.B}$

The Boolean equation for bubbled OR gate is $Y = \overline{A} + \overline{B}$

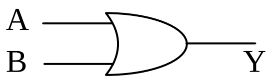
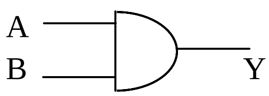
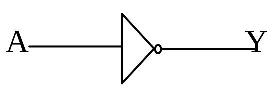
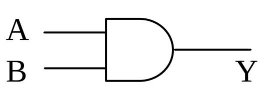
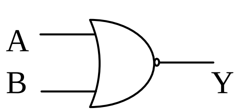
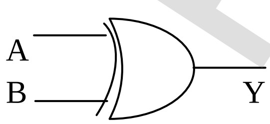
A	B	A.B	$\overline{A.B}$	$\overline{A}$	$\overline{B}$	$\overline{A} + \overline{B}$
0	0	0	1	1	1	1
0	1	0	1	1	0	1
1	0	0	1	0	1	1
1	1	1	0	0	0	0

From the above truth table we can conclude $\overline{A.B} = \overline{A} + \overline{B}$

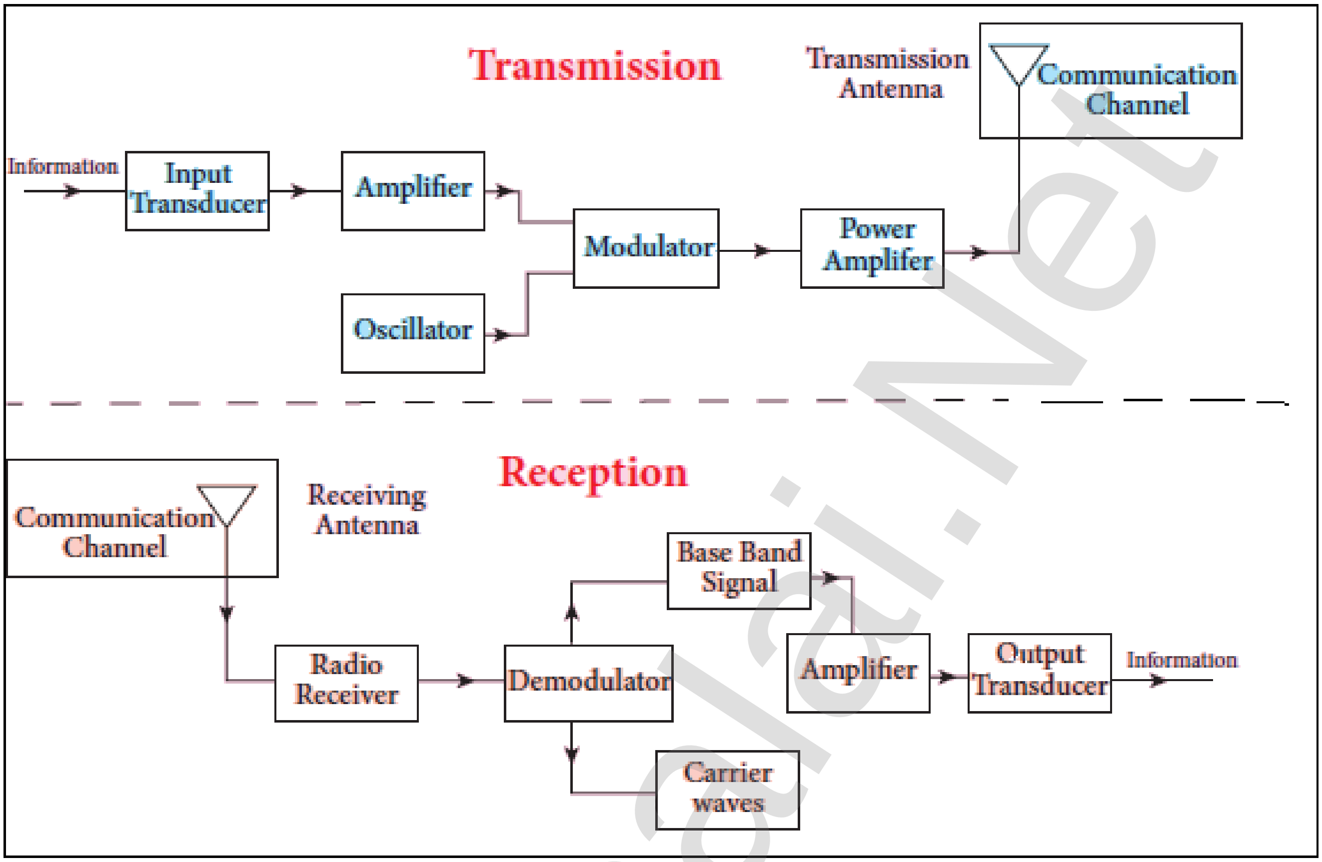
Thus De Morgan's second theorem is proved.

Hence, a NAND gate is equal to a bubbled OR gate.

4. Give circuit symbol, logical operation, truth table, and Boolean expression of i) AND gate ii) OR gate iii) NOT gate iv) NAND gate v) NOR gate and vi) EX-OR gate.

GATE	CIRCUIT SYMBOL	LOGICAL OPERATION	TRUTH TABLE	BOOLEAN EXPRESSION
OR gate		The output of AND gate is high only when all the inputs are high. In the rest of the cases, the output is low.	Inputs: A, B; Output: Y = A+B 0 0 → 0 0 1 → 1 1 0 → 1 1 1 → 1	Y = A+B
AND gate		The output of OR gate is high (logic 1 state) when either of the inputs or both are high.	Inputs: A, B; Output: Y = A.B 0 0 → 0 0 1 → 0 1 0 → 0 1 1 → 1	Y = A.B
NOT gate		The output is the complement of the input. It is also called as inverter.	Input: A; Output: $Y = \overline{A}$ 0 → 1 1 → 0	$Y = \overline{A}$
NAND gate		The output *Y* equals the complement of AND operation. The circuit is an AND gate followed by a NOT gate. Therefore, it is summarized as NAND. The output is at logic zero only when all the inputs are high. The rest of the cases, the output is high.	Inputs: A, B; Output: $Y = \overline{A.B}$ 0 0 → 1 0 1 → 1 1 0 → 1 1 1 → 0	$Y = \overline{A.B}$
NOR gate		The output *Y* equals the complement of OR operation. The circuit is an OR gate followed by a NOT gate and is summarized as NOR. The output is high when all the inputs are low. The output is low for all other combinations of inputs.	Inputs: A, B; Output: $Y = \overline{A+B}$ 0 0 → 1 0 1 → 0 1 0 → 0 1 1 → 0	Y =
EX-OR gate		The output is high only when either of the two inputs is high. In the case of an Ex-OR gate with more than two inputs, the output will be high when odd number of inputs are high.	Inputs: A, B; Output: $Y = A \oplus B$ 0 0 → 0 0 1 → 1 1 0 → 1 1 1 → 0	$Y = A \oplus B$

5. Explain the basic elements of communication system with the necessary block diagram.



i) Information (Baseband or input signal)

Information can be in the form of speech, music, pictures or computer data. This information is given as input to the input transducer.

ii) Input transducer

In communication system, the transducer converts the information (in the form of sound, music, pictures or computer data) into corresponding electrical signals. The electrical equivalent of the original information is called the baseband signal.
The best example for the transducer is the microphone that converts sound energy into electrical energy.

iii) Transmitter

It feeds the electrical signal from the transducer to the communication channel. It consists of circuits such as amplifier, oscillator, modulator and power amplifier. The transmitter is located at the broadcasting station.
Amplifier:
The transducer output is very weak and is amplified by the amplifier.

Oscillator:

It generates high-frequency carrier wave (a sinusoidal wave) for long distance transmission into space. As the energy of a wave is proportional to its frequency, the carrier wave has very high energy.

Modulator:

It superimposes the baseband signal onto the carrier signal and generates the modulated signal.

Power amplifier:

It increases the power level of the electrical signal in order to cover a large distance.

iv) Transmitting antenna

It radiates the radio signal into space in all directions. It travels in the form of electromagnetic waves with the speed of light.

v) Communication channel

Communication channel is used to carry the electrical signal from transmitter to receiver with less noise or distortion. The examples for communication medium are wires, cables,
optical fibres in wireline communication and free space in wireless communication.

vi) Receiver

The signals that are transmitted through the communication medium are received by a receiving antenna which converts EM waves into RF signals and are fed into the receiver.

The receiver consists of electronic circuits like demodulator, amplifier etc. The demodulator extracts the baseband signal from the modulated signal. Then the baseband signal is amplified using amplifier. Finally, it is fed to the output transducer.

vii) Repeaters

Repeaters are used to increase the range or distance through which the signals are sent. It is a combination of transmitter and receiver. The signals are received, amplified and retransmitted with a carrier signal of different frequency to the destination. The best example is the communication satellite in space.

viii) Output transducer

It converts the electrical signal back to its original form such as sound, music, pictures or data. Examples of output transducers are loudspeakers, picture tubes, computer monitor etc.

UNIT – XI RECENT DEVELOPMENTS IN PHYSICS

1. Discuss the applications of Nanomaterials in various fields.

Automotive industry • Lightweight construction • Painting • Catalysts • Tires • Sensors Coatings for wind-screen • and car bodies	**Chemical industry** • Fillers for paint systems • Coating systems based on nanocomposites • Impregnation of papers • Switchable adhesives • Magnetic fluids	**Engineering** • Wear protection for tools and machines • Lubricant-free bearings
Electronic industry • Data memory • Displays • Laser diodes • Glass fibers • Optical switches • Filters (IR-blocking) • Conductive, antistatic coatings	**Construction** • Construction materials • Thermal insulation • Flame retardants • Surface-functionalised building materials for wood, floors, stone, facades, tiles, roof tiles, etc. • Facade coatings Groove mortar	**Medicine** • Drug delivery systems • Active agents • Contrast medium • Medical rapid tests • Prostheses and implants • Antimicrobial agents and coatings • Agents in cancer therapy
Textile/fabrics/ non-wovens • Surface-processed textiles • Smart clothes	**Energy Fuel cells** • Solar cells • Batteries • Capacitors	**Cosmetics** • Sun protection • Lipsticks • Skin creams • Tooth paste
Food and drinks • Package materials • Storage life sensors • Additives Clarification of fruit juices	**Household** • Ceramic coatings for irons • Odors catalyst • Cleaner for glass, ceramic, floor, windows	**Sports/ outdoor** • Ski wax • Antifogging of glasses/goggles • Antifouling coatings for ships/boats • Reinforced tennis rackets and balls

2. What are the possible harmful effects of usage of Nanoparticles? Why?

- The research on the harmful impact of application of nanotechnology is also equally important and fast developing.
- The major concern here is that the nano particles have the dimensions same as that of the biological molecules such as proteins.
- They may easily get absorbed onto the surface of living organisms and they might enter the tissues and fluids of the body.
- The adsorbing nature depends on the surface of the nanoparticle. Indeed, it is possible to deliver a drug directly to a specific cell in the body by designing the surface of a nanoparticle so that it adsorbs specifically onto the surface of the target cell.
- The interaction with living systems is also affected by the dimensions of the nanoparticles. For instance, nanoparticles of a few nanometers size may reach well inside bio molecules, which is not possible for larger nanoparticles.
- Nanoparticles can also cross cell membranes. It is also possible for the inhaled nanoparticles to reach the blood, to reach other sites such as the liver, heart or blood cells.
- Researchers are trying to understand the response of living organisms to the presence of nanoparticles of varying size, shape, chemical composition and surface characteristics.