



ASSOCIATION OF PHYSICS TEACHERS, KOZHIKODE
Kerala, India

+2 PHYSICS: PREVIOUS YEAR QUESTIONS

CHAPTERWISE
SOLVED PAPERS
2021 – 2025

2026 MARCH

10 SETS OF QUESTION PAPERS

Including March & Say Exams



Fully Solved with
Detailed Explanations



Strictly Based on Latest
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Organized by Chapter
for Targeted Practice

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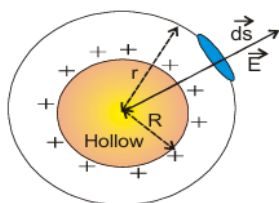


Chapter 1

ELECTRIC CHARGES AND FIELDS

MARCH 2025

- The electrostatic force per unit charge is known as-----
(a)Electric current (b)Electric potential (c)Electric field (1)
Ans : (c) Electric field
- (a)Define electric dipole moment.
(b)Write an expression for torque acting on an electric dipole placed in a uniform electric field. When will it become maximum? (1+2)
Ans:
(a) A dipole moment is the product of the magnitude of the charge and the distance between the centers of the positive and negative charges. $P = q \times 2a$
(b) $\tau = PE \sin\theta$ or $\vec{\tau} = \vec{P} \times \vec{E}$
 τ is maximum when $\theta = 90^\circ$
- (a)A spherical shell of radius 'R' is uniformly charged with charge '+q'. Using Gauss's law find the electric field intensity at a point
(i)Outside the spherical shell.
(ii)On the surface of the spherical shell.
(b)A point charge causes an electric flux - $2 \times 10^{14} \text{ Nm}^2/\text{C}$ to pass through a spherical Gaussian surface. ($\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$)
(i)Calculate the value of the point charge.
(ii)If the radius of the Gaussian surface is doubled, how much flux would pass through the surface?
(2+1+1+1)



Ans:

- (i) $\oint \vec{E} \cdot d\vec{s} = q/\epsilon_0$
 $\oint E ds \cos\theta = q/\epsilon_0$
 $E \oint ds = q/\epsilon_0$
 $E 4\pi r^2 = q/\epsilon_0$
 $E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2}$
 or $E = \frac{1}{4\pi\epsilon_0} \frac{\sigma 4\pi R^2}{r^2} = \frac{\sigma}{\epsilon_0} \frac{R^2}{r^2}$
- (ii) $r=R$
 $E = \frac{\sigma}{\epsilon_0}$
- (b) (i) $\phi = \frac{q}{\epsilon_0}$

$$q = \epsilon_0 \phi = 8.85 \times 10^{-12} \times (-2 \times 10^{14}) = -17.7 \times 10^2 \text{ C}$$

(ii) Same or $-2 \times 10^{14} \text{ Nm}^2/\text{C}$

SAY 2025

4. When the distance between two charged particle is halved the force between them becomes
 a) One fourth c) Double b) One half d) Four times (1)
 Ans: d) Four times
5. Fill in the Blanks.

	Electrostatics	Magnetism
Dipole moment	_____	m
Equatorial field for a short dipole	$\frac{-1}{4\pi\epsilon_0} \frac{p}{r^3}$	_____
External field : Torque	_____	$m \times B$
External field : Energy	- P. E	_____

$$(4 \times \frac{1}{2} = 2)$$

Ans :

P

$$\frac{\mu_0 m}{4\pi r^3}$$

$\mathbf{P} \times \mathbf{E}$

$-\mathbf{m} \cdot \mathbf{B}$

6. Derive an expression for the electric field on a point on the axial line of an electric dipole with the help of figure. (3)

Ans:

Figure

Dervivation

E due to +q ($\frac{1}{2}$ score)

E due to -q ($\frac{1}{2}$ score)

Total electric field ($1\frac{1}{2}$ score)

Or – Final equation only (1 score)

7. a) State Gauss's law in electrostatics.
 b) Using Gauss's theorem find the expression for electric field due to an infinitely long charged wire of linear charge density λ at a perpendicular distance 'r' from it.
 c) A point charge of $2 \mu\text{C}$ is enclosed within a spherical Gaussian surface of radius 10 cm. Calculate the electric flux through the surface. (4)

Ans:

(a) Statement or equation of Gauss Law (1 score)

(b) Derivation

Figure ($\frac{1}{2}$ score)

Derivation ($1\frac{1}{2}$ score)

OR Final equation only (1 score)

(c) $\phi = \frac{q}{\epsilon_0}$ ($\frac{1}{2}$ score)

$$\frac{2 \times 10^{-6}}{8.85 \times 10^{-12}} = 2.25 \times 10^5 \text{ N/Cm}^2 \quad (\frac{1}{2} \text{ score})$$

MARCH 2024

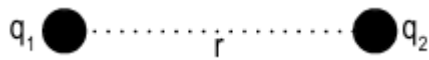
8. The SI unit of electric flux

(a) NC^{-1} (b) NmC (c) Nm^2C^{-1} (d) Nm^2C (1)

Ans: Nm^2C^{-1}

9. State and explain the force between electric charges. (3)

Ans:



The force of attraction or repulsion between two point charges is directly proportional to the product of the charge and inversely proportional to the square of the distance between them. The force between the charges is given by,

$$F \propto q_1 q_2$$

$$F \propto \frac{1}{r^2}$$

$$F \propto \frac{q_1 q_2}{r^2}$$

$$F = K \frac{q_1 q_2}{r^2}$$

When the medium between the charges is air or vacuum

$$F_{\text{vacuum}} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$$

10. (a) Complete the diagram with proper making of direction.



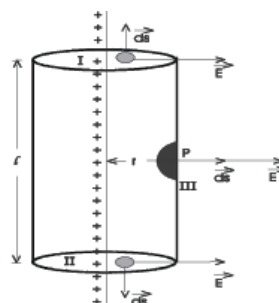
(b) Derive the expression for electric field intensity at a point from an infinitely long straight conductor carrying charge. (1+3)

Ans:

(a)



(b)



$$\text{Derivation of } E = \frac{\lambda}{2\pi\epsilon_0 r}$$

11. The net electric field inside a conductor when placed in an external electric field is (a) Zero (b) Half (c) Two times (d) Four times (1)

Ans : (a) Zero

SAY 2024

12. When a glass rod is rubbed with silk, it
 (a) gains electron from silk (b) gives electron to silk (c) gains proton from silk (d) gives proton to silk (1)
 Ans : (b) gives electron to silk

13. (a) Define electric dipole moment. Is it a scalar or vector quantity ?
 (b) What is the condition for maximum torque acting on an electric dipole in a uniform electric field ?
 (2 + 1)

Ans :

(a) Electric dipole moment is defined as the product of magnitude of either charges and the distance between the positive and negative charge of the electric dipole.

$$\mathbf{P} = q \times 2\mathbf{a}$$

Vector quantity

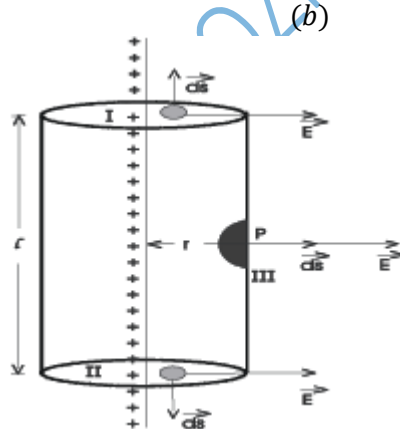
(b) When electric dipole is placed perpendicular to the direction of electric field.

14. (a) Define electric flux. Write its S.I. unit.
 (b) Using Gauss's law, derive an expression for the electric field intensity at a point 'r' from an infinitely long straight wire having linear charge density λ C/m (2 + 3)

Ans:

(a) Electric flux through a surface is total number of electric lines of force that normally pass through that surface.

$$\text{Nm}^2\text{C}^{-1} \text{ or } \text{JmC}^{-1}$$



$$\text{Derivation of } E = \frac{\lambda}{2\pi\epsilon_0 r}$$

MARCH 2023

State true or false :

15. Two field lines never intersect. (1)

Ans : True

16. Explain the basic properties of electric charge. (3)

Ans:

Electric charge can be + ve or - ve.

Forces b/w charges can be attractive or repulsive depending whether they are unlike or like.

Charge is a scalar quantity.

Charge is additive in nature.

Electric charge is always conserved.

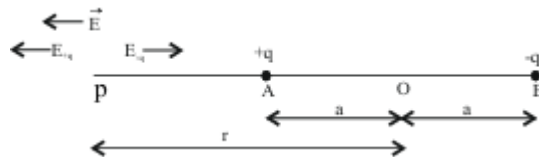
Charge is quantized. $q = \pm ne$

17. (a) What is an electric dipole?
 (b) Obtain the expression for the electric field intensity at a point on the axial line of an electric dipole. (1 + 3)

Ans:

(a) A system of two equal and opposite charges separated by some distance is called an electric dipole.

(b)



Derivation of $E = \frac{2Kp}{r^3}$

SAY 2023

18. The fact that electric charge is always an integral multiple of basic unit of charge is termed as _____ (1)

Ans:

Quantisation

19. A dipole is placed in a uniform electric field. By drawing the force acting on each point charge. Find the torque acting on the dipole. (2)

Ans:

Diagram showing the Force

Derivation of or $\vec{\tau} = \vec{P} \times \vec{E}$

20. A Spherical shell of radius 'R' is uniformly charged with charge '+q'. Using Gauss's theorem find the electric field intensity at a point 'P' when 'P' is

(a) Outside the spherical shell.

(b) On the surface of the spherical shell.

(c) Inside the spherical shell. (3+1+1)

Ans:

(a) Derivation outside the shell (3)

Or $\phi = \frac{q}{\epsilon_0}$ (1)

Figure (1)

$$E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \text{ or } E = \frac{\sigma}{\epsilon_0} \frac{R^2}{r^2} \quad (1)$$

(b)) $r=R$

$$E = \frac{\sigma}{\epsilon_0} \quad (1)$$

(c) $E=0$ (1)

MARCH 2022

21. .SI unit of electric field

(a) NC-1 (b) Vm (c) Cm (d) Nm (1)

Ans: (a) NC-1

22. Electric field at the surface of a charged conductor must be normal to the surface at every point. Is the statement true or false ? (1)

Ans : True

23. Explain earthing.

Ans:

Earthing is the method of transmitting the instant electricity discharge directly to the ground through low resistance wires.

24. (i) State Gauss's law.

(ii) What is meant by a Gaussian surface ?

(iii) Using Gauss's law, find the electric field due to a uniformly charged thin spherical shell at a point outside the shell. (2+1+3)

Ans :

(i) The Gauss's theorem states that the electric flux through any closed surface in free space is equal to $(1/\epsilon_0)$ times the net charge enclosed within the surface.

(ii) A gaussian surface is around a symmetric charge distribution is any imaginary closed surface such that the intensity of electric field at all points on the surface is same

(iii) Derivation of $E = \frac{\sigma}{\epsilon_0} \frac{R^2}{r^2}$

SAY 2022

25. An electric dipole is placed in a uniform electric field. The net resultant force acting on the dipole is ----- (1)

Ans : Zero

26. (a) State principle of quantization of electric charge.

(b) Force between two electric charges is 10N when placed in free space and the force reduces to 5N when placed in a medium of dielectric constant 'K'. Find the value of 'K'. (1+1)

Ans :

(a) According to quantization of charge, the charge of a body is always an integral multiple of a fundamental charge e

(b) $K = \frac{F_{vacuum}}{F_{medium}} = \frac{10}{5} = 2$

27. A small charge 'q' is placed inside a closed surface.

(a) What is the flux through the surface ?

(b) Name and state the law which is used to find the flux through the surface

(c) Using the above law find the electric field at a point distant 'r' from an infinitely long straight uniformly charged wire. (1+2+3)

Ans:

(a) $\frac{q}{\epsilon_0}$

(b) Gauss's theorem The Gauss's theorem states that the electric flux through any closed surface in free space is equal to $(1/\epsilon_0)$ times the net charge enclosed within the surface

(c) Derivation of $E = \frac{\lambda}{2\pi\epsilon_0 r}$

MARCH 2021

28. Fill in the blanks : "The force between two point charge is directly proportional to the product of ---- and inversely proportional to the ----- of the distance between them" (1)

Ans:

charges, square

29. (a) Define electric dipole moment.

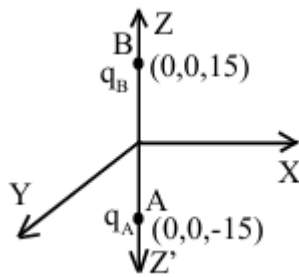
(b) A system has two charges $q_A = 2.5 \times 10^{-7} \text{ C}$ and $q_B = -2.5 \times 10^{-7} \text{ C}$ located at points A(0,0,-15cm) and B(0,0,+15cm) respectively. Determine the magnitude and direction of electric dipole moment of the system (1+2)

Ans:

(a) The electric dipole moment is the product of the magnitude of the charge and the distance between the centres of positive and negative charges. $P = q \times 2a$

(b) The distance between A and B is the length of dipole, $AB = 2a = 30 \times 10^{-2} \text{ m}$

The electric dipole moment, $P = q_A \times 2a = 2.5 \times 10^{-7} \times 30 \times 10^{-2} = 7.5 \times 10^{-8} \text{ Cm}$

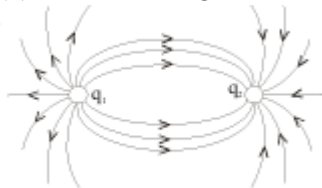


The direction of the dipole moment is always from negative charge to positive charge that is along B to A

30. (a) Write any two properties of electric field lines.

(b) Observe the figure and write the signs of the charges q_1 and q_2 .

(1+2)



Ans:

(a) Any two properties

(b) q_1 - positive, q_2 - negative

31. Gauss law in electrostatics relates electric flux with electric charge.

(a) Electric flux and electric charge are scalar quantities. State whether this statement is true or false

(b) State Gauss law in electrostatics.

(c) Using Gauss law derive an expression for the intensity of electric field at a point due to an infinitely long straight charged wire (1+2+2)

Ans:

(a) True

(b) The Gauss's theorem states that the electric flux through any closed surface in free space is equal to $(1/\epsilon_0)$ times the net charge enclosed within the surface.

(c) Derivation

SAY 2021

32. How many electrons constitute an electric charge of 1C ? (1)

(a) 6.25×10^{18}

(b) 6.25×10^{19}

(c) 6.25×10^{-18}

(d) 6.25×10^{-19}

Ans:

(a) 6.25×10^{18}

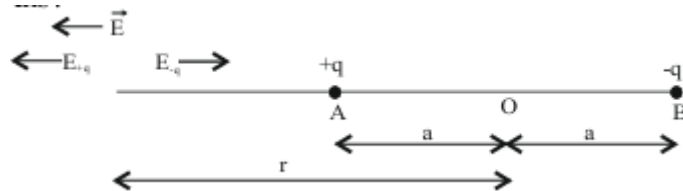
33. State Coulomb's law in electrostatics (2)

Ans:

The force of attraction or repulsion between two point charges is directly proportional to the product of the charge and inversely proportional to the square of the distance between them.

34. Derive an expression for electric field E due to a dipole of length $2a$ at a distance r from the centre of the dipole on axial line. (3)

Ans:



$$E_{+q} = \frac{q}{4\pi\epsilon_0(r-a)^2} \text{ along AP}$$

$$E_{-q} = \frac{q}{4\pi\epsilon_0(r+a)^2} \text{ along PB}$$

$$E = E_{+q} - E_{-q} = \frac{q}{4\pi\epsilon_0} \left(\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2} \right) = \frac{2Kp}{r^3} \text{ along AP}$$

35. Give any three properties of electric field lines. (3)

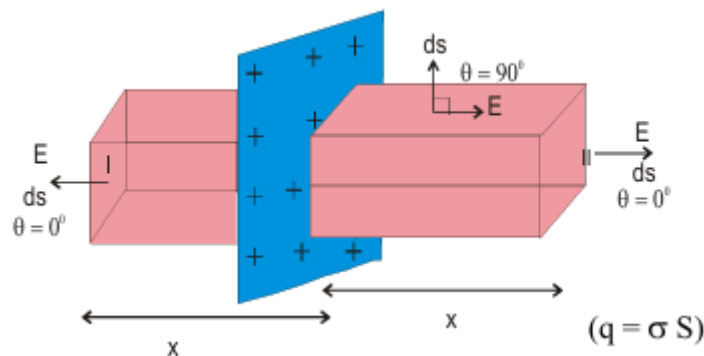
Ans:

Any 3 properties

36. State Gauss Law in electrostatics. Apply Gauss Law to find the electric field due to an infinite plane sheet of charge (5)

Ans:

The Gauss's theorem states that the electric flux through any closed surface in free space is equal to $(1/\epsilon_0)$ times the net charge enclosed within the surface.



Electric flux crossing through the Gaussian surface is given by

$$\phi = ES + ES = 2ES$$

Applying Gauss Theorem

$$2ES = \frac{q}{\epsilon_0} = \frac{\sigma S}{\epsilon_0}$$

$$\text{So } E = \frac{\sigma}{2\epsilon_0}$$

Chapter 2

ELECTROSTATIC POTENTIAL AND CAPACITANCE

MARCH 2025

1. A circle of radius r is drawn with a charge $+q$ placed at the centre. The work done in moving a point charge around the circumference of the circle is ----- (1)

Ans: Zero

2. (a) What is equipotential surface ?
(b) Write two properties of equipotential surfaces. (1+2)

Ans:

(a) An equipotential surface is the locus of all those points at which the potential due to charge distribution is the same.

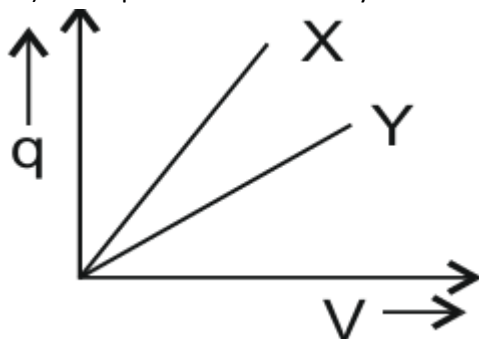
(b) Any two

No work is done in moving a test charge from one point to another on an equipotential surface.

The electric field (lines of force) are at right angles to the equipotential surface.

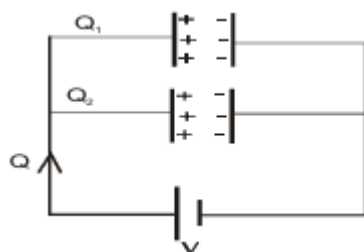
Two equipotential surfaces can never intersect each other.

3. (a) Obtain an expression for the equivalent capacitance when two capacitors C_1 and C_2 are connected in parallel
(b) Given graph variation of charge ' q ' with potential difference ' V ' for two capacitors C_1 and C_2 . Both the capacitors have same plate separation but plate area of C_2 is greater than that of C_1 . Which line (X or Y) corresponds to C_1 and why? (2+2)



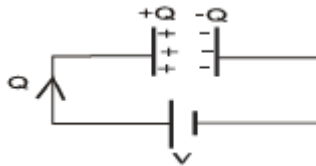
Ans:

(a)



$$Q = Q_1 + Q_2$$

If C be the effective capacitance of the parallel combination, then



$$Q = CV$$

So

$$CV = C_1 V + C_2 V$$

$$C = C_1 + C_2$$

$$(b) C = \frac{A\epsilon_0}{d} = \frac{Q}{V} = \text{Slope}$$

Slope $\propto A$

Plate area of $C_2 >$ Plate area of C_1

$\text{Slope}_x > \text{Slope}_y$

Y corresponds to C_1

SAY 2025

4. State which one of the following is correct.

a) Joule = Coulomb/volt

b) Joule = Volt/ampere

c)

Joule = Coulomb $\times$ volt

d) Joule = Volt/meter

Ans:

c) Joule = Coulomb $\times$ volt

5. Three capacitors of capacitance 2PF, 3PF and 4PF are connected in parallel.

a) What is the effective capacitance of the combination ?

b) Determine the charge on each capacitor if the combination is connected to a 100V supply. (1+2=3)

Ans:

(a) For parallel combination

$$C = C_1 + C_2 + C_3 = 2 + 3 + 4 = 9 \text{ PF}$$

(b) $Q = CV$

$$\text{Charge on 2PF} = C_1 V = 2 \times 10^{-12} \times 100 = 200 \times 10^{-12} \text{ F}$$

$$\text{Charge on 3PF} = C_2 V = 3 \times 10^{-12} \times 100 = 300 \times 10^{-12} \text{ F}$$

$$\text{Charge on 4PF} = C_3 V = 4 \times 10^{-12} \times 100 = 400 \times 10^{-12} \text{ F}$$

6. The electric field through a point is normal to equipotential surface.

a) What is meant by equipotential surface ?

b) Draw the equipotential surface for a uniform electric field.

c) Derive an expression for the energy stored in a parallel plate capacitor.

(1+1+3)

Ans:

(a) A surface with same potential .

(b)

(i) For a uniform electric field



(c) $dw = vdq$

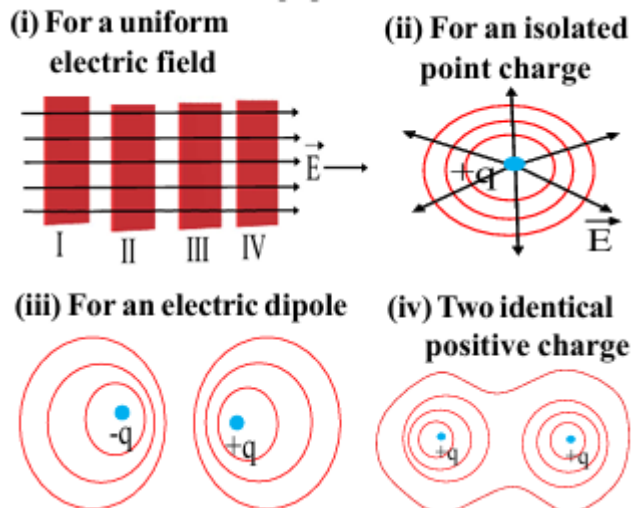
$$W = \int dw = \int \frac{Q}{C} dq$$

$$\text{Energy} = W = \frac{Q^2}{2C} = \frac{CV^2}{2}$$

MARCH 2024

7. What is an equipotential surface ? Give an example. (2)

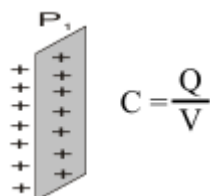
Ans: An equipotential surface is the locus of all those points at which the potential due to charge distribution is the same. Example : The surface of a charged conductor. Earth is an equipotential surface.



8. (a) What is the principle of a capacitor ?
 (b) Derive the expression for capacitance of a parallel plate capacitor.
 (c) A 12 pF capacitor is connected to 50V battery. How much electrostatic energy is stored in the capacitor ? (1+2+3)

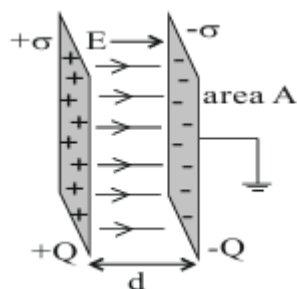
Ans:

(a)



Another earthed conductor P_2 is kept very close to P_1 . By induction P_2 is charged negatively. As a result of this the potential of the plate P_1 falls to V' . Hence capacitance increases

(b)



Electric field between the plate is given by

$$E = \frac{\sigma}{\epsilon_0} = \frac{Q}{A\epsilon_0}$$

Potential difference between the 2 plates

$$V = Ed = \frac{Qd}{A\epsilon_0}$$

$$\text{Capacitance } C = \frac{Q}{V} = \frac{A\epsilon_0}{d}$$

$$(c) U = \frac{CV^2}{2} = \frac{12 \times 10^{-12} \times 50^2}{2} = 1.5 \times 10^{-8} \text{ J}$$

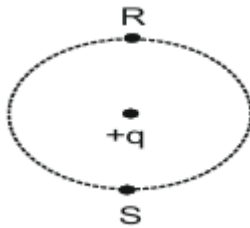
SAY 2024

9. One volt is equivalent to

- (a) Newton/second (b) Newton/Coulomb
(c) Joule/Coulomb (d) Joule/second (1)

Ans: (c) Joule/Coulomb

10. (a) A circle is drawn with a charge +q placed at the centre. What is the work done in moving a point charge from R to S along the circumference of a circle?



(b) Write any two characteristics of equipotential surface. (1+2)

Ans:

(a) Zero

(b) No work is done in moving a test charge from one point to another on an equipotential surface.
The electric field lines of force are at right angles to the equipotential surface.

Two equipotential surfaces can never intersect each other

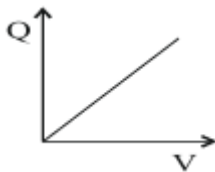
11. (a) Derive an expression for the equivalent capacitance of two capacitors connected in parallel.

(b) Sketch a graph to show the variation of charge (Q) with potential (V) of a capacitor. What does the area of the graph represent? (2+2)

Ans :

(a) Derivation

(b)



Energy of the capacitor

MARCH 2023

12. (a) Derive the expression for the capacitance of a parallel plate capacitor.

(b) What happens to the capacitance if a medium of dielectric constant K is introduced between the plates? (2+1)

Ans :

(a) Derivation of $C = \frac{A\epsilon_0}{d}$

(b) increases

13. (a) Give the relation between electric field and potential.

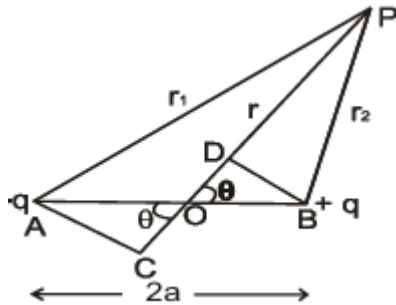
(b) Derive the expression for the potential due to an electric dipole.

(c) Calculate the potential at a point due to a charge of $4 \times 10^{-7} \text{ C}$ located 9 cm away. (1+2+2)

Ans:

(a) $E = \frac{-dv}{dx}$

(b)



Potential at P due to -q is $V_A = \frac{q}{4\pi\epsilon_0 r_1}$

Potential at P due to +q is $V_B = \frac{q}{4\pi\epsilon_0 r_2}$

Total Potential at P is $V = V_A + V_B = \frac{q}{4\pi\epsilon_0} \left(\frac{1}{r_2} \right) - \frac{q}{4\pi\epsilon_0} \left(\frac{1}{r_1} \right) \dots \dots \dots (1)$

$r_1 = AP \approx PC = r + a \cos\theta$

$r_2 = BP \approx PD = r - a \cos\theta$

Substituting in (1)

$V = \frac{q}{4\pi\epsilon_0} \left(\frac{1}{r - a \cos\theta} - \frac{1}{r + a \cos\theta} \right) = \frac{q}{4\pi\epsilon_0} \left(\frac{2a \cos\theta}{r^2 - a^2 \cos^2\theta} \right)$

If $r \gg a$

$V = \frac{p \cos\theta}{4\pi\epsilon_0 r^2}$

(c) $V = \frac{q}{4\pi\epsilon_0 r} = \frac{9 \times 10^9 \times 4 \times 10^{-7}}{9 \times 10^{-2}} = 4 \times 10^4 \text{ V}$

SAY 2023

14. In a capacitor energy is stored

(a) in the positive plate

(b) in the negative plate

(c) in the electric field between the plates

(d) no energy is stored

(1)

Ans: (c) in the electric field between the plates

15. For any charge configuration equipotential surface through a point is normal to electric field at that point.

(a) The amount of work done to move a point charge on the equipotential surface is _____. (b) Draw the equipotential surface of a single point charge. (1+1)

Ans:

(a) Zero

(b) Diagram

16. A capacitor is a key element of most ac circuits :

(a) Write any two factors on which capacitance of a parallel plate capacitor depends.

(b) Three capacitor C1, C2, C3 are connected in series. Derive an expression for capacitance of combination

- (c) When a dielectric substance is introduced between the plates what happens to its capacitance ?
(1+3+1)

Ans:

(a) Any 2 factors

(b) Derivation

Figure (1)

$Q = CV$ (1)

$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ (1)

(c) Increases

MARCH 2022

17. Electric field at the surface of a charged conductor must be normal to the surface at every point. Is the statement true or false ? (1)

Ans: True

18. Write down any three properties of an equipotential surfaces (3)

Ans

No work is done in moving a test charge from one point to another on an equipotential surface. The electric field (lines of force) are at right angles to the equipotential surface.

Two equipotential surfaces never intersect each other

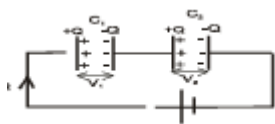
19. (a) SI unit of capacitance is -----

(b) Two capacitors C_1 and C_2 are connected in series. Derive an expression for the capacitance of the combination. (1+3)

Ans :

(a) Farad

(b)



$$V = V_1 + V_2 = \frac{Q}{C_1} + \frac{Q}{C_2} \dots \dots \dots (1)$$

If C be the effective capacitance of the series combination, then

$$V = \frac{Q}{C} \dots \dots \dots (2)$$

Comparing equations (1) and (2)

$$\frac{Q}{C} = \frac{Q}{C_1} + \frac{Q}{C_2}$$

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

SAY 2022

20. Work done to bring a charge from one place to another place in an equipotential surface is ----- (1)

Ans: Zero

21. A capacitor is a system of two conductors separated by an insulator.

22. (a) Three capacitors of equal capacitance when connected in series have a net capacitance C_1 and when connected in parallel have a net capacitance C_2 . What will be the ratio C_1 / C_2 ? (b) Write down the equation for equivalent capacitance when three capacitors of capacitance C_1 , C_2 and C_3 connected in (i) series (ii) parallel (2 + 1)

Ans:

$$(a) \frac{1}{C_1} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C} = \frac{3}{C}$$

$$C_1 = \frac{C}{3}$$

$$C_2 = C + C + C = 3C$$

$$\frac{C_1}{C_2} = \frac{1}{9}$$

$$(b) \text{ Series } \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\text{Parallel } C = C_1 + C_2 + C_3$$

23. A capacitor is a system of two conductors with charge +Q and -Q.

(a) What is the S.I unit of capacitance ?

(b) When two capacitors are connected in series, the capacitance of the combination (i) increases (ii) decreases

(c) Derive an expression for the energy stored in a capacitor. (1+1+2)

Ans :

(a) Coulomb/volt or farad (F)

(b) (ii) decreases

(c) At charging process, the potential difference between the plates is, $v = q/C$ The additional work dW needed to transfer the next increment of charge is

$$dW = Vdq = \frac{q}{C} dq$$

The total work required to charge the capacitor from its initial value 0 to a final value Q is,

$$W = \int dw = \int_0^Q \frac{q}{C} dq = \frac{1}{C} \left(\frac{Q^2}{2} - 0 \right) = \frac{Q^2}{2C}$$

$$\text{Energy} = \frac{Q^2}{2C}$$

MARCH 2021

24. Calculate the electric potential at a point 9 cm away from a point charge of $4 \times 10^{-7}C$. (2)

Ans:

$$V = \frac{Q}{4\pi\epsilon_0 r} = \frac{9 \times 10^9 \times 4 \times 10^{-7}}{9 \times 10^{-2}} = 4 \times 10^4 \text{ V}$$

25. Derive an expression for the energy stored in a capacitor in terms of capacitance and potential difference across the capacitor. (3)

Ans: Derivation

26. Write any one difference between polar and non-polar molecule. Give one example each for polar and non-polar molecule. (3)

Ans:

The centres of gravity of positive and negative charges do not coincide, is called a polar dielectric;

because of a symmetric shape of molecule. (In polar material molecule have permanent electric dipole moments) eg : H_2O , HCl , NH_3 The centres of gravity of positive and negative charges coincide, is

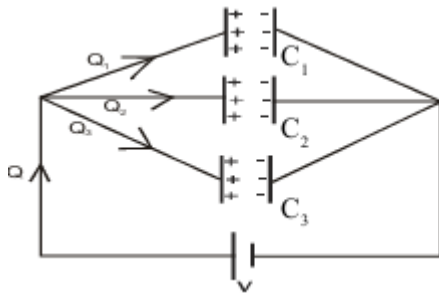
called a non-polar dielectric, because of symmetric shape of molecule. (In non-polar material molecule

do not have permanent electric dipole moments) eg: H_2 , O_2 , Cl_2

27. (a) Draw a figure of a parallel combination of three capacitors of capacitance C_1 , C_2 and C_3 . (b) Derive an expression for the effective capacitance of this combination (2+2)

Ans:

(a)



(b) Derivation

28. .Derive the expression for the energy stored in a capacitor. (3)

Ans: Derivation

29. In a parallel plate capacitor with air between the plates, each plate has an area of $6 \times 10^{-3} \text{ m}^2$ and the separation between the plates is 3 mm.

(a) Calculate the capacitance of the capacitor.

(b) If this capacitor is connected to 100 V supply, what would be the charge on each plate ?

$$(1\frac{1}{2} + 1\frac{1}{2} = 3)$$

Ans:

$$(a) C = \frac{A\epsilon_0}{d} = \frac{6 \times 10^{-3} \times 8.85 \times 10^{-12}}{3 \times 10^{-3}} = 17.7 \times 10^{-12} \text{ F}$$

$$(b) Q = CV = 17.7 \times 10^{-12} \times 100 = 17.7 \times 10^{-10} \text{ C}$$

30. .Derive expression for the equivalent capacitance of three capacitors C_1 , C_2 and C_3 connected (a) in series and (b) in parallel (2+2)

Ans:

Derivation

CURRENT ELECTRICITY

2025 SAY EXAM

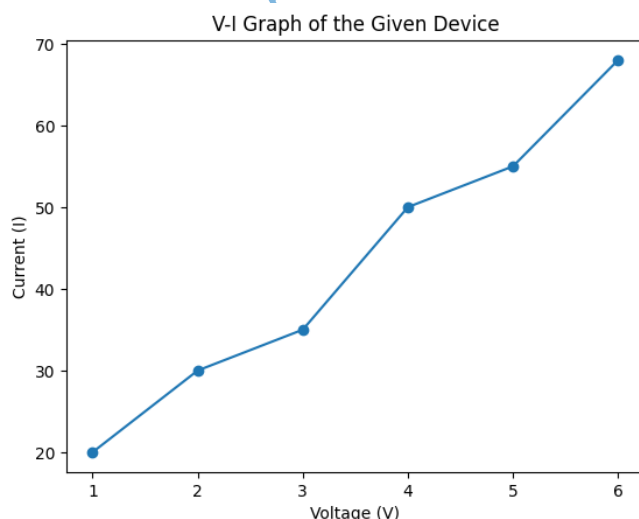
1. The table given shows the V-I relationship of a device.(2)

Voltage (V)	Current (I)
1	20
2	30
3	35
4	50
5	55
6	68

a) Draw V-I graph.

b) From the graph identify whether the device is an ohmic or non-ohmic device.

Ans: a)



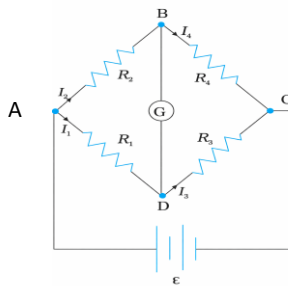
b) Since the d

does not pass uniformly through the origin, it is a **non-ohmic device**.

2. a) State Kirchoff's voltage rule.
b) Obtain the balancing condition of Wheatstone's bridge with the help of a diagram. (1+2)

Ans: a) The algebraic sum of changes in potential around any closed loop must be zero.

b)



When the bridge is balanced, current through the galvanometer $I_g = 0$

Apply Kirchoff's junction rule at junctions B and D,

$$I_1 = I_3 \dots\dots\dots(1)$$

$$I_2 = I_4 \dots\dots\dots(2)$$

Apply Kirchoff's loop rule to closed loops ADBA and CBDC,

$$I_1 R_1 - I_2 R_2 = 0$$

$$I_1 R_1 = I_2 R_2 \dots\dots\dots(3)$$

$$I_3 R_3 - I_4 R_4 = 0$$

$$I_3 R_3 = I_4 R_4 \dots\dots\dots(4)$$

$$\frac{\text{Eqn (3)}}{\text{Eqn (4)}}, \frac{I_1 R_1}{I_3 R_3} = \frac{I_2 R_2}{I_4 R_4}$$

$$\text{Therefore, } \frac{R_1}{R_3} = \frac{R_2}{R_4}$$

2025 MARCH

3. Show that the resistance of a conductor can be expressed by $R = \frac{ml}{ne^2 \tau A}$, where symbols have their usual meanings.(2)

Ans: $I = neAv_d$

$$v_d = \frac{eE\tau}{m}$$

$$I = neA\left(\frac{eE\tau}{m}\right)$$

$$E = \frac{V}{l}$$

$$\text{Therefore } I = neA\left(\frac{eV\tau}{ml}\right)$$

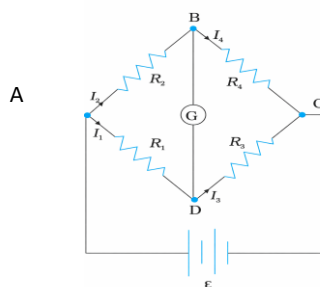
$$I = \left(\frac{ne^2 \tau A}{ml} \right) V$$

$$\frac{V}{I} = \frac{ml}{ne^2 \tau A} = R$$

4. a) Kirchoff's voltage law is in accordance with the conservation of
 (i) mass (ii) energy (iii) momentum (iv) charge
 b) With the help of a diagram, arrive at the Wheatstone's principle. (1+3)

Ans: a) (ii) energy

b)



When the bridge is balanced, current through the galvanometer $I_g = 0$

Apply Kirchoff's junction rule at junctions B and D,

$$I_1 = I_3 \dots\dots\dots(1)$$

$$I_2 = I_4 \dots\dots\dots(2)$$

Apply Kirchoff's loop rule to closed loops ADBA and CBDC,

$$I_1 R_1 - I_2 R_2 = 0$$

$$I_1 R_1 = I_2 R_2 \dots\dots\dots(3)$$

$$I_3 R_3 - I_4 R_4 = 0$$

$$I_3 R_3 = I_4 R_4 \dots\dots\dots(4)$$

$$\frac{\text{Eqn (3)}}{\text{Eqn (4)}}, \frac{I_1 R_1}{I_3 R_3} = \frac{I_2 R_2}{I_4 R_4}$$

$$\text{Therefore, } \frac{R_1}{R_3} = \frac{R_2}{R_4}$$

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

2024 SAY EXAM

5. (a) The temperature coefficient of resistance is positive for _____.

(b) Temperature (T) dependence of resistivity (ρ) of two materials are shown below.

Identify them. (1+1)

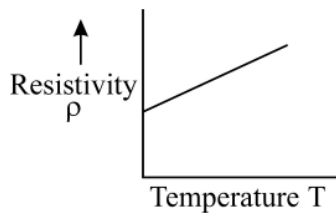


Fig. 1

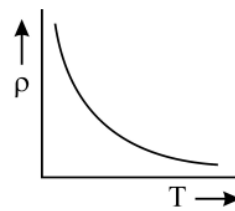


Fig. 2

Ans: a) metals

b) fig 1 — Nichrome

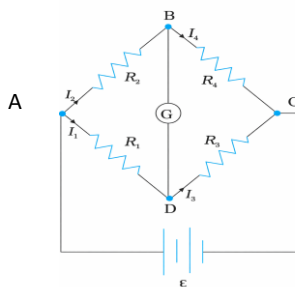
fig 2 — Semi conductor

6. (a) State Kirchhoff's voltage law.

(b) With the help of a diagram, arrive at the Wheatstone's principle. (1+3)

Ans: **Ans:** a) The algebraic sum of changes in potential around any closed loop must be zero.

b)



When the bridge is balanced, current through galvanometer $I_g = 0$

Apply Kirchhoff's junction rule at junctions B and D,

$$I_1 = I_3 \dots\dots\dots(1)$$

$$I_2 = I_4 \dots\dots\dots(2)$$

Apply Kirchhoff's loop rule to closed loops ADBA and CBDC,

$$I_1 R_1 - I_2 R_2 = 0$$

$$I_1 R_1 = I_2 R_2 \dots\dots\dots(3)$$

$$I_3 R_3 - I_4 R_4 = 0$$

$$I_3 R_3 = I_4 R_4 \dots\dots\dots(4)$$

$$\frac{\text{Eqn (3)}}{\text{Eqn (4)}}, \frac{I_1 R_1}{I_3 R_3} = \frac{I_2 R_2}{I_4 R_4}$$

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

2024 MARCH

7. Define drift velocity, give its equation.(2)

Ans : Drift velocity is defined as the average velocity with which the free electrons get drifted towards the positive terminal under the effect of an applied electric field.

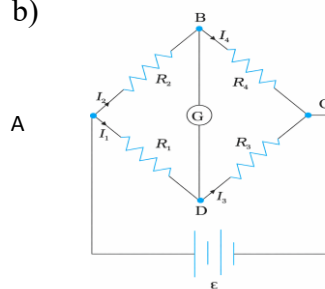
$$v_d = \frac{-eE}{m} \tau$$

8. (a)State Ohm's law

(b)Derive Wheatstone's network principle.(1+3)

Ans : (a)At constant temperature the current flowing through a conductor is directly proportional to the potential difference between its ends. $V \propto I$

b)



When the bridge is balanced, current through the galvanometer $I_g = 0$

Apply Kirchoff's junction rule at junctions B and D,

$$I_1 = I_3 \dots\dots\dots(1)$$

$$I_2 = I_4 \dots\dots\dots(2)$$

Apply Kirchoff's loop rule to closed loops ADBA and CBDC,

$$I_1 R_1 - I_2 R_2 = 0$$

$$I_1 R_1 = I_2 R_2 \dots\dots\dots(3)$$

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$$\frac{\text{Eqn (3)}}{\text{Eqn (4)}}, \frac{I_1 R_1}{I_3 R_3} = \frac{I_2 R_2}{I_4 R_4}$$

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

9. a) What is drift velocity
b) Write the equation connecting drift velocity and current(1+1)

Ans: Drift velocity is the average velocity with which free electrons drift towards the positive terminal under the influence of an applied electric field

Relation between drift velocity and current:

$$I = neAv_d$$

Where,

I = current

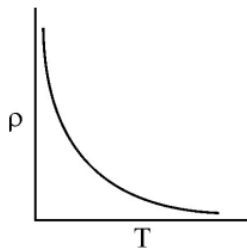
n = number of free electrons per unit volume

e = charge of electron

A = area of cross section of the conductor

v_d = drift velocity

10. The temperature dependence of resistivity of a material is shown below



- a) Identify the type of material
b) Write the relation between resistivity and average collision time of electrons(1+1)

Ans: a) Semi conductor

b) Relation between resistivity and average collision time:

$$\rho = \frac{m}{ne^2\tau}$$

Where,

ρ = resistivity

m = mass of electron

n = number of free electrons per unit volume

e = charge of electron

τ = average collision time

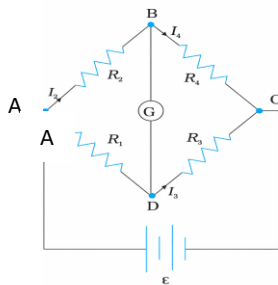
11. Kirchhoff's rules are very useful for the analysis of complicated electric circuits
a) State Kirchhoff's junction rule and loop rule

b) Draw the circuit diagram of Wheatstones bridge (2+1)

Ans: a) Junction rule: At any junction, the sum of the currents entering the junction is equal to the sum of the currents leaving the junction.

Loop rule: The algebraic sum of changes in potential around any closed loop must be zero.

b)



2023 MARCH

12. The SI unit of resistance is(1)

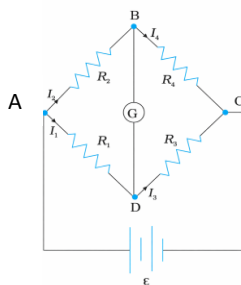
Ans: Ohm(Ω)

13. a) State Kirchoff's laws

b) Obtain the balancing condition of Wheatstone's bridge with the help of a diagram(2+3)

Ans: a) Junction rule: At any junction, the sum of the currents entering the junction is equal to the sum of the currents leaving the junction.

Loop rule: The algebraic sum of changes in potential around any closed loop must be zero. b)



When the bridge is balanced, current through galvanometer $I_g = 0$

Apply Kirchoff's junction rule at junctions B and D,

$$I_1 = I_3 \text{(1)}$$

$$I_2 = I_4 \text{(2)}$$

Apply Kirchoff's loop rule to closed loops ADBA and CBDC,

$$I_1 R_1 - I_2 R_2 = 0$$

$$I_1 R_1 = I_2 R_2 \dots\dots\dots(3)$$

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$$I_3 R_3 = I_4 R_4 \dots\dots\dots(4)$$

$$\frac{\text{Eqn (3)}}{\text{Eqn (4)}}, \frac{I_1 R_1}{I_3 R_3} = \frac{I_2 R_2}{I_4 R_4}$$

$$\text{Therefore, } \frac{R_1}{R_3} = \frac{R_2}{R_4}$$

2022 SAY

14. Write down the equation for drift velocity acquired by an electron when a potential difference is applied to conductor.(2)

Ans: $v_d = \frac{eE\tau}{m}$

$$E = \frac{V}{l}$$

Therefore, $v_d = \frac{eV\tau}{ml}$

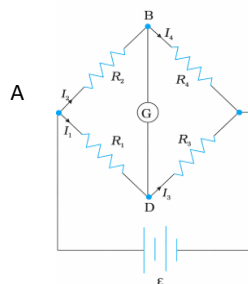
15. To analyse electric circuit Kirchhoff's rules are very useful

a) State Kirchhoff's loop rule

b) Draw the circuit diagram of Wheatstone's bridge apparatus (1+2)

Ans: a) Loop rule: The algebraic sum of changes in potential around any closed loop must be zero.

b)



2022 MARCH

16. A light bulb is rated at 100W for a 220V supply. Find the resistance of the bulb.(2)

Ans: Given :

Power, $P=100 \text{ W}$

Voltage, $V=220 \text{ V}$

We know,

$$P = \frac{v^2}{R}$$

$$R = \frac{v^2}{P}$$

$$R = \frac{220^2}{100}$$

$$R = 484 \Omega$$

Resistance of the bulb = 484 Ω

17. SI unit of resistance is....(1)

Ans: Ohm(Ω)

18. Write down the Wheatstone bridge principle(2)

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

2021 SAY

19. A battery of emf 10V and internal resistance 3 Ω is connected to an external resistor. If the current in the circuit is 0.5A, what is the value of the external resistance? What is the terminal voltage of the battery when the circuit is closed?(3)

Ans: Given :

$$E = 10 \text{ V}$$

$$r = 3 \Omega$$

$$I = 0.5 \text{ A}$$

External resistance

$$R_{total} = \frac{E}{I}$$

$$R_{total} = \frac{10}{0.5} = 20 \Omega$$

$$R_{total} = R + r$$

$$20 = R + 3$$

Therefore, **External resistance R = 17 Ω**

(ii) Terminal voltage

$$V = E - Ir$$

$$V = 10 - (0.5 \times 3)$$

$$V = 8.5 \text{ V}$$

$$\text{Terminal voltage} = 8.5 \text{ V}$$

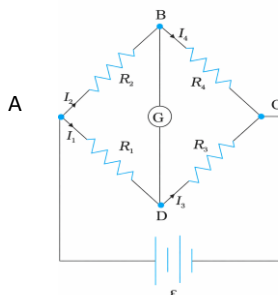
20. a) State Kirchoff's rules

b) Use Kirchoff's rules to obtain conditions for the balance in Wheatstones bridge. (2+3)

Ans: a) 1. Junction rule: At any junction, the sum of the currents entering the junction is equal to the sum of the currents leaving the junction.

2. Loop rule: The algebraic sum of changes in potential around any closed loop must be zero.

b)



When the bridge is balanced, current through galvanometer $I_g = 0$

Apply Kirchoff's junction rule at junctions B and D,

$$I_1 = I_3 \dots\dots\dots(1)$$

$$I_2 = I_4 \dots\dots\dots(2)$$

Apply Kirchoff's loop rule to closed loops ADBA and CBDC,

$$I_1 R_1 - I_2 R_2 = 0$$

$$I_1 R_1 = I_2 R_2 \dots\dots\dots(3)$$

$$I_3 R_3 - I_4 R_4 = 0$$

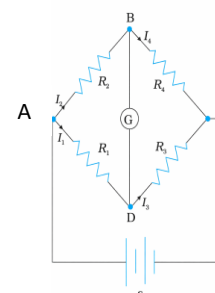
$$I_3 R_3 = I_4 R_4 \dots\dots\dots(4)$$

$$\frac{\text{Eqn (3)}}{\text{Eqn (4)}}, \frac{I_1 R_1}{I_3 R_3} = \frac{I_2 R_2}{I_4 R_4}$$

$$\text{Therefore, } \frac{R_1}{R_3} = \frac{R_2}{R_4}$$

21. Draw Wheatstones bridge and write its balancing condition(2)

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



2021 MARCH

MOVING CHARGES AND MAGNETISM

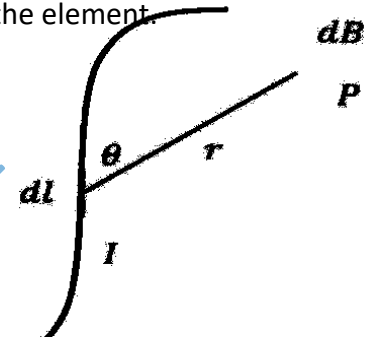
1. Current loop behaves as a -----(Magnetic dipole/Electric dipole)

Ans: Magnetic dipole

March 2023

2. State Biot – Savarts law and express it mathematically (March 2021, March 2023 , SAY 2024)

Ans: The Biot- Savarts law states that the magnetic field induction $d\vec{B}$ at a point due to a small current carrying element $(I d\vec{l})$ is directly proportional to the current I , the length of the element dl , the sine of the angle θ between the element and the position vector $\vec{r}$, and inversely proportional to the square of the distance r from the element.



$$dB \propto I \quad dB \propto \sin\theta \quad dB \propto dl \quad dB \propto \frac{1}{r^2}$$

$$dB \propto \frac{Idl \sin\theta}{r^2} \quad dB = k \frac{Idl \sin\theta}{r^2}$$

$$B = \int \frac{\mu_0}{4\pi} \frac{Idl \times \vec{r}}{r^3}$$

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

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

$\mu_0 = 4\pi \times 10^{-7} \text{ NA}^{-2}$

3. Obtain the expression for the magnetic field on the axis of a circular current loop.

(March 2023)

Or

4. A circular coil of radius R and N turns carries a current I . Show that the intensity of magnetic field at an axial point distant x from the centre is $B = \frac{\mu_0 N I R^2}{2(R^2 + x^2)^{3/2}}$

(March 2021)

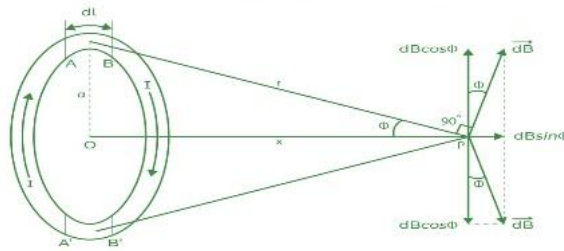
Or

State Biot – Savart's law and derive the expression for magnetic field on the axis of a circular coil carrying current

(March 2024, SAY 2024)

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

Magnetic field at the Axis of a Current carrying Circular Loop



$$= \frac{\mu_0}{4\pi} \frac{Idl}{r^2} \frac{a}{r}$$

$$\text{Effective field, } dB = \frac{\mu_0}{4\pi} \frac{Idl}{r^2} \sin \phi$$

$$\begin{aligned} &= \frac{\mu_0}{4\pi} \frac{I}{r^2} \frac{a}{r} \int dl \\ &= \frac{\mu_0}{4\pi} \frac{I}{r^2} \frac{a}{r} 2\pi a = \frac{\mu_0}{4\pi} \frac{2\pi a^2 I}{r^3} \\ &= \frac{\mu_0}{4\pi} \frac{2\pi a^2 I}{(a^2 + x^2)^{\frac{3}{2}}} \end{aligned}$$

$$B = \frac{\mu_0}{4\pi} \frac{2\pi a^2 I}{(a^2 + x^2)^{\frac{3}{2}}}$$

At the centre of the coil, $x = 0$, then $B = \frac{\mu_0 I}{2a}$

5. (a) Derive the expression for the torque on a rectangular current loop in a uniform magnetic field with the help of a diagram. **(March 2023)**

Or

A rectangular loop of area A and carrying a steady current I is placed in a uniform magnetic field. Derive the expression of torque $\vec{\tau} = \vec{m} \times \vec{B}$ acting on the loop. (March 2020)

Ans: Torque on a rectangular loop in a magnetic field

Let θ be the angle between the plane of the loop and the direction of the magnetic field. The axis of the coil is perpendicular to the magnetic field.

Force on side SP

$$F_{SP} = B l \sin \theta \text{ Acting upwards}$$

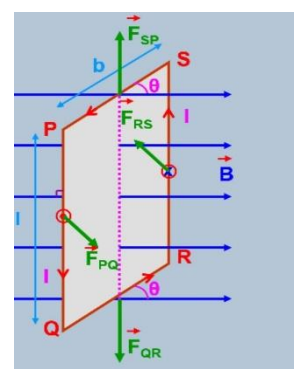
$$F_{QR} = B l \sin \theta \text{ Acting downwards}$$

They cancel each other

$$F_{PQ} = B l \sin \theta = B l \sin 90 = B l \text{ Acting perpendicular to the coil, outward}$$

$$F_{SR} = B l \sin \theta = B l \sin 90 = B l \text{ Acting perpendicular to the coil, inward}$$

These two forces result in a torque on the loop.



Torque = Force x perpendicular distance

$$= BIl \times b \cos \theta$$

$$= BIA \cos \theta$$

If the loop has N turns, total torque $\tau = NIAB \cos \theta = NMB \cos \theta$

Where M is the magnetic moment.

$$M = IA$$

(b) A 100 turn closely wound circular coil of radius 10cm carries a current of 3.2 A. What is the magnetic moment of the coil **March 2023, March 2024**

$$\begin{aligned} \text{Ans: magnetic moment, } m &= NIA \\ &= 100 \times 3.2 \times 3.14 \times (10 \times 10^{-2})^2 \\ &= 10.048 \text{ Am}^2 \end{aligned}$$

6. Derive the expression for force between two current carrying conductors. (March 2024)

$$\text{Ans: Field due to 1 on 2: } B_1 = \frac{\mu_0}{4\pi} \frac{2I_1}{r}$$

The force acting on I_2 due to this field,

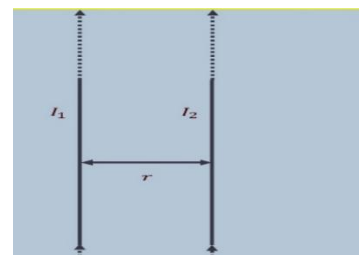
$$F = BIl \sin \theta, \theta = 90^\circ \quad \sin \theta = 1$$

$$= \frac{\mu_0}{4\pi} \frac{2I_1 I_2 l}{r}$$

The force acting on I_2 per unit length,

$$\frac{F}{l} = \frac{\mu_0}{4\pi} \frac{2I_1 I_2}{r}$$

Similarly, the force acting on I_1 due to I_2 can be written as, $\frac{F}{l} = \frac{\mu_0}{4\pi} \frac{2I_1 I_2}{r}$



7. Using Ampere's circuital law show that the intensity of magnetic field at an axial point near the centre of a current carrying solenoid is $B = \mu_0 nI$ **(March 2021)**

Or

Write down the equation for magnetic field inside a solenoid **(March 2022)**

Ans: Ampere circuital law – The line integral of magnetic field along any closed loop is equal to

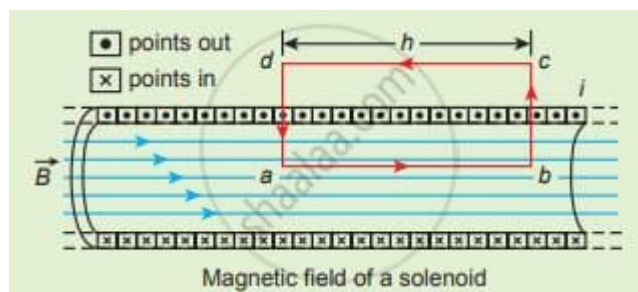
μ_0 times the total current enclosed by that loop

$$\oint B \cdot dl = \mu_0 I_{enc}$$

Infinitely long solenoid

$$\oint B \cdot dl = \mu_0 I_{enc}$$

$$\oint B \cdot dl = \int_a^b B \cdot dl + \int_b^c B \cdot dl + \int_c^d B \cdot dl + \int_d^a B \cdot dl = BI$$



$$BI = \mu_0 NI$$

$$B = \mu_0 nI$$

8. With a circuit diagram explain how a moving coil galvanometer can be converted to an ammeter (March 2021)

Ans: Galvanometer can be converted into ammeter by shunting it with a very small resistance.

Potential difference across the galvanometer and shunt resistance are equal.

$$\therefore (I - I_g)S = I_g G$$

Or

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

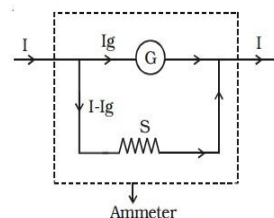


Fig 3.30 Conversion of galvanometer into an ammeter

9. Name the force experienced by a charge q moving through a uniform magnetic field with a velocity V . (March 2022)

Ans : Magnetic Lorentz force

10. The path of a charged particle entering parallel to uniform magnetic field will be

(a) circular (b) helical (c) straight line (d) None of these (March 2020)

Ans: © straight line

11. Ampere's circuital theorem helps to find the magnetic field in a region around a current carrying conductor.

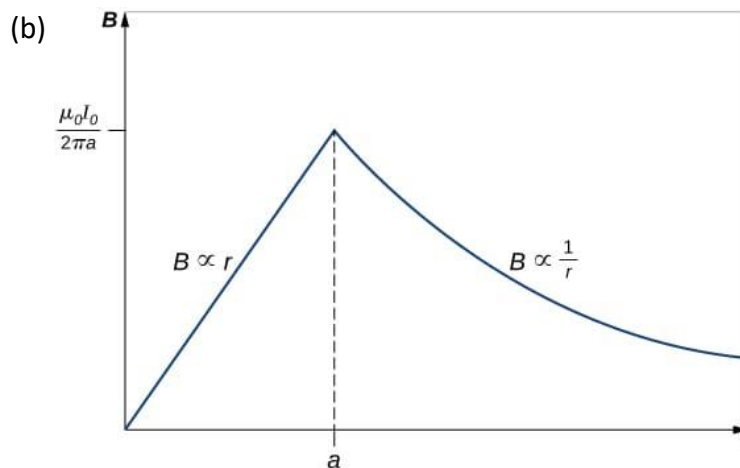
(a) Write the expression of Ampere's theorem.

(b) Draw a graph showing the variation of intensity of magnetic field with the distance from the axis of a current carrying conductor. (March 2020)

Ans: (a) Ampere circuital law – The line integral of magnetic field along any closed loop is equal to

μ_0 times the total current enclosed by that loop

$$\oint B \cdot dl = \mu_0 I_{enc}$$



12. Increasing the current sensitivity may not necessarily increase the voltage sensitivity of a galvanometer. Justify (March 2020)

Ans : Increasing the current sensitivity ($I_s = \frac{nBA}{k}$) of a galvanometer by increasing the number of turns (n) often increases the coil's resistance (R) proportionally. Since voltage sensitivity ($V_s = \frac{I_s}{R}$) depends on both current sensitivity and resistance, the increased resistance often negates the increase in current sensitivity, resulting in no net change or a decrease in voltage sensitivity.

13. What is a solenoid ?

(March 2022)

Ans : solenoid is along wire wound in the form of a helix.

14. Which law help us to find the magnetic field on the axis of a circular current loop?

(March 2022)

Ans : Biot – Savarts law.

15. Consider a tightly wound 100 turn coil of radius 10 cm, carrying current of 1 A .What is the magnitude of the magnetic field at the centre of the coil? (March 2022)

Ans : Magnetic field at the centre of a coil, $B = \frac{\mu_0 nI}{2R}$

$$B = \frac{4\pi \times 10^{-7} \times 10^2 \times 1}{2 \times 10 \times 10^{-2}} = 2\pi \times 10^{-4} \text{ T}$$

$$= 6.28 \times 10^{-4} \text{ T}$$

14. The direction of magnetic field around a current carrying conductor is given by ----- (March 2024)

Ans: Right hand thumb rule/ grip rule / right hand screw rule.

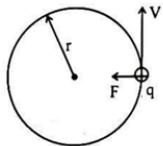
15. (a) What is Lorentz force?

(March 2025)

Ans: When a charged particle moves in a region where both electric field and magnetic field exists, then it experiences a net force called Lorentz force

$$\vec{F} = \vec{F}_e + \vec{F}_m = q\vec{E} + q(\vec{V} \times \vec{B})$$

(b) The figure shows the path of motion of a charged particle (+q) in a magnetic field:



(i) What will be the direction of magnetic field with respect to the velocity of the charged particle?

(ii) Show that the frequency of revolution of charged particle is independent of the radius of the path.

(iii) Is there any change in kinetic energy of the charged particle? Explain. (March 2025)

Ans : (i) Magnetic field is perpendicular to the direction of velocity or magnetic field is into the plane.

$$(ii) \quad qvB = \frac{mv^2}{r}$$

$$r = \frac{mv}{qB}$$

$$\text{Time period, } T = \frac{2\pi r}{v} = \frac{2\pi}{v} \left(\frac{mv}{qB} \right)$$

Frequency is the reciprocal of time period, $\therefore f = \frac{qB}{2\pi m}$

That is frequency is independent of the radius of the path.

(iii) No.

Magnetic force acts perpendicular to the velocity of the particle. This means that the magnetic force does not do any work on the particle. Therefore the speed of the particle and hence its kinetic energy does not change.

16. What is the working principle of a moving coil galvanometer?

(March 2025)

Ans: When a current carrying coil is placed in a magnetic field, it experiences a torque.

17. How will you convert a galvanometer into an ammeter?

(March 2025)

Ans: By connecting a low resistance (called shunt resistance) in parallel to the galvanometer.

18. An ammeter is always connected in series with the circuit . Why.?

(March 2025)

Ans: An ammeter is a low resistance instrument to measure the current flowing through it.

19. When a positively charged particle enters perpendicular to a uniform magnetic field the path of the charged particle will be

(SAY 2024)

(a) Elliptical (b) circular (c) Helical (d) straight

Ans: circular

20. An electron enters with a velocity of 10^5 m/s at right angles to a magnetic field of 19 T . Calculate the radius of the circular path described by the electron

(SAY 2024)

Ans : circular radius , $r = \frac{mv}{qB}$

$$r = \frac{9.1 \times 10^{-31} \times 10^5}{19 \times 1.6 \times 10^{-19}} = 2.993 \times 10^{-8} \text{ m.}$$

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Chapter 5

MAGNETISM AND MATTER

1. A magnetized needle in uniform magnetic field experiences a torque but no net force but an iron nail near a bar magnet, however experiences a force of attraction in addition to torque. Why?

(March 2020)

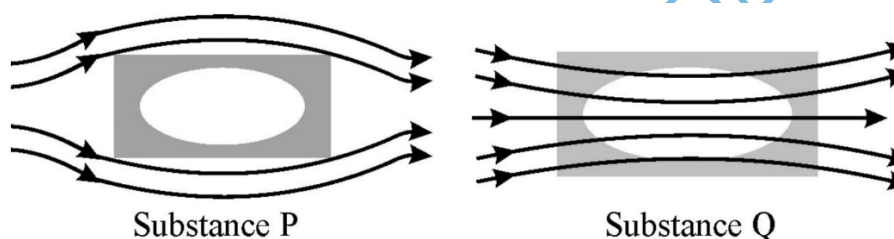
Ans : in uniform magnetic field a magnet experiences a torque only. But in non uniform magnetic field just like near a bar magnet it always experiences both torque as well as force

2. The expression $\sum \vec{B} \cdot d\vec{s} = 0$ is
- Gauss law in Electrostatics
 - Gauss law in magnetism
 - Ampere's circuital law
 - Lenz's law

(March 2021)

Ans: Gauss law in magnetism

3. The behaviour of magnetic field lines near two magnetic substances P and Q are shown below



- (a) From the figure identify paramagnetic substance.
- (b) Susceptibility of substance P is ----- (positive / negative)

(March 2021)

Ans: (a) substance Q

(b) negative

4. The temperature at which a ferromagnetic substance becomes paramagnetic substance is-----

- Cut-off temperature
- Absolute temperature
- Curie temperature

(March 2022)

Ans : Curie temperature

5. Current loop behaves as a -----

(Magnetic dipole / Electric dipole)

(March 2023)

Ans : Magnetic dipole

6. Define magnetization . Give its dimension

(March 2023)

Ans : Magnetisation is defined as the magnetic dipole moment per unit volume. $M = \frac{m_{net}}{V}$

Dimension [$L^{-1}A$]

7. Differentiate between paramagnetic , diamagnetic, and ferromagnetic substances

(March 2023)

Or

8. Compare dia, para, and ferromagnetic substance with suitable examples.

(March 2024)

Diamagnetic substances

1. These substances when placed in a magnetic field acquire feeble magnetism opposite to the direction of the magnetic field
2. These substances are feebly repelled by a magnet
3. Diamagnetic rod always align perpendicular to the applied field
4. The relative permeability of these substances are slightly less than 1
5. In non uniform magnetic field they move from stronger to weaker magnetic field
6. The susceptibility of these substances is small and negative
7. When they are placed in a magnetic field ,the magnetic field lines do not prefer to pass through them

Examples - Copper, Silver, Bismuth, Zinc , Diamond, Salt ,Water, Mercury, Nitrogen,Hydrogen, Gold

Paramagnetic substances

1. These substances when placed in a magnetic field acquire feeble magnetism in the direction of the magnetic field
 2. These substances are feebly attracted by a magnet
 3. Paramagnetic rod becomes parallel to the magnetic field
 4. In non uniform magnetic field they move from weaker to stronger magnetic field
 5. The relative permeability of these substances are slightly greater than 1
 6. The susceptibility of these substances is small and positive
 7. When they are placed in a magnetic field ,the magnetic field lines prefer to pass through them
- Examples -Aluminium, Sodium ,Potassium ,Platinum ,Manganese, Copper sulphate, Oxygen

Ferromagnetic substances

1 These substances when placed in a magnetic field are strongly magnetized in the direction of the magnetic field

2. These substances are strongly attracted by a magnet

3 Diamagnetic rod becomes parallel to the magnetic field

4. In non uniform magnetic field they move from weaker to stronger magnetic field rapidly
5. The relative permeability of these substances are very high
6. The susceptibility of these substances is large and positive

7. When they are placed in a magnetic field most of the magnetic field lines prefer to pass through them

Examples – Iron, Nickel, Cobalt, Magnetite or natural magnet

9. What is magnetic flux and how is it measured? (March 2024)

Ans: Magnetic flux is defined as the number of magnetic field lines passing through the surface.

$$\phi = \sum \vec{B} \cdot d\vec{S}$$

10. Relative permeability of a material $\mu_r < 1$, identify the magnetic material. Write the relation between relative permeability and magnetic susceptibility. (March 2025, March SAY 2024)

Ans: Diamagnetic substance

$$\mu_r = (1 + \chi)$$

11. a) State Gauss's law in magnetism. (March 2025, March SAY 2025)

(b) A short bar magnet placed with its axis at 30° with a uniform external magnetic field of 0.3 T experiences a torque of magnitude equal to 5×10^{-2} J. What is the magnitude of the magnetic moment of the magnet? (March 2025)

Ans : (a) The net magnetic flux through any closed surface is zero.

$$\phi_B = \sum_{all} B \cdot ds = 0$$

(b) $\tau = mB \sin \theta$

$$m = \frac{5 \times 10^{-2}}{0.3 \times \sin 30} = 0.33 \text{ Am}^2$$

12. Match the following. (SAY 2025)

A	B	C
Ferromagnetism	Magnetic susceptibility small and negative	Al, Ca
Para magnetism	Magnetic susceptibility is high and positive	Pb, Bi
Diamagnetism	Magnetic susceptibility small and positive	Fe, Co

Ans. Ferromagnetism - Magnetic susceptibility is high and positive- Fe, Co

Para magnetism - Magnetic susceptibility small and positive- Al, Ca

Diamagnetism- Magnetic susceptibility small and negative - Pb, Bi

13. Magnetic susceptibility of a diamagnetic material is-----

(positive/negative/zero) (March SAY 2024)

Ans: negative

14. A magnetic dipole is free to rotate in a uniform magnetic field.

- (i) Write the expression for potential energy stored in the dipole
- (ii) What are the conditions for the potential energy to be maximum and minimum?
(March SAY 2024)

Ans: (i) $PE = -mB\cos\theta$

(ii) $\theta = 0$, PE minimum

$\theta = 180$, PE maximum

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Chapter 6

ELECTROMAGNETIC INDUCTION

1) Current in a circuit falls from 5.0 A to 0.0 A in 0.1 s. If an average emf of 200 V is induced, Calculate the self inductance of the circuit? **(March 2021)**

Ans:

$$\epsilon = L \frac{dI}{dt}$$

$$200 = \frac{L(5-0)}{0.1}$$

$$L = 4 \text{ H}$$

2) a) Lenz's law is in accordance with law of conservation of _____

b) A jet plane is travelling towards west at a speed of 1800 Km/hr. What is the voltage difference developed between the ends of the wing having a span of 25m, if the vertical component of earth's magnetic field at the location is $2.9 \times 10^{-4} \text{ T}$. **(March 2021)**

Ans:

a) Energy

$$\text{b) } \epsilon = Blv = 2.9 \times 10^{-4} \times 25 \times 1800 \times \frac{5}{18}$$

$$\epsilon = 3.625 \text{ V}$$

3) State Faraday's laws of electromagnetic induction? **(SAY 2021), (March 2022), (March 2023)**

Ans:

(i) Whenever the magnetic flux linked with the circuit changes, an emf is induced in the circuit. The induced emf lasts as long as change in magnetic flux exists.

(ii) The magnitude of induced emf is equal to rate of change of magnetic flux linked with the circuit.

$$\epsilon = \frac{d\phi}{dt}$$

4) State the principle of an ac generator and explain the working with the help of a labelled diagram. Obtain the equation for the instantaneous emf induced in an ac generator.

(SAY 2021), (March 2023), (SAY 2023), (March 2025)

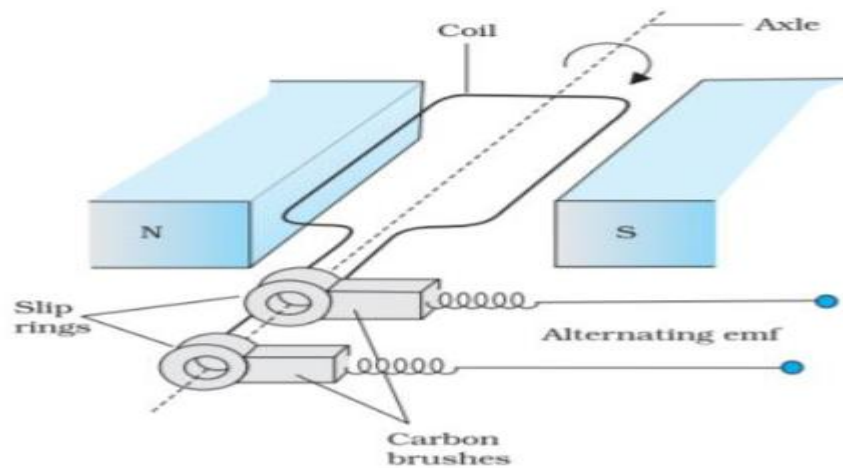
Ans:

Principle:

Ac generator works on the principle of Electromagnetic induction. When the magnetic flux linked with the coil changes, an emf is induced in the coil.

Working:

An ac generator converts mechanical energy into electrical energy. It consists of a coil which is mechanically rotated in a uniform magnetic field by some external means (hydroelectric, wind, geothermal etc). The rotation of the coil causes the magnetic flux through it to change, so an emf is induced in the coil.



The magnetic flux at any time t is $\phi = BA \cos\theta = BA \cos\omega t$

From Faraday's law, the induced emf for a rotating coil of N turns is

$$\varepsilon = \frac{-Nd\phi}{dt}$$

$$\varepsilon = \frac{-Nd(BA\omega \sin\omega t)}{dt} = NBA \sin \omega t$$

Induced emf, $\varepsilon = \varepsilon_0 \sin \omega t$

where $\varepsilon_0 = NBA$ is the maximum value of the emf.

5) Lenz's law gives the polarity of induced e.m.f in a conductor in a clear and concise fashion.

(a) Lenz's law is a consequence of the law of conservation of _____

(b) State Lenz's law.

(c) Of which of the following, e.m.f induced in a coil does not depend on

(i) number of turns in the coil (ii) resistance of the coil (iii) rate of change of magnetic flux **(SAY 2022)**

Ans:

(a) energy

(b) According to Lenz's law, the direction of induced e.m.f or induced current is such that it opposes the change in magnetic flux that produced it.

(c) (ii) resistance of the coil

6) The direction of induced emf in a conductor placed in a varying magnetic field is given by :

- (a) Lenz's law (b) Newton's law (c) Maxwell's law (d) Faraday's law **(SAY 2023)**

Ans : (a) Lenz's law

7) _____ is the electromagnetic analogue of mass in mechanics. **(SAY 2023)**

Ans: Self inductance

8) What is self induction and derive the expression for self inductance of a solenoid?

(March 2024)

Ans :

Self induction is the property of the circuit by virtue of which it opposes the growth or decay of current in it.

The magnetic flux through one turn of the solenoid is given by,

$$\phi = BA = (\mu_0 nI)A$$

The magnetic flux linkage in the solenoid with a total number of $N(N=nl)$ turns is given by,

$$\Phi = N (\mu_0 nI)A = nl (\mu_0 nI)A = \mu_0 n^2 IAl$$

$$\text{but } \Phi = LI$$

$$LI = \mu_0 n^2 IAl$$

$$L = \mu_0 n^2 Al$$

9) Choose the correct alternative:

Self inductance _____ (increases / decreases) when the number of turns of the coil is double. **(SAY 2024)**

Ans: increases

10) An e.m.f induced in a coil due to change of magnetic flux in the coil.

a) This phenomenon is called _____

b) Derive an expression for energy stored in an inductor? **(SAY 2024)**

Ans:

(a) Electromagnetic Induction

(b) Let I be the current flowing through an inductor L at any instant during the growth of current from 0 to I . Then $\Phi = LI$

Let an infinitesimal charge dq be driven through the inductor. So the work done by external voltage is given by,

$$dw = \epsilon dq = L \frac{dI}{dt} dq = LI dI$$

The total work done for complete growth ,

$$W = \int LI dI = \frac{1}{2} LI^2$$

This work is stored as energy in magnetic field produced by the inductor. Thus energy stored in an inductor ,

$$U = \frac{1}{2} LI^2$$

11) Which of the following gives the polarity of induced emf?

- (i) Biot- Savart's law (ii) Lenz's law
(iii) Ampere's circuital law (iv) Fleming's right hand rule **(March 2025) ,(SAY 2025)**

Ans: (ii) Lenz's law

12) Faraday found that electric current can be generated with the help of magnetic field.

- a) State the laws of electromagnetic induction?
b) If the magnetic field linked with a coil perpendicular to its plane

$$\phi = (3t^2 + 5t + 2) \text{ Wb}$$

Find the induced emf?

(SAY 2025)

Ans:

(a) (i) Whenever the magnetic flux linked with the circuit changes, an emf is induced in the circuit. The induced emf lasts as long as change in magnetic flux exists.

(ii) The magnitude of induced emf is equal to rate of change of magnetic flux linked with the circuit.

$$\epsilon = \frac{d\phi}{dt}$$

(b)

$$\epsilon = \frac{d\phi}{dt}$$

$$\epsilon = d \frac{(3t^2 + 5t + 2)}{dt} = (6t + 5) \text{ V}$$

Chapter 7

ALTERNATING CURRENTS

1. The instantaneous current and voltage of an a.c circuit are given by $i = 10 \sin(314t)$ Ampere and $v = 50 \sin(314t + \frac{\pi}{2})$ Volt. What is the (a) phase difference between voltage and current? (b) power dissipation in the circuit ? **(March 2025)**

Ans: a) $\frac{\pi}{2}$

$$b) P = V_{rms} I_{rms} \cos \phi = V_{rms} I_{rms} \cos \cos \frac{\pi}{2} = 0$$

2. With the help of a phasor diagram, find the impedance of a series LCR circuit.

- (b) A series LCR circuit is connected to an ac source of variable frequency as shown in fig below. At what frequency the impedance of this circuit will be minimum? **(March 2025)**

The resultant voltage is

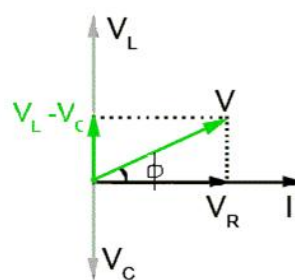
$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$

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

$$\frac{V}{I} = Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Impedance $Z = \sqrt{R^2 + (X_L - X_C)^2}$,

(b) $f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2 \times 3.14 \times \sqrt{4.5 \times 72 \times 10^{-6}}} = 8.85 \text{ Hz}$



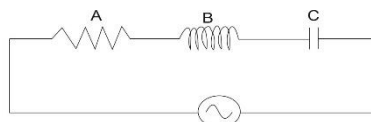
Phasor Diagram

3. The household line voltage of ac measured is 220V, calculate its peak voltage. **(March 2024)**

Ans: $V_m = V_{rms} \times \sqrt{2} = 220 \times 1.414 = 311 \text{ v}$

4. (a) Write the expression for instantaneous emf of a.c.

- (b) Identify A, B and C in figure.



- (c) Draw the phasor diagram of the above circuit and write the expression for impedance in the circuit, then mention the terms. **(March 2024)**

Ans:

(a) $V = V_0 \sin \omega t$

(b) A – Resistance, B – Inductor ,C – Capacitor

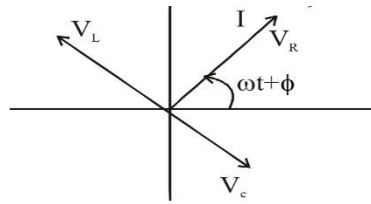
(c) Impedance

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

R- Resistance

X_L – Inductive reactance

X_C – Capacitive reactance



5. Obtain the expression for the current flowing through a resistor when an a.c voltage is applied to it.

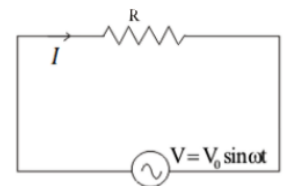
(MARCH 2024)

Ans :

$$V = V_0 \sin \omega t$$

then

$$\text{Current } I = \frac{V}{R} = \frac{V_0 \sin \omega t}{R} \text{ or } I = I_0 \sin \omega t$$



6. (a)State the principle of a transformer

(b)Explain the working of a transformer

(c)Differentiate between step up transformer and step down transformer

(March 2023)

Ans:

(a) Mutual Induction between two circuits is the property of the circuits by virtue of which a change of current in one of them induces an instantaneous e.m.f. in the other.

(b) When an input AC voltage is applied to the primary, the alternating current in it establishes a changing magnetic field in the iron core. Since the magnetic field is changing, the flux through the primary and secondary is also changing, and hence an emf is induced in both coils

Flux through primary , $\phi_1 = N_1 BA$

Flux through secondary, $\phi_2 = N_2 BA$

$$\frac{\phi_2}{\phi_1} = \frac{N_2}{N_1} \quad \phi_2 = \phi_1 \times \frac{N_2}{N_1}$$

differentiating

$$\frac{d\phi_2}{dt} = \frac{d\phi_1}{dt} \times \frac{N_2}{N_1}$$

$$V_2 = V_1 \times \frac{N_2}{N_1} \quad \text{or} \quad \frac{V_2}{V_1} = \frac{N_2}{N_1}$$

(c)

Step-up Transformer	Step-down Transformer
It increases the voltage	It decreases the voltage.
It decreases the current strength.	It increases the current strength.
The number of turns in secondary coil is greater than that of primary coil.	The number of turns in primary coil is greater than that of secondary coil.
The wire of primary coil is thicker than that of the secondary coil.	The wire of the secondary coil is thicker than that of the primary coil.

7. In purely inductive or capacitive circuit, power factor ($\cos\phi$) is ----- (March 2022)

- (a) 0 (b) 1 (c) -1

Ans : 0

8. State the principle of working of a transformer

(b) Explain briefly any three energy losses in a transformer. (March 2022)

Ans :

(a) Mutual Induction

(b) 1. Copper loss: The wire used to make the coils has a finite resistance. When current flows through these wires energy is dissipated as heat. (Joules heat loss)

2. Eddy current loss: The changing magnetic flux induces a current in the iron core which leads to the heating of the core.

3. Magnetic flux leakage: All the magnetic flux linked with the primary coil does not pass through the secondary coil. This is due to air gaps in the core.

9. A light bulb of resistance 484Ω is connected with 220V ac supply. Find the peak value of current through the bulb. (March 2021)

$$I_0 = \frac{V_0}{R} = \frac{V_{RMS}\sqrt{2}}{R} = \frac{220 \times \sqrt{2}}{484} = 0.64A$$

10. Prove that when an alternating voltage is applied to an inductor, the current through it lags behind the voltage by a phase angle $\frac{\pi}{2}$. (March 2021)

$$V = V_0 \sin \omega t$$

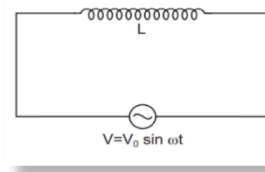
$$\text{we have } V = L \frac{dI}{dt}$$

$$dI = \frac{V}{L} dt = \frac{V_0 \sin \omega t}{L} dt$$

$$I = \int \frac{V_0 \sin \omega t}{L} dt = \frac{V_0}{L} \int \sin \omega t dt =$$

$$I = \frac{V_0}{L\omega} \sin \left(\omega t - \frac{\pi}{2} \right)$$

$$I = I_0 \sin \left(\omega t - \frac{\pi}{2} \right)$$



$$\frac{V_0}{L} \left(-\frac{\cos \omega t}{\omega} \right)$$

11. a) Working principle of transformer is

(i) mutual induction (ii) motional emf (iii) resonance (iv) LC oscillations

(b) Write any one difference between step-up and step-down transformer.

(c) A power transmission line feeds input power at 3300 V to a step-down transformer with its primary windings having 6000 turns. What should be the number of turns in the secondary in order to get output power at 220 V ?
(March 2021)

Ans:

(a) Mutual Induction

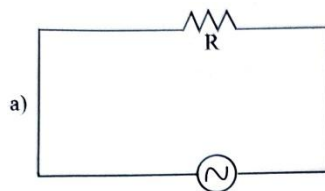
(b) Step up transformer increases the voltage. Step down transformer decreases the voltage.

$$(c) \quad \frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$\frac{220}{3300} = \frac{N_s}{6000}, \quad N_s = 400$$

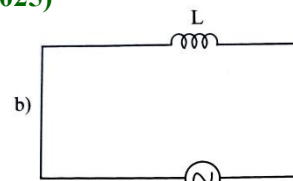
12. Two electrical circuits having AC sources of variable frequency are shown in the figure.

If the frequency of the applied AC source increase, how will the current flowing in these circuits be affected ?
(SAY 2025)



(a) No

change. R is independent of frequency



$$(b) \quad I = \frac{V_0}{L\omega} = \frac{V_0}{L \times 2\pi f}, \text{ or } I \propto \frac{1}{f}. \text{ Current decreases with increase of frequency}$$

13. A transformer is working on the principle of mutual induction.

a) What are the two types of transformer ?

b) Write any two energy losses in a transformer

c) A transformer has 1000 primary turns and 500 secondary turns. If the primary voltage is 220V, calculate secondary voltage **(SAY 2025)**

Ans:

a) Step up transformer and step down transformer

b) Joules heat loss (copper loss) and Eddy current loss

c)
$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

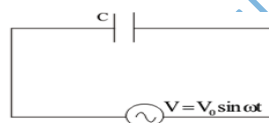
$$\frac{V_s}{220} = \frac{500}{1000} \quad V_s = \frac{500 \times 220}{1000} = 110V$$

14. In a step up transformer, the ratio of number of turns of primary to secondary is 1:10 and primary voltage is 230 volt. If the load current is 2A, find the current in the primary. **(SAY 2024)**

$$\frac{N_s}{N_p} = \frac{I_p}{I_s}$$

$$\frac{10}{1} = \frac{I_p}{2} \quad I_p = \frac{2 \times 10}{1} = 20 A$$

15. (a) An ac voltage $\epsilon = \epsilon_0 \sin \omega t$ is applied across a capacitor of capacitance C. Derive an expression for instantaneous current I.



b) A capacitor blocks dc but allows ac. Explain.

(c) At resonance, what is the value of power factor in the case of LCR series **(SAY 2024)**

Ans:

(a) $V = V_0 \sin \omega t$

we have $I = \frac{dq}{dt} = \frac{d}{dt}(Cv)$

$$= C \frac{dV}{dt}$$

$$= C \frac{d}{dt}(V_0 \sin \omega t)$$

$$= C V_0 \omega \cos \omega t$$

$$= \frac{V_0}{1/C\omega} \cos \omega t$$

$$I = \frac{V_0}{1/C\omega} \sin \left(\omega t + \frac{\pi}{2} \right)$$

$$I = \frac{V_0}{X_C} \sin \left(\omega t + \frac{\pi}{2} \right) \quad \text{OR} \quad I = I_0 \sin \left(\omega t + \frac{\pi}{2} \right)$$

(b) Capacitor offers infinite resistance to dc current.

$$\text{we have, } X_C = \frac{1}{2\pi f c}$$

$$\text{for dc, } f=0. \text{ so } X_C = \infty$$

Capacitor does not allow dc to pass through it. Capacitor blocks dc

(c) Power factor = 1

16. The phase difference between current and voltage in an ac circuit having inductor only (SAY 2022)

- (a) 0 (b) π (c) $\frac{\pi}{2}$ (d) $\frac{\pi}{4}$.

$$\text{Ans : } \frac{\pi}{2}$$

17. Instantaneous voltage applied to an ac circuit is $V_m = 220 \sin 100\pi t$. The frequency of ac is ----- (SAY 2022)

$$\text{Ans : } 50 \text{ Hz}$$

18.1 (a) The power factor of an LCR series circuit is unity. The impedance of the circuit is

- (i) Capacitive (ii) Inductive (iii) Resistive

(b) Write down the condition for resonance to occur in LCR series circuit. . (SAY 2022)

Ans :

(a) Resistive

$$\cos \phi = \frac{R}{Z} \quad 1 = \frac{R}{Z} \quad \text{or } R = Z$$

(b) $X_L = X_C$

19. When a capacitor is connected to an ac source, it limits or regulates the current, but does not completely prevent the flow of charge.

(a) Draw a circuit diagram consisting of a capacitor and an ac source

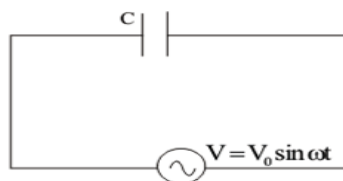
(b) Show that in an ac circuit containing capacitor only the current leads the voltage

(c) If the frequency of ac is increased, the capacitive reactance of the circuit

- (i) increases (ii) decreases (SAY 2022)

Ans:

(a)



(b) $V = V_0 \sin \omega t$

$$I = \frac{dq}{dt} = \frac{d}{dt}(Cv)$$

$$= C \frac{dV}{dt} = C \frac{d}{dt}(V_0 \sin \omega t) = C V_0 \omega \cos \omega t = \frac{V_0}{1/C\omega} \cos \omega t$$

$$I = \frac{V_0}{1/C\omega} \sin \left(\omega t + \frac{\pi}{2} \right)$$

$$I = \frac{V_0}{X_C} \sin \left(\omega t + \frac{\pi}{2} \right)$$

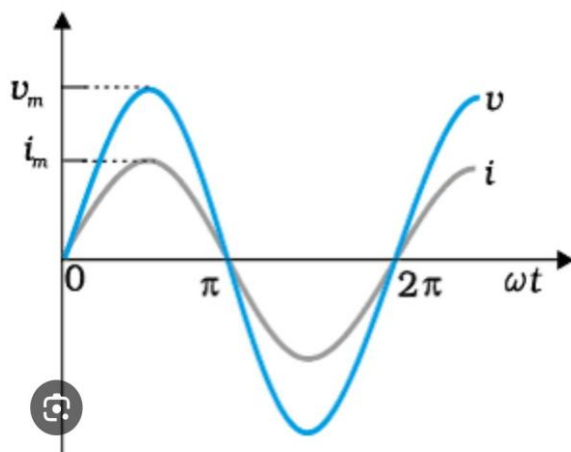
OR $I = I_0 \sin \left(\omega t + \frac{\pi}{2} \right)$

(c) decreases

$$, X_C = \frac{1}{2\pi f C}$$

When f increases, X_C decreases

20. An alternating voltage is applied across a Resistance R . Draw the graphical variation of current and voltage with respect to ωt (SAY 2021)

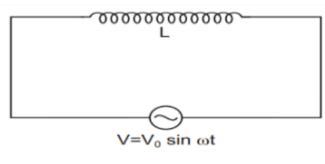


21. An alternating voltage is connected across an inductor . (SAY 2021)

(a) Draw a circuit diagram.

(b) Derive the expression for the instantaneous current Ans:

(a)



(b) $V = V_0 \sin \omega t$

we have $V = L \frac{dI}{dt}$

$$dI = \frac{V}{L} dt = \frac{V_0 \sin \omega t}{L} dt$$

$$I = \int \frac{V_0 \sin \omega t}{L} dt = \frac{V_0}{L} \int \sin \omega t dt = \frac{V_0}{L} \left(-\frac{\cos \omega t}{\omega} \right)$$

$$I = \frac{V_0}{L\omega} \sin \left(\omega t - \frac{\pi}{2} \right)$$

$$I = I_0 \sin \left(\omega t - \frac{\pi}{2} \right)$$

22. State the working principle of a transformer. Derive the equation for the efficiency of a

Transformer. Mention the various energy losses in a Transformer. . (SAY 2021)

Ans : Mutual Induction

$$\text{Efficiency } \eta = \frac{\text{output power}}{\text{input power}} = \frac{V_s I_s}{V_p I_p}$$

Energy losses

1. Joules heat loss (copper loss) 2. Eddy current loss 3. Magnetic flux leakage
4. Hysteresis loss

APT KOZHIKODE

Chapter 8

ELECTROMAGNETIC WAVES

1. Frequencies of gamma rays (ν_1), ultraviolet rays (ν_2), and X-rays (ν_3).

Ans: (ii) $\nu_1 > \nu_3 > \nu_2$

2. (a) Which electromagnetic wave is used in cellular phones to transmit voice communication?
(b) In the process of charging of a parallel plate capacitor, the current produced between the plates of the capacitor is

(i) $\mu_0 \frac{d\Phi_E}{dt}$

(ii) $\frac{1}{\mu_0} \frac{d\Phi_E}{dt}$

(iii) $\epsilon_0 \frac{d\Phi_E}{dt}$

(iv) $\frac{1}{\epsilon_0} \frac{d\Phi_E}{dt}$

where symbols have their usual meanings.

Ans: a) Radio waves

b) $\epsilon_0 \frac{d\Phi_E}{dt}$

[2025 March]

3. -----rays are used as a diagnostic tool in medicine and as a treatment for certain forms of cancer.

Ans: Xrays

4. The magnetic field in a plane electromagnetic wave is given by

$$B = B_o \sin(Kx + \omega t)$$

- a) In which direction does the above wave propagate?
- b) Write an expression for the electric field of the above electromagnetic wave.

Ans: a) in negative x direction

b) $E = E_o \sin(Kx + \omega t)$

[2025 SAY]

5. Briefly explain the electromagnetic spectrum

Ans: The electromagnetic spectrum is the complete range of all types of electromagnetic waves arranged according to their wavelength or frequency.

Radio waves – Used in communication (TV, FM, mobile signals)

Microwaves – Used in ovens and radar

Infrared (IR) – Heat radiation

Visible light – The only part our eyes can see

Ultraviolet (UV) – used in for eye surgery

X-rays – diagnostic tool in medicine

Gamma rays – cancer treatment

[2024 March]

6. Which of the following electromagnetic waves has maximum frequency ?

- (a) Radio waves (b) X – rays
(c) Visible rays (d) Gamma rays

Ans: d) Gamma rays.

7. (a) What is Maxwell's displacement current ?

(b) Write an expression for the speed of electromagnetic waves in free space.

Ans: a) it is a special current produced due to change in electric field in free space.

b) $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$

[2024 SAY]

8. An accelerating charge produces ----- waves.

- (a) electric (b) magnetic
(c) electromagnetic (d) None of these

Ans : (c) electromagnetic

9. How Maxwell modified Ampere's law ?

Ans : Ampere's law, $\oint B \cdot dl = \mu_0 I$

When a capacitor is charged using AC no charge is passed through capacitor, still AC pass through it. Maxwell argued that a changing electric field between the capacitor plates must induce a magnetic field. This will happen, when there is a current associated with the changing electric field in the non-conductor between the plates. Maxwell

called this current as the displacement current and extended Ampere's law by introducing the displacement current into the electric current term. Displacement current is given by $I_d = \epsilon_0 \frac{d\Phi_E}{dt}$

Ampere's circuital theorem in corrected form, $\oint B \cdot dl = \mu_0 I + \epsilon_0 \frac{d\Phi_E}{dt}$

[2023 March]

10. Which electromagnetic wave is used for the following purposes :

- (a) Radar system used in aircraft navigation.
- (b) Remote switches of household electronic systems.
- (c) LASIK eye surgery
- (d) Used in medicine to destroy cancer cells.

Ans: a) Microwaves, b) Infrared waves, c) ultraviolet rays, c) Gamma rays [2023 SAY]

11. Relation between velocity of light c , permeability of free space ϵ_0 , and permittivity of free space μ_0 : is given by

Ans.) $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$

12. Infra-red waves are also referred to as heat waves. Why ?

Ans: When infrared radiation falls on a body, it is strongly absorbed.

The absorbed energy increases the vibrations of atoms and molecules in the material. This increases the temperature of the body. [2022 March]

13. The frequency of an electromagnetic wave in free space is 5×10^{19} Hz. What will be the wave length of the electromagnetic wave ?

Ans: 6×10^{-12} m

14. Arrange the given electromagnetic waves in the decreasing order of wave lengths, microwaves, visible light, Gamma rays, radio waves.

Ans: Radio waves, microwaves, visible light, Gamma rays [2022 SAY]

15. The electromagnetic waves used in LASIK eye surgery is

- (i) micro waves (ii) ultraviolet rays
- (iii) infra-red waves (iv) gamma rays

Ans: Ultraviolet rays [2021 March]

16. Match the following

- (1) Ultraviolet light– Cancer cell killing
- (2) Gamma– Kill bacteria and germs
- (3) Infrared –Communications
- (4) Radio waves –Remote control
- (5) X-rays– Aircraft navigation
- (6) Microwave– Ionization tubes

Ans. (1) Ultraviolet light — Kill bacteria and germs

- (2) Gamma rays — Cancer cell killing
- (3) Infrared — Remote control
- (4) Radio waves — Communications
- (5) X-rays — Ionization tubes
- (6) Microwave — Aircraft navigation

[2021 SAY]

RAY OPTICS AND OPTICAL INSTRUMENTS

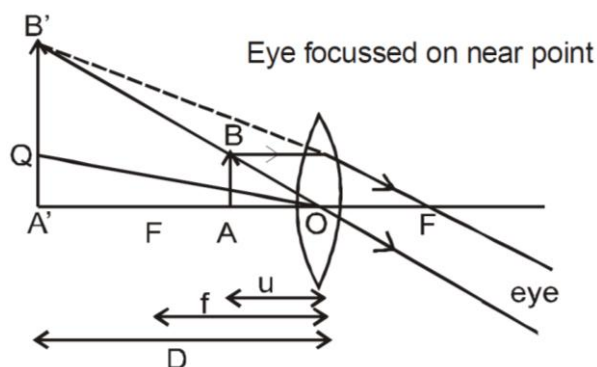
1. Two thin lenses of power +4 D and -2 D are in contact. The focal length of the combination is _____.

Ans: Total power of the combination $P = P_1 + P_2 = 2D$

$$\text{Focal length } f = \frac{1}{P} = 0.5 \text{ m}$$

2. (a) Draw a ray diagram of simple microscope showing image formation at the least distance of distinct vision (D).
 (b) The magnification of a compound microscope is 20. The focal length of the eyepiece is 5 cm and the image is formed at the near point (25 cm). Find the magnification of objective lens.

Ans: a)



b) Total magnification of compound microscope, 20

Focal length of eyepiece $f_e = 5 \text{ cm}$

Least distance of distinct vision, $D = 25 \text{ cm}$

$$m = m_o \times m_e$$

$$m_o = \frac{m}{m_e} = \frac{20}{6} = 3.33$$

[2025 March]

3. It is possible to observe total internal reflection when a ray of light travels from

- a) air to water
- b) air to glass
- c) water to glass
- d) glass to water

Ans: d) glass to water

4. Derive the equation for the refractive index of the material of a prism in terms of angle of prism A and angle of minimum deviation d.

Ans; refer question 11

5. When a ray of light obliquely enters another medium, it undergoes changes at the interface of the two media.

a) Refraction at a spherical surface can be explained using the relation

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

Using this derive lens maker's formula.

b) Double convex lenses are manufactured from glass of refractive index 1.55 with both faces having the same radius. What is the radius of curvature if the focal length is 20 cm?

Ans: a) Refer question 8

b)

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

$$\frac{1}{20} = (1.55 - 1) \left[\frac{1}{R} - \frac{1}{-R} \right]$$

$$\frac{1}{20} = 0.55 \frac{2}{R}$$

$$R = 22 \text{ cm}$$

(2025 SAY)

6. The SI unit of power of lens

(a) N (b) J (c) W (d) D

Ans: d) D

7. (a) State Snell's law of refraction.

(b) Explain critical angle and total internal reflection.

(2024 March)

Ans: a) The ratio of the sine of the angle of incidence to the sine of the angle of refraction for a pair of media is a constant.

$$\frac{\sin i}{\sin r} = n_{21}$$

where n_{21} relative refractive index of the medium 2 with respect to the medium 1

b) Critical angle for the given pair of media (i_c) is the angle of incidence when angle of refraction is 90° , when light ray is passing from denser medium to rarer medium.

When a ray of light enters from a denser medium to a rarer medium inclined at an angle slight greater than critical angle, all the light rays will reflect back to the same medium.

This phenomenon is called total internal reflection.

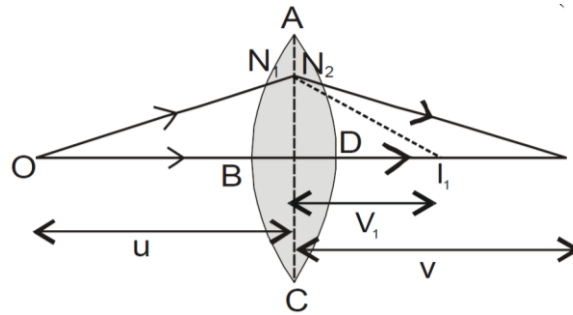
8. (a) Derive lens maker's formula.

(2023 March)

(b) Draw the image formation in a simple microscope.

(c) Write the value of least distance of distinct vision.

Ans: a)



O is a point object placed at a distance u from B. After refraction at the face ABC, an image I_1 would be formed at distant V_1 from B such that,

$$-\frac{n_1}{u} + \frac{n_1}{v_1} = \frac{(n_2 - n_1)}{R_1}$$

Image I_1 act as a virtual object for refraction at the face ADC and the final image is formed at a distance V from D such that,

$$-\frac{n_1}{v} + \frac{n_2}{-v_1} = \frac{(n_2 - n_1)}{-R_2}$$

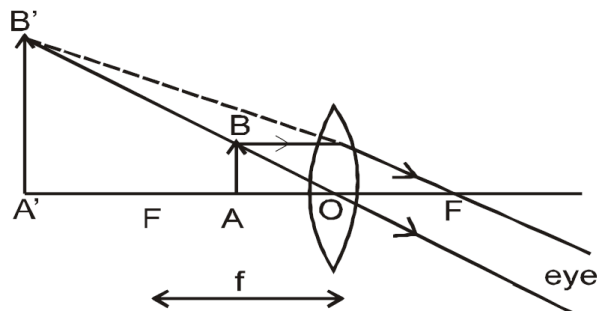
Adding these equations

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

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

When $u \rightarrow \infty$, $v \rightarrow f$

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



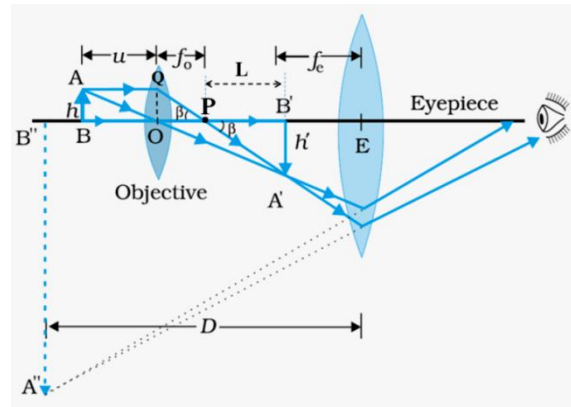
(b)

(c) 25 cm

[2024 March]

9. (a) Draw the ray diagram of a compound microscope .
(b) Obtain an expression for the magnification produced by a compound microscope.

Ans: (a)



(b) From $\triangle POQ$

$$\tan \beta \cong \beta = \frac{OQ}{OP}$$

or $\beta = \frac{h}{f_o}$

From $\triangle A'B'P$

$$\tan \beta \cong \beta = \frac{A'B'}{B'P}$$

$$\beta = -\frac{h'}{L}$$

comparing above equations

$$\frac{h'}{h} = m_o = -\frac{L}{f_o}$$

The eye piece acts as a simple microscope, so the magnification m_e due to it, when the final image is formed at the near point is (by equation 34)

$$m_e = \left(1 + \frac{D}{f_e}\right)$$

So the magnification of the compound microscope, when the image formed at the near point is

$$m = m_o \times m_e$$

$$m = -\frac{L}{f_o} \left(1 + \frac{D}{f_e}\right)$$

10. (a) Using the equation for refraction at a spherical surface

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

where, n_1 – refractive index of rarer medium, n_2 – refractive index of denser medium, derive Lens maker's formula.

(b) A convex lens of refractive index 1.5 is immersed in a medium of refractive index 1.65. Will the lens now act as converging or diverging ? Explain

Ans: (a) Refer question 8

- (b) Refractive index of lens, $n_l=1.5$
 Refractive index of medium, $n_m=1.65$

$$\frac{1}{f} = \left(\frac{n_l}{n_m} - 1 \right) \left[\frac{1}{R_1} - \frac{1}{R_2} \right]$$

$$\frac{n_l}{n_m} = \frac{1.5}{1.65} < 1$$

So $\frac{n_l}{n_m} - 1$ become neative

So the focal length become negative and the lens behaves like a **diverging lens**.

[2024 SAY]

11. Derive the expression for the refractive index of a prism with the help of a diagram. (2021 March)

Ans:

In the quadrilateral AQNR, two of the angles are right angles.

So $A + QNR = 180^\circ$

from the triangle ΔQNR ,

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

Comparing these equations

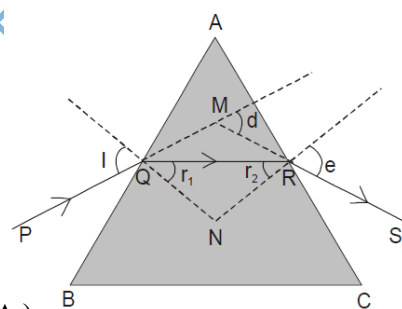
$$r_1 + r_2 = A$$

d is an exterior angle ,

so $d = MQR + MRQ$

$$d = (i - r_1) + (e - r_2)$$

$$d = i + e - A \quad (\text{Since } r_1 + r_2 = A)$$



At the minimum deviation D_m ,

$$d = D_m, \quad i = e \quad \text{and} \quad r_1 = r_2.$$

So

$$r = \frac{A}{2}$$

$$i = \frac{D_m + A}{2}$$

From Snell's law the refractive index of prism

$$n_{21} = \frac{\sin i}{\sin r}$$

$$n_{21} = \frac{\sin \left(\frac{D_m + A}{2} \right)}{\sin \left(\frac{A}{2} \right)}$$

12. The radii of curvature of the faces of a double convex lens are 10 cm and 15 cm. Its focal length is 12 cm. What is the refractive index of glass? (2022 March)

Ans;

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

$$\frac{1}{12} = (n_{21} - 1) \left[\frac{1}{10} - \frac{1}{-15} \right]$$

$$n_{21} - 1 = 0.5$$

$$n_{21} = 1.5$$

[2023 March]

13. Draw a diagram showing the ray of light passing through a glass prism. Derive an expression for refractive index. (refer ***)
14. A Telescope is used to provide angular magnification of distant objects :
- Find the magnifying power of a telescope.
 - If f_o is the focal length of the object and f_e that of eye piece, what is the length of the Telescope tube ?
 - Write any two advantages of reflecting telescope over refracting telescope. 2
15. An object is placed at 10 cm in front of a concave mirror of radius of curvature 15 cm. Find magnification

Ans: Object distance, $u = -10$ cm
 Radius of curvature, $R = 15$ cm
 Focal length $f = \frac{R}{2} = 7.5$ cm

mirror formula, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$$v = \frac{uf}{u - f}$$

$$v = \frac{-10 \times -7.5}{-10 - (-7.5)} = -30 \text{ cm}$$

Magnification,

$$m = -\frac{v}{u} = -\frac{-30}{-10} = -3$$

[2023 SAY]

16. Optical fibres make use the phenomenon -----
- Ans:** Total Internal Reflection
17. (i) If $f = 0.5$ m, for a glass lens, what is the power of the lens?
 (ii) The radii of curvature of the faces of a double convex lens are 10 cm and 15 cm. Its focal length is 12 cm. What is the refractive index of glass?
- Ans:** $P = \frac{1}{f} = \frac{1}{0.5} = 2D$
18. (i) State Laws of refraction.
 (ii) Obtain a relation for the total deviation produced for a ray incident on a prism with the help of a ray diagram.

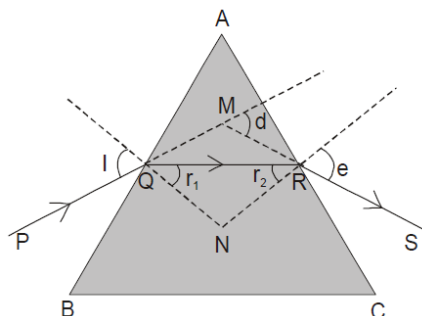
Ans: (i)

First law: The incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane.

Second law (Snell's law): The ratio of the sine of the angle of incidence to the sine of angle of refraction for a pair of media is constant.

$$\frac{\sin i}{\sin r} = n_{21}$$

(ii)



In the quadrilateral AQNR, two of the angles are right angles.

So $A + QNR = 180^\circ$

from the triangle ΔQNR ,

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

Comparing these equations

$$r_1 + r_2 = A$$

d is an exterior angle ,

$$\text{so } d = MQR + MRQ$$

$$d = (i - r_1) + (e - r_2)$$

$$d = i + e - A$$

[2022 March]

19. You might have noticed while moving in a bus or a car during hot summer day a distant patch of road. Surface of road appears to be wet. This is due to total internal reflection.

(a) Write the conditions for the phenomenon of total internal reflection.

(b) Write the relation between refractive index and critical angle of a medium.

Ans: (a) Refer question 26

(b)

$$i_c = \sin\left(\frac{1}{n_{12}}\right)$$

20. A thin lens is a transparent optical medium bounded by two surfaces, at least one of which should be spherical.

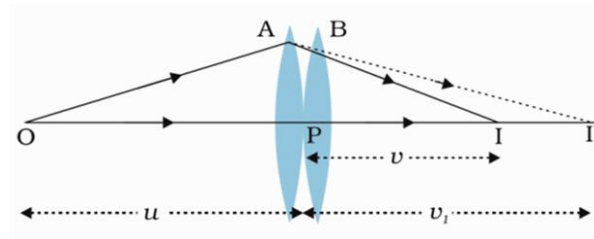
(a) What is the S.I. unit of the power of a lens ?

(b) Two thin convex lenses of focal length f_1 and f_2 are kept in contact with each other. Draw a neat ray diagram, obtain an expression to find the equivalent focal length of the combination.

(c) Two thin convex lenses of focal lengths 10 cm and 20 cm are kept in contact with each other. Find the equivalent focal length and power of the combination.

Ans: a) diopter

b)



For the image formed by the first lens A, we get

$$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u}$$

For the image formed by the second lens B, we get

$$\frac{1}{f_2} = \frac{1}{v} - \frac{1}{v_1}$$

Adding these equations

$$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{v} - \frac{1}{u}$$

But

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

so we get

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

c)

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\frac{1}{f} = \frac{1}{10} + \frac{1}{20}$$

$$\frac{1}{f} = \frac{3}{20}$$

$$f = \frac{20}{3} = 6.66 \text{ cm}$$

[2022 SAY]

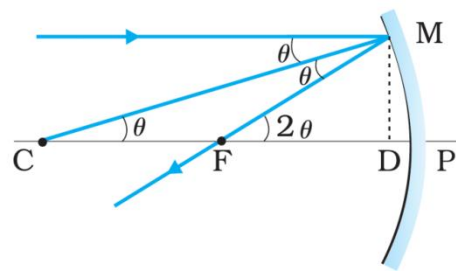
21. Write Lens maker's formula.

Ans:

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

22. Using a suitable ray diagram prove that the radius of curvature of a spherical mirror is twice its focal length.

Ans:



From right angled triangle CPM,

for small angle, $\tan \theta \cong \theta = \frac{MP}{CP}$

From right angled triangle FPM,

for small angle, $\tan 2\theta \cong 2\theta = \frac{MP}{FP}$

so

$$2 \frac{MP}{CP} = \frac{MP}{FP}$$

or $2 \frac{1}{CP} = \frac{1}{FP}$

or $2 FP = CP$

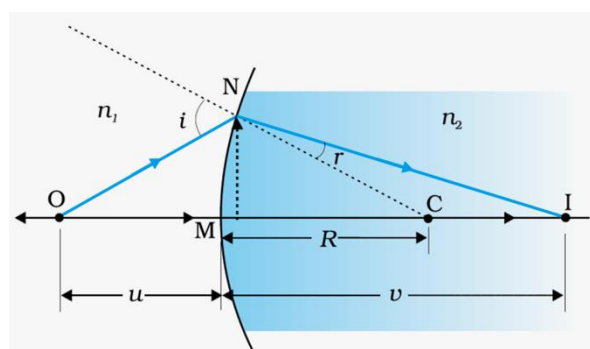
$R = 2f$, hence proved

23. Using a suitable ray diagram derive the relation

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

for refraction at a spherical surface.

Ans:



For small angles,

$$\tan \angle NOM \cong \angle NOM = \frac{MN}{u}$$

$$\tan \angle NCM \cong \angle NCM = \frac{MN}{R}$$

$$\tan \angle NIM \cong \angle NIM = \frac{MN}{v}$$

For ΔNOC , i is the exterior angle. Therefore,

$$i = \angle NOM + \angle NCM$$

$$i = \frac{MN}{u} + \frac{MN}{R}$$

Similarly, for ΔNCI r is interior, so

$$r = \angle NCM - \angle NIM$$

$$r = \frac{MN}{R} - \frac{MN}{v}$$

By Snell's law

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

$$\text{or } n_2 \sin i = n_1 \sin r$$

For small angle

$$n_1 i = n_2 r$$

Substituting i and r we get

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

By sign convention

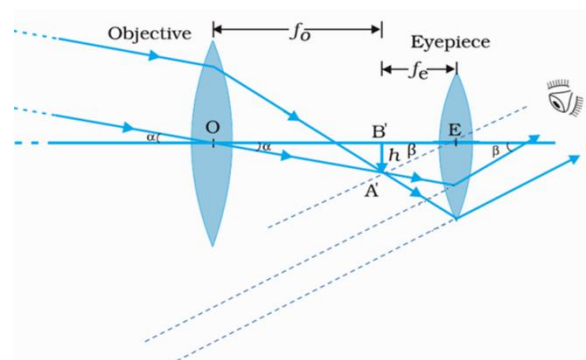
$$-\frac{n_1}{u} + \frac{n_2}{v} = \frac{n_2 - n_1}{R}$$

Or

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

24. Draw a ray diagram showing the image formation in a refracting telescope when the final image is formed at infinity. Write an equation for the length of the telescope tube in terms of focal length of the objective and eyepiece.

Ans:



$$\text{Length of the telescope tube} = f_o + f_e$$

[2021 March]

25. One diopter is the power of a lens of focal length

- (a) 1 cm
- (b) 1 m
- (c) -1 cm
- (d) -1 m

Ans; (b) 1 m

26. Write necessary conditions for the phenomenon of total internal reflection to occur.

- Ans:**
1. Light rays must travel from denser to rarer medium
 2. The angle of incidence must be greater than critical angle

27. (a) Derive the equation for refraction at single spherical surface.

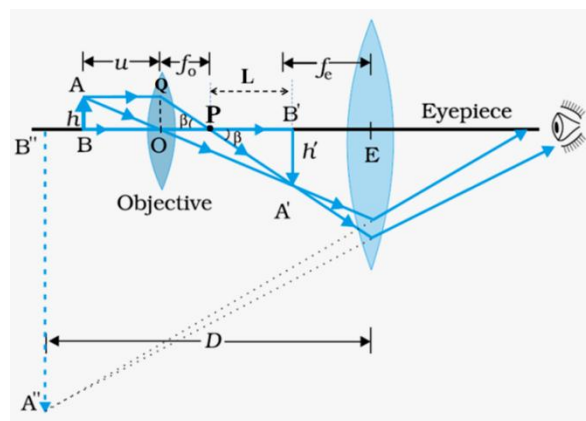
(b) Obtain lens makers formula.

Ans: (a) **Refer question 23**

(b) **Refer question 8**

28. Draw a labeled diagram for image formation in a compound microscope and write an expression for its magnifying power.

Ans:



29. Draw the ray diagram showing refraction of light through a glass prism and hence obtain the relation between the refractive index of the prism, angle of prism and angle of minimum deviation

[2021 SAY]

Ans: **Refer question 11**

WAVE OPTICS

1. A narrow slit is illuminated by blue light and the diffraction pattern is obtained on a white screen
 - (a) How width of the band changes as distance from the centre increases?
 - (b) What happens to the width of the pattern if yellow light is used instead of blue light?

(March 2020)

Ans (a) Width of the band decreases
 (b) If yellow light is used wavelength increases

2. The redistribution of energy due to the superposition of two or more light wave is called interference
 - (a) What are the essential conditions for observing interference of light
 - (b) Write down the expression for band width in Young's double slit experiment
 - (c) If the distance between two sources is 1mm and the screen is placed 1m away, what is the fringe separation for light of wavelength 5×10^{-7} m

(September 2020)

Ans (a) Sources should be coherent

Sources must be close to each other

Sources must be point source

(b) $\beta = \frac{\lambda D}{d}$ λ – wavelength of light used. D – distance between screen and slit,
 d – distance between slits

(c) $\beta = \frac{\lambda D}{d} = \frac{5 \times 10^{-7} \times 1}{1 \times 10^{-3}} = 5 \times 10^{-4} \text{ m}$

3. Name the property of light that prove its transverse nature

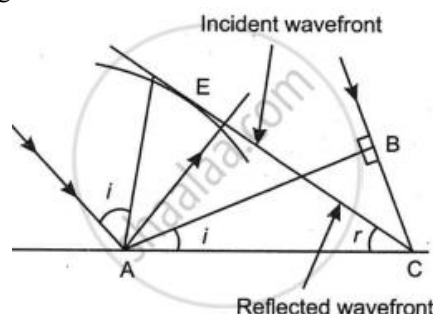
(March 2021)

Ans Polarization

4. Using Huygens wave theory prove that angle of incidence is equal to angle of reflection

(March 2021, June 2022)

Ans Since triangle ABC and AEC are congruent $i=r$



5. What is the shape of the wave front diverging from a point source

(June 2021, June 2022)

Ans Spherical

6. (a) What is meant by Plane polarized light?

(b) Which type of waves shows the property of polarization. Transverse or Longitudinal
(June 2021)

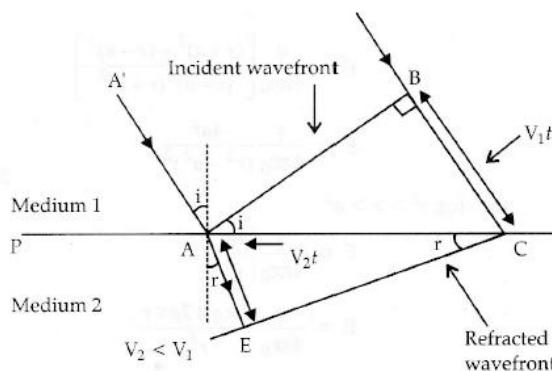
Ans (a) The phenomenon of restricting electric field vibrations in one plane is called Polarization and the resultant light is called plane polarized light
(b) Transverse

7. State Huygens principle. Prove law of refraction using Huygens principle
(June 2021, March 2022, March 2023, March 2025, June 2025)

Ans Huygens principle states that every point on the wave front acts as a source of secondary wavelets. Common tangent to the secondary wavelets gives the position of the new wave front

From $\triangle ABC$ $\sin i = \frac{v_1 t}{AC}$

From $\triangle AEC$ $\sin r = \frac{v_2 t}{AC}$ $\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{n_2}{n_1}$



8. Light waves are----- in nature
(March 2022)

Ans Transverse

9. In Young's double slit experiment, distance between the slits is halved and distance between screen and slits is doubled, what will happen to the band width produced?
(June 2022)

Ans $\beta^I = \frac{\lambda 2D}{\frac{d}{2}} = 4\beta$, Band width increases 4 times

10. When speed of light is independent of direction secondary waves are.....
(March 2023)

Ans spherical

11. The redistribution of energy due to the superposition of two or more light wave is called-----
(June 2023)

Ans Interference

12. (a) State Huygens principle of wave theory

(b) What are coherent sources
(June 2023, March 2024)

Ans (a) Huygens principle states that every point on the wave front acts as a source of secondary wavelets. Common tangent to the secondary wavelets gives the position of the new wave front.

(b) Two sources are said to be coherent if they emit light of same Wavelength, frequency, amplitude and phase or constant phase difference

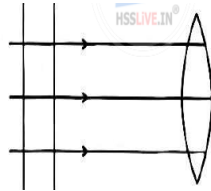
a. "The locus of points which have the same phase are called wavefront". This statement is True/False
(March 2024)

Ans True

13. (a) Define wave front

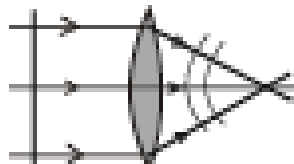
(b) Figure shows a plane wave front incident on a convex lens draw the corresponding Refracted wave front

(March 2025)



Ans (a) Wave front is defined as locus of point which are in same phase

(b)



14. (a) Which of the following phenomenon is not common to light and sound waves

- (i) Interference
- (ii) Diffraction
- (iii) Polarization
- (iv) Reflection
- (v) Refraction

(b) Write any two uses of Polaroid

(June 2025)

Ans (a) Polarization

- (b) 1. used in sunglasses
- 2. used in the glass window of train and aeroplane

DUAL NATURE OF RADIATION AND MATTER

- The work function of caesium metal is 2.14 eV. When light of frequency 6×10^{14} Hz is incident on the metal surface, photoemission of electron occurs. ($h = 6.6 \times 10^{-34}$ Js)
 - Define work function
 - Calculate the maximum kinetic energy of the emitted electron
 - Calculate the stopping potential (March 2020, March 2023)

Ans.

(a) Work function is defined as minimum energy required for the electron to escape from the metal surface

$$(b) \quad h\nu = \phi_0 + \frac{1}{2}mv^2$$

$$\frac{1}{2}mv^2 = h\nu - \phi_0 = (6.6 \times 10^{-34} \times 6 \times 10^{14}) - (2.14 \times 1.6 \times 10^{-19}) = 0.536 \times 10^{-19} \text{ J}$$

$$(c) \quad KE_{max} = eV_0$$

$$V_0 = \frac{KE_{max}}{e} = \frac{0.536 \times 10^{-19}}{1.6 \times 10^{-19}} = 0.335 \text{ V}$$

- When surface of an alkali metal is illuminated with yellow monochromatic light of sufficient frequency, electrons are ejected
 - State laws of photoemission
 - Monochromatic light of frequency 6×10^{14} Hz is produced by a laser. The power emitted is 2×10^3 W. What is the energy of a photon in the light beam (September 2020)

Ans

- (i) For a given photosensitive material, there exist a minimum frequency of incident radiation called the threshold frequency, below which no emission of photoelectrons takes place.
- (ii) For a given photosensitive material and frequency of incident radiation photoelectric current is directly proportional to the intensity of incident light
- (iii) For a given photosensitive material and frequency of incident radiation saturation current is proportional to the intensity of light where as stopping potential independent of intensity.
- (iv) Photoelectric emission is instantaneous

$$(b) \quad E = h\nu = 6.63 \times 10^{-34} \times 6 \times 10^{14} = 39.78 \times 10^{-20} \text{ J}$$

- Write the equation for wavelength of deBroglie wave associated with a moving particle (March 2021, March 2024, June 2025)

Ans $\lambda = \frac{h}{p}$

- (a) Write Einstein's photoelectric equation.

(b) Using this equation show that photoelectric emission is not possible if frequency of radiation is less than threshold frequency” (March 2021)

Ans

(a) $h\nu = \phi_0 + \frac{1}{2}mv^2$

(b) $KE_{max} = h(\nu - \nu_0)$, if $\nu < \nu_0$, KE becomes negative, means electron lacks sufficient energy to escape

5. The equation for momentum of a photon of frequency ν is..... (June 2021, June 2022)

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

6. (a) State Einstein's photoelectric equation and explain the symbol used
(b) Define stopping potential (June 2021, March 2024)

Ans

(a) $h\nu = \phi_0 + \frac{1}{2}mv^2$
 $h\nu$ – Energy of incident radiation
 ϕ_0 – Work function
 $\frac{1}{2}mv^2$ – Maximum kinetic energy

(b) The minimum negative potential of emitter plate A for which the photocurrent becomes zero is called stopping potential

7. Photons are electrically ----- (March 2022)

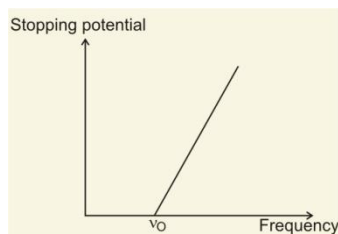
Ans neutral

8. (a) What is meant by threshold frequency of a photosensitive material?
(b) Draw the graph showing the variation of stopping potential with frequency (March 2022)

Ans

(a) Minimum frequency of incident radiation below which photoemission is not possible is called threshold frequency

(b)



9. A minimum amount of energy is required to remove an electron from a metal surface

(a) Name the minimum energy required

(b) Derive Einstein's photoelectric equation (June 2022, June 2023)

Ans

(a) Work function

(b) Energy of photon = work function + maximum kinetic energy of electron

$$h\nu = \phi_0 + \frac{1}{2}mv^2$$

$$\frac{1}{2}mv^2 = h\nu - h\nu_0$$

10. (a) Write Einstein's photoelectric equation

(b) Monochromatic light of frequency 6×10^{14} Hz is produced by a laser. The power emitted

is 2×10^3 W. How many photons per second on an average are emitted by the source?

($h = 6.63 \times 10^{-34}$ Js)

(June 2023)

Ans

(a) $h\nu = \phi_0 + \frac{1}{2}mv^2$

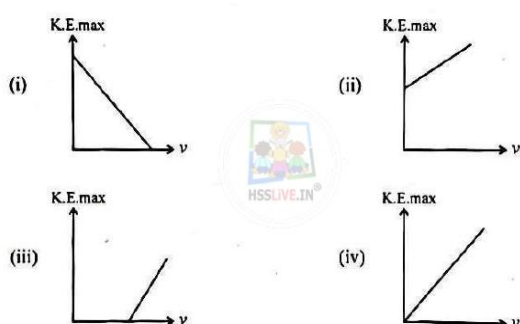
(b) Let number of photons emitted per second = n

Energy of one photon $E = h\nu$

Energy emitted by the source in one second = P

$$\text{Number of photons emitted by the source in 1s} = \frac{P}{E} = \frac{P}{h\nu} = \frac{2 \times 10^3}{6.63 \times 10^{-34} \times 6 \times 10^{14}} = 5 \times 10^{15}$$

11. (a) Which one of the following is the correct graph showing the variation of maximum kinetic energy (KE_{max}) of emitted photoelectrons and the frequency of incident radiation (ν) for a given photosensitive surface



(b) A photosensitive surface has a work function of 2.00 eV. Find the maximum kinetic energy of electrons ejected from this surface by radiation of wavelength 300 nm (Planck's constant $h = 6.63 \times 10^{-34}$ Js)

(March 2025)

Ans (a) iii

(b) $KE_{max} = h\nu - \phi_0$

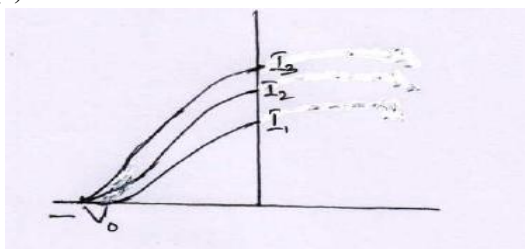
$$= \frac{hc}{\lambda} - \phi_0 = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{300 \times 10^{-9}} - 2 \times 1.6 \times 10^{-19} = 3.42 \times 10^{-19} \text{ J}$$

12. (a) Draw the graph showing the retarding potential and photocurrent in case of photoelectric emission with three different intensities of light

(b) When a certain metal is illuminated with light of frequency ν , the stopping potential for photoelectrons is V_0 . When the same surface is illuminated by light of frequency 0.5ν , the stopping potential becomes $0.25 V_0$. The threshold frequency for photoelectric emission is.....

(June 2025)

Ans (a)



(c) $h\nu = h\nu_0 + eV_0$

(d) $0.5 h\nu = h\nu_0 + 0.25eV_0$

$$0.5 (h\nu_0 + eV_0) = h\nu_0 + 0.25eV_0$$

$$h\nu_0 = 0.5eV_0$$

$$h\nu = 1.5eV_0$$

$$\nu_0 = \frac{\nu}{3}$$

Chapter 12

ATOMS

1. What is meant by ionisation energy? Write its value for hydrogen atom. (2)

Ans : The minimum energy required to remove the electron from the ground state of an atom, is called the ionization energy of the atom.

The ionisation energy of hydrogen atom is +13.6 eV or 21.76×10^{-19} J

(March 2025)

2. Mention any two drawbacks of Rutherford model of atom ?(1)

Ans

(a) Rutherford model could not explain the stability of matter.

(b) It could not explain the characteristic line spectra of atoms of different elements.

3. The radius of first orbit of hydrogen atom is r_0 . Find the radius of the second and third orbit.

(Given $r_0 = 0.53 \text{ \AA}$) (2)

Ans .

$$r_n = n^2 r_0$$

$$r_2 = 2^2 r_0 = 4 \times 0.53 \text{ \AA} = 2.12 \text{ \AA}$$

$$r_3 = 3^2 r_0 = 9 \times 0.53 \text{ \AA} = 4.77 \text{ \AA}$$

SAY 2025

4. Write the postulates of Bohr atom model. (3)

Ans :

First postulate : An electron in an atom revolves in certain stable orbits without the emission of radiant energy.

Second postulate : The orbital angular momentum of electron is an integral multiple of $\frac{h}{2\pi}$

$$mvr = \frac{nh}{2\pi}, \text{ where } n = 1, 2, 3, \dots$$

Third postulate : When an electron makes a transition from higher energy level to lower energy level a photon is emitted having energy equal to the energy difference between the initial and final states. The frequency of the emitted photon is then given by

$$h\nu = E_i - E_f$$

March 2024

5.(a) In alpha particle scattering experiment, what is the impact parameter for scattering angle of 180° ?

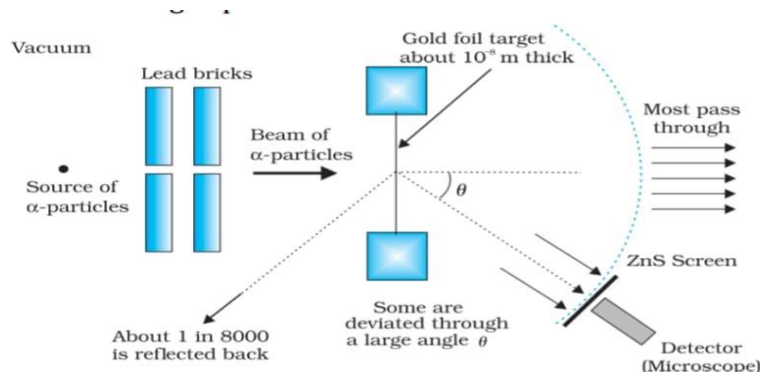
(b) The ground state energy of hydrogen atom is -13.6 eV. What is the ionisation energy of the electron in this state ? (1 + 1)

Ans : (a) Zero (b) 13.6 eV

SAY 2024

6. Explain Rutherford's alpha particle scattering experiment. (3)

Ans :



Alpha-particles emitted by ${}_{83}\text{Bi}^{214}$ radioactive source were collimated into a narrow beam by passing through lead bricks. The beam was allowed to fall on a thin foil of gold of thickness 2.1×10^{-7} m. The scattered alpha-particles were observed through a rotatable detector consisting of zinc sulphide screen and a microscope.

Observations :

- (i) Most of the α particles passed through the gold foil undeflected.
- (ii) Some were scattered through a small angle and some of them in large angles.
- (iii) A very few were reflected back.

March 2023

7. (a) What are the observations in α -particle scattering experiment ?

b) Define impact parameter. (2+1)

Ans .

a. Refer Q 6

b) Impact parameter is the perpendicular distance of the initial velocity vector of the α particle from the centre of the nucleus.

SAY2023

8. The minimum energy required to free an electron from the ground state of a hydrogen atom is _____ (1 March 2022)

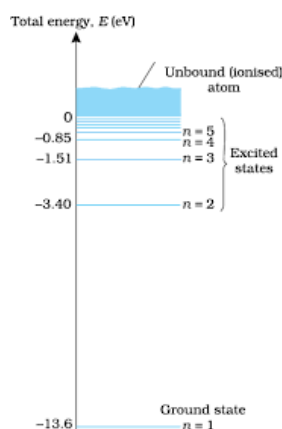
a. +13.6 J b. -13.6 J c. +13.6 eV

d. - 13.6 eV

Ans +13.6 eV

9. Draw the energy level diagram of hydrogen atom.

March 2022



10. In hydrogen spectrum the highest energy of state corresponds to $n = \infty$. What is the energy of the highest energy state? (1)

Ans : Zero

SAY 2022

11. Energy of electron in the n th orbit of hydrogen atom is $E_n = -\frac{13.6}{n^2}$ eV. What is the energy required to make electron free from first orbit of hydrogen atom? (1)

Ans : 13.6 eV

12. If radius of first electron orbit of hydrogen is a_0 , radius of second electron orbit of hydrogen is ---- (1)

Ans : $4a_0$. (Hint: $r_n = n^2 a_0$)

13. Write any two postulates of Bohr model of hydrogen atom.

Ans Refer Q 4.

March 2021

14. Ionization potential of hydrogen atom is _____ eV. (1)

Ans 13.6

15. Name the experiment which led to the discovery of atomic nucleus.(1)

Ans α particle scattering experiment or Rutherford's gold foil experiment.

16.. State any two postulates Bohr's atom model.

Ans Refer Q4.

17. Write down any two drawbacks of Rutherford atom model.(2)

Ans Refer Q2

SAY 2021

APT KOZHIKODE

Chapter 13

NUCLEI

1.----- process is responsible for the production of energy in sun.(Nuclear fission/Nuclear fusion) (1)

Ans : Nuclear fusion

2.The carbon isotope ${}^6\text{C}^{12}$ has a nuclear mass of 12.000000 u. Calculate the binding energy of its nucleus.

Given $m_p = 1.007825$ u; $m_n = 1.008665$ u,

1 a.m.u (u) = 931 MeV. : (2)

Ans

$$(\Delta m) = (6m_p + 6m_n) - m$$

$$= (6 \times 1.007825 + 6 \times 1.008665) - 12$$

$$= 0.09894 \text{ u}$$

$$\text{Binding energy} = \Delta m \times 931 \text{ MeV}$$

$$= 0.09894 \times 931 = 92.113 \text{ MeV}$$

MARCH 25

3.. The mass number ratio of two nuclei is 1 : 8. Find the ratio of nuclear radii and nuclear densities.(2)

Ans :

$$R = R_0 A^{\frac{1}{3}}$$

$$R_1/R_2 = \left(\frac{A_1}{A_2}\right)^{\frac{1}{3}}$$

$$\frac{R_1}{R_2} = \left(\frac{1}{8}\right)^{\frac{1}{3}} = \frac{1}{2}$$

Ratio of nuclei radii= 1:2

Nuclear density is independent of mass number.

Therefore ratio of nuclear density = 1:1

SAY2025

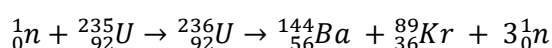
4.Which element in the periodic table shows maximum binding energy per nucleon ? (1)

Ans : Fe_{56} Or Iron

5.What is nuclear fission? Give one example.(2)

Ans : The splitting of a heavy nucleus into two lighter nuclei is called the nuclear fission.

Eg -Splitting of the uranium-235 nucleus when it is bombarded with neutrons.



MARCH 24

6.Isotones have same number of -----(1)

Ans : Neutrons

7.Define mass defect. How is it related to binding energy ?(2)

Ans : The difference between total mass of the nucleons and actual mass of the nucleus is called the mass defect.

$$\text{Mass defect, } \Delta m = m_p Z + m_n(A-Z) - M$$

$$\text{Binding energy} = \Delta m c^2 = (m_p Z + m_n(A-Z) - M) c^2$$

$$= \Delta m \times 931 \text{ MeV}$$

SAY 2024

8. Atoms of same element differing in mass are called
(a) Isotones (b) Isobars (c) Isotopes (d) Isomers (1 mark)

Ans : (c) Isotopes

9. Differentiate between nuclear fission and nuclear Fusion. (2)

Ans : The splitting of a heavy nucleus into two lighter nuclei is called the nuclear fission. In nuclear fusion, two or more light nuclei fuse to form a heavier nucleus, with emission of energy. **March 23**

10. The energy required to separate nucleons in the nucleus is Binding Energy.

a) What is mass defect ?

b) Write expression for binding energy in terms of mass defect.

c) Which nucleus has maximum binding energy/nucleon ? (1+1+1)

Ans a) and b) Refer Q.7

c) Iron

SAY 2023

11. What will be the ratio of radii of two nuclei, if their mass numbers are in the ratio 8:27 ? (1)

Ans : 2:3

$$\frac{R_1}{R_2} = \left(\frac{A_1}{A_2} \right)^{\frac{1}{3}} = \left(\frac{8}{27} \right)^{\frac{1}{3}} = \frac{2}{3} = 2:3$$

SAY 2022

12. Write any two properties of nuclear force.

Ans :

(i) Nuclear force is independent of electric charge.

(ii) It is short-ranged and strong attractive force.

March 2021

13. What is nuclear fission ? (2)

Nuclear fission is the process in which a heavier nucleus splits into lighter nuclei with the release of large amount of energy. **SAY 2021**

Chapter 14

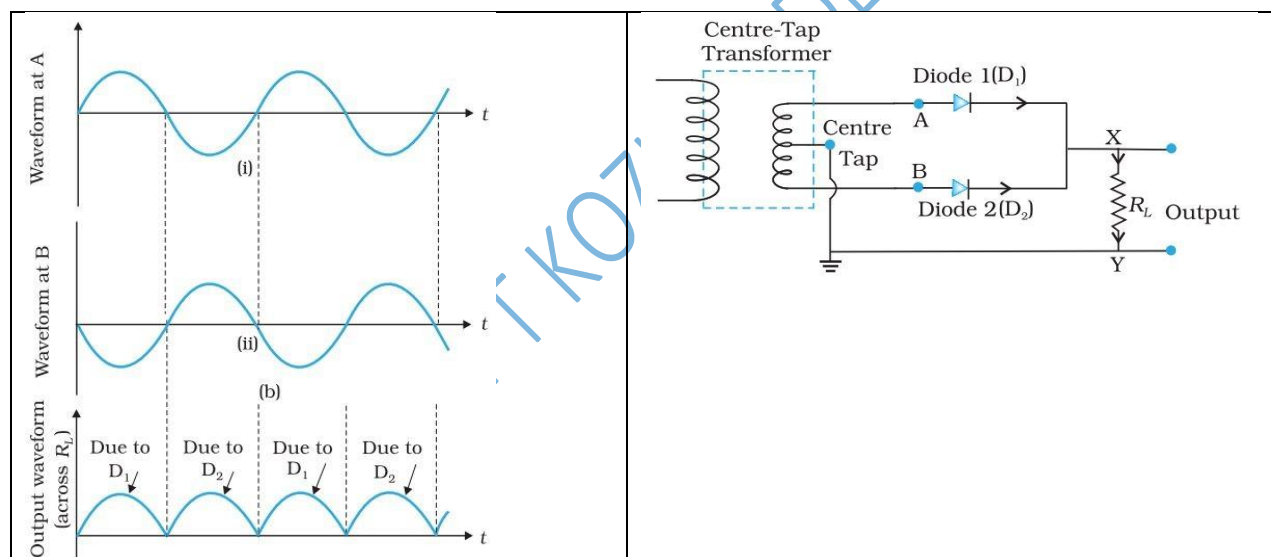
SEMICONDUCTOR ELECTRONICS: MATERIALS, DEVICES AND SIMPLE CIRCUITS

2025 SAY EXAM

Question-1

Explain the working of a full wave rectifier using 2 diodes with figure. Draw the input and output wave forms. (3)

Solution:



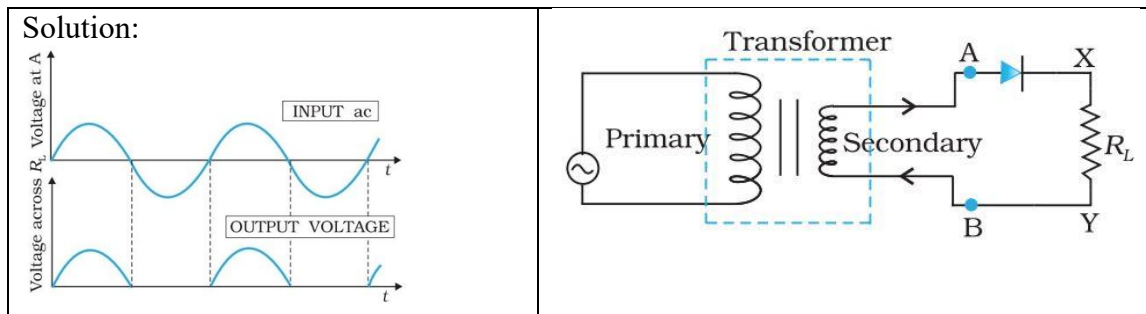
Explanation

During this positive half cycle, diode D_1 gets forward biased and conducts, while D_2 being reverse biased is not conducting. Hence we get an output current and a output voltage across the load resistor R_L . During negative half cycle, diode D_1 would not conduct but diode D_2 conducts, giving an output current and output voltage across R_L in the same direction as in positive half.

2025 MARCH EXAM

Question-2

With the help of a circuit diagram, explain the working of a half wave rectifier. Draw the input and output waveforms. (3)



Explanation

In the positive half-cycle of ac there is a current through the load resistor R_L and we get an output voltage, whereas there is no current in the negative half cycle. Since the rectified output of this circuit is only for half of the input ac wave it is called as half-wave rectifier.

2024 SAY EXAM

Question-3

- Which property of the diode is used to rectify a.c voltage? (1)
- With the help of a circuit diagram, explain the working of a half wave rectifier. (2)

Solution:

- Diode conduct only in the forward biased condition or does not conduct in the reverse biased condition.
- Refer Question-2

2024 MARCH EXAM

Question-4

What is an intrinsic semiconductor: (1)

Solution:

Semiconductor in its purest form

Question-5

What is a rectifier? Draw the circuit diagram and input, output wave forms of a full wave rectifier. (3)

Solution:

The device used for the conversion of ac voltage into dc voltage is called a rectifier.

For circuit diagram and waveforms refer Question-1

2023 SAY EXAM

Question-6

A rectifier is used to change AC voltage into DC voltage:

- With a diagram explain the working of a full wave rectifier, having two diodes. (1+2)
- What is the output frequency of full wave rectifier if the input frequency is 50 Hz? (1)

Solution:

(a) Refer Question-1.

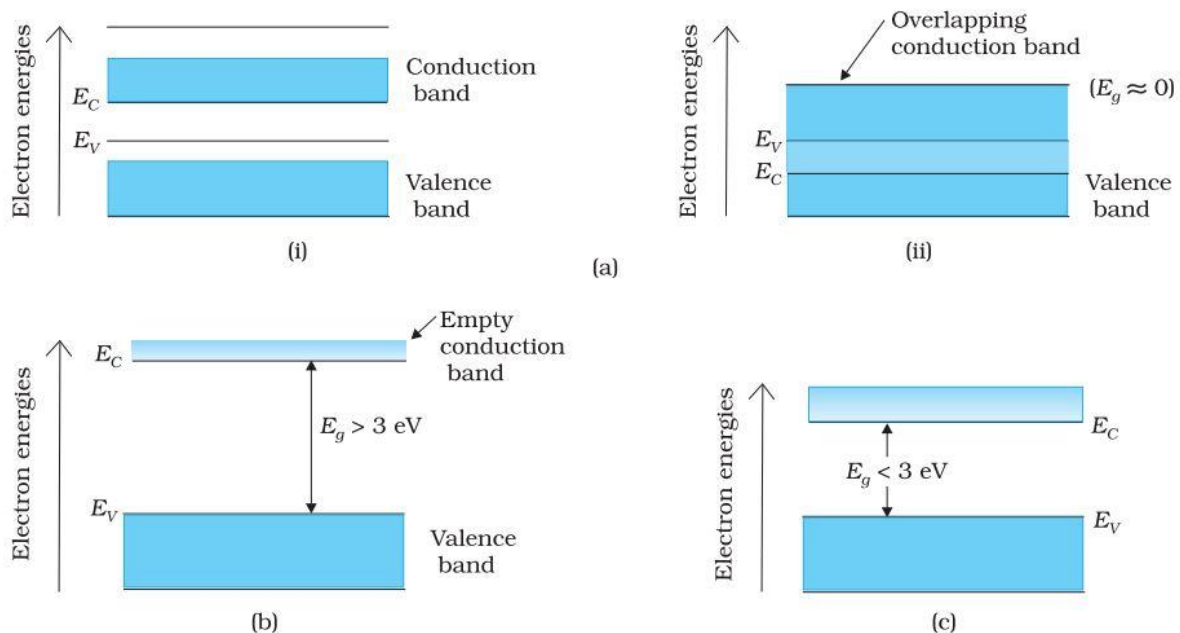
(b) 100Hz (Input AC frequency = 50 Hz, This means there are 50 cycles per second. In a full wave rectifier, each half cycle produces one output pulse. So for every 1 input cycle, we get 2 output pulses)

2023 MARCH EXAM

Question-7

- Give the classification of materials based on energy band diagram. (1+1+1)
- Differentiate between intrinsic and extrinsic semiconductors. (1)

Solution:



(a) Metals (b) Insulators and (c) Semiconductors

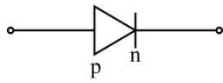
(b) Pure semiconductors are called intrinsic semiconductors, while impurity semiconductors or doped semiconductors are called extrinsic semiconductors.

2022 SAY EXAM

Question-8

A p-n junction is the basic building block of many semiconductor devices

(a) Identify the figure given below. (1)



(b) Explain the terms diffusion and drift. (2)

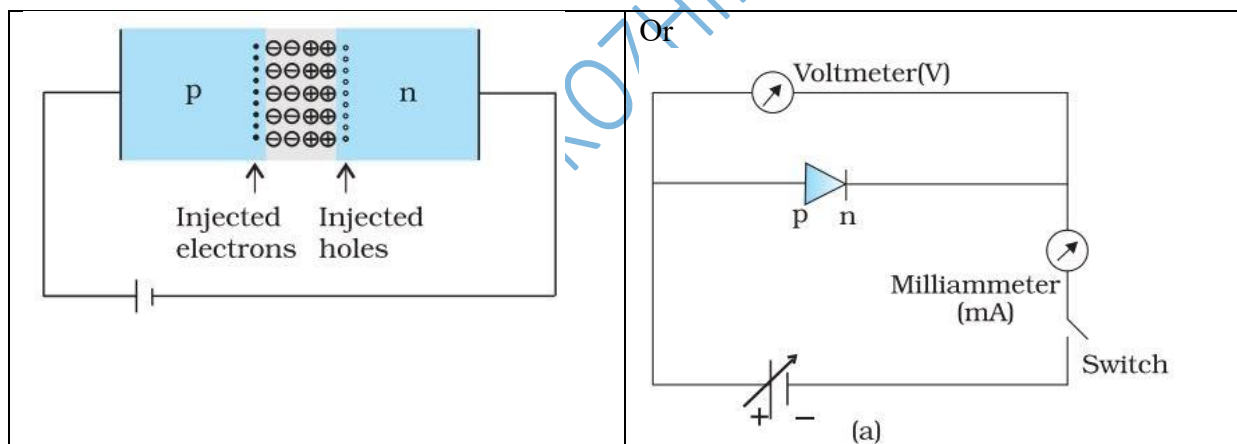
(c) Current conducts through a p-n junction diode when it is connected in forward biasing. Draw the circuit diagram of a diode connected in forward biasing. (1)

Solution:

(a) p-n junction diode or junction diode or diode.

(b) In a p-n junction, the holes moves from p-side to n-side ($p \rightarrow n$) and electrons moves from n-side to p-side ($n \rightarrow p$) due to the difference in the concentration is called diffusion. Due to the electric field at p-n junction, an electron (minority carrier) on p-side of the junction moves to n-side and a hole (minority carrier) on n- side of the junction moves to p-side. The motion of charge carriers due to the electric field is called drift.

(c)

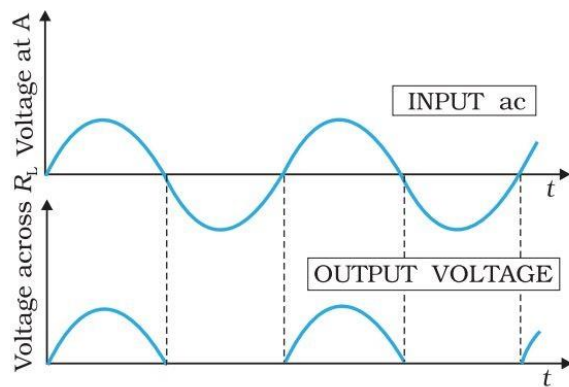


2022 MARCH EXAM

Question-9

Draw the input and output waveform of a half-wave rectifier. (2)

Solution:



2021 SAY EXAM

Question-10

With the help of the circuit diagram, explain the working of a full wave rectifier using p-n junction. Draw the input and the output wave forms. (4)

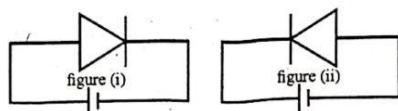
Solution:

Refer Question-1

2021 MARCH EXAM

Question-11

(a) In which figure the diode is under forward biased condition? (1)



(b) Draw the circuit diagram of a full wave rectifier and explain its working.

Solution:

(a) Figure (i)

(b) Refer Question-1

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