

Previous IPE
SOLVED PAPERS

MARCH -2025(TS)

PREVIOUS PAPERS

IPE: MARCH-2025(TS)

Time : 3 Hours

SR.PHYSICS

Max.Marks : 60

SECTION-A**I. Answer all questions :****10 × 2 = 20**

1. What is dispersion ? Which colour gets relatively more dispersed ?
2. Define modulation. Why is it necessary?
3. A circular coil of radius r having N turns carries a current i . What is its magnetic moment ?
4. Define magnetic declination.
5. What is work function ?
6. A transformer converts 200 V AC into 2000 V AC. Calculate the number of turns in the secondary if the primary has 10 turns.
7. Magnetic lines form continuous closed loops. Why?
8. Microwaves are used in Radars. Why?
9. State Heisenberg's Uncertainty Principle.
10. Draw the circuit symbols for p-n-p and n-p-n transistors.

SECTION-B**II. Answer any six of the following Questions.****6 × 4 = 24**

11. Explain the formation of a rainbow.
12. Explain Doppler effect in light. Distinguish between red shift and blue shift.
13. Derive the equation for the couple acting on an electric dipole in a uniform electric field.
14. Derive an expression for the capacitance of a parallel plate capacitor.
15. Find the magnetic induction due to a long current carrying conductor.
16. Describe the ways in which Eddy currents are used to advantage.
17. Explain the different types of spectral series.
18. What is rectification ? Explain the working of a full wave rectifier.

SECTION-C**III. Answer any two of the following Questions.****2 × 8 = 16**

19. How are stationary waves formed in closed pipes ? Explain the various modes of vibration and obtain relations for their frequencies.
A closed organ pipe 70cm long is sounded. If the velocity of sound is 331m/s, what is the fundamental frequency of vibration of the air column?
20. State Kirchoff's law for an electrical network. Using these laws deduce the condition for balance in a Wheatstone bridge.
21. Explain the principle and working of a nuclear reactor with the help of a labelled diagram.
If one microgram of ${}_{92}\text{U}^{235}$ is completely destroyed in an atom bomb, how much energy will be released ?

ipe ts march-2025

SOLUTIONS

SECTION-A

1. What is dispersion? Which colour gets relatively more dispersed ?

A: 1) **Dispersion** : When a beam of white light passes through a glass prism, white light splits up into its spectrum of colours. This phenomenon is called 'dispersion' of light.

Dispersion of white light gives VIBGYOR colours.

2) **Violet** is more dispersed because of its less wavelength .

2. Define modulation. Why is it necessary?

A: 1) **Modulation**: The process of combining **Low frequency audio signal** with **High frequency carrier signal** is called Modulation.

2) **Necessity of Modulation**:

(i) To transmit audio frequency signal to long distances.

(ii) To avoid mixing of signals from different transmitters.

(iii) To reduce the size of antenna.

3. A circular coil of radius r having N turns carries a current i . What is its magnetic moment ?

A: 1) Magnetic moment(M) of circular coil of N turns carrying current ' i ' is $M = NiA$ where $A = \pi r^2$ is area of cross section of the coil.

2) Hence the Magnetic moment is $M = Ni \pi r^2$

4. Define magnetic declination.

A: **Magnetic Declination** : It is the angle between the 'Geographical Meridian' and the 'Magnetic meridian' at a given place.

5. What is Work function ?

A: **Work Function**: The 'minimum energy' required by an electron 'to escape from the surface of a metal' is called work function (ϕ_0) of the metal.

6. A transformer converts 200 V AC into 2000 V AC. Calculate the number of turns in the secondary if the primary has 10 turns.

A: Given that $V_p = 200$ V, $V_s = 2000$ V, $N_p = 10$, $N_s = ?$

Transformer formula : $\frac{N_s}{N_p} = \frac{V_s}{V_p} \Rightarrow N_s = \frac{V_s}{V_p} N_p = \frac{2000}{200} \times 10 = 100$

7. Magnetic lines form continuous closed loops. Why ?

A: The magnetic poles N and S always exist together in pairs.

So the magnetic field lines of a magnet (or a solenoid) form continuous closed loops.

8. Microwaves are used in Radars. Why?

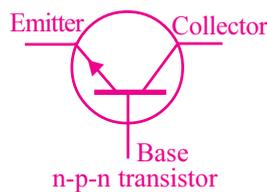
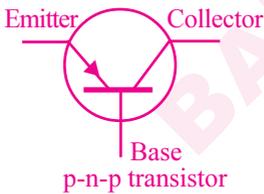
- A: 1) Due to their short wavelengths, microwaves easily penetrate the earth's atmosphere.
2) Hence they are used in radars for space-vehicle communication.

9. State Heisenberg's Uncertainty Principle.

- A: 1) **Heisenberg's Uncertainty Principle:** It is **impossible** to measure 'both the position and momentum' of an electron (or any other particle) at the same time exactly.
2) If the uncertainty in position is Δx and uncertainty in momentum is Δp then $\Delta x \Delta p = \hbar$ (where $\hbar = h/2\pi$)

10. Draw the circuit symbols for p-n-p and n-p-n transistors.

A:



SECTION-B

11. Explain the formation of a rainbow.

A: 1) Rainbow :

- i) The multicoloured arc that appears in the sky, opposite to sun on a rainy day is called rainbow.
- ii) Rainbow is the combined effect of dispersion, refraction and total internal reflection of sunlight
- iii) This happens due to spherical water droplets of rain in atmosphere.
- iv) The water drops in atmosphere act as small prisms and cause dispersion and total internal reflection of sunlight to form rainbow.

2) Primary rainbow:

- i) Sunlight is first refracted as it enters a rain drop, which causes different colours.
- ii) These refracted rays strike the inner surface of the drop and get reflected internally.
- iii) These internally reflected rays again get refracted at the opposite surface and come out.
- iv) As red is less deviated, it comes straight to observer and appears on top.
- v) As violet is deviated more, it comes from lower level drops and appears at bottom.

3) Secondary rainbow: It is formed due to double internal reflection of sunlight in the rain drops. This appears faint and the colours in it will be in reverse order.

12. Explain Doppler effect in light. Distinguish between red shift and blue shift.

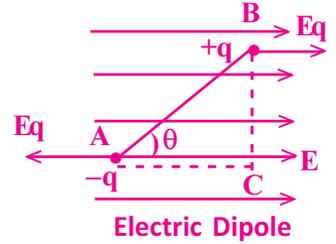
A : 1) Doppler effect in Light: To an observer on the earth the light from a star moving towards him appears with high frequency or less wave length. Similarly, the apparent wave length is high in the case of star moving away from him. This change in apparent frequency or wavelength of light due to relative motion of the source is called Doppler effect in light.

2) Red Shift: According to Doppler effect, when a star goes away from the observer on the earth, its light appears to him with higher wavelength. As a result, the wavelength in the middle of the visible region of the spectrum (VIBGYOR) moves towards the red end of the spectrum. This is called red shift.

3) Blue Shift: According to Doppler effect, when a star moves towards the observer on the earth, its light appears to him with less wavelength. As a result, the wavelength in the middle of the visible region of the spectrum (VIBGYOR) moves towards the violet (or blue which is more sensitive to eye) end of the spectrum. This is called blue shift.

13. Derive the equation for the couple acting on an electric dipole in a uniform electric field.

A : 1) **Electric Dipole:** Consider an electric dipole consisting of two equal and opposite charges q & $-q$ separated by a distance $2a$. The dipole is placed in a uniform electric field of intensity E at an angle θ to the direction of electric field.



2) **Couple:** The electrostatic forces acting on the charges q and $-q$ are Eq and E_{-q} respectively.

They form a torque or couple which tends to rotate the dipole into the direction of the electric field.

Torque = Force \times Perpendicular distance between the forces.....(1)

Here, Force = Eq and perpendicular distance between the forces is BC .

From ΔABC , $\sin \theta = \frac{BC}{2a} \Rightarrow BC = 2a \sin \theta$(2)

\therefore Torque $\tau = (Eq) 2a \sin \theta = 2aEq \sin \theta$. But $q(2a) = p =$ dipole moment

\therefore Torque $\tau = pE \sin \theta$(3). In vector form, $\vec{\tau} = \vec{p} \times \vec{E}$

Direction of the torque $\vec{\tau}$ is perpendicular to the plane containing \vec{p} and \vec{E} .

14. Derive an expression for the capacitance of a parallel plate capacitor.

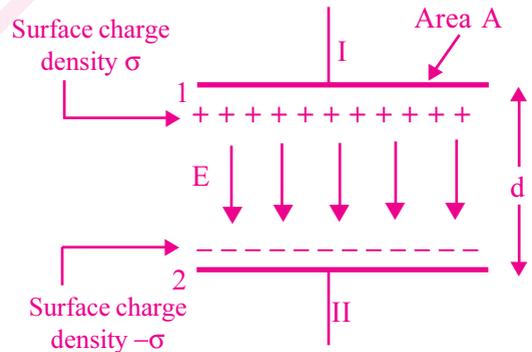
A: Capacitance of a parallel plate capacitor :

Consider a parallel plate capacitor consisting of two parallel plates of area A , separated by a small distance 'd'.

Let 'V' be the potential difference between two plates.

The charges of the plates are Q and $-Q$.

The plate 1 has uniform surface charge density $\sigma = Q/A$ and the plate 2 has uniform charge density $-\sigma$.



The electric field due to plate 1 is $\frac{\sigma}{2\epsilon_0}$.

The electric field due to plate 2 is $-\frac{\sigma}{2\epsilon_0}$.

Electric field between two charged plates is

$$E = \frac{\sigma}{2\epsilon_0} + \frac{\sigma}{2\epsilon_0} = \cancel{\frac{\sigma}{2\epsilon_0}} = \frac{\sigma}{\epsilon_0}$$

But, $\sigma = Q/A$

\therefore The field inside the capacitor is $E = \frac{Q}{\epsilon_0 A}$ (1)

$$\Rightarrow \frac{V}{d} = \frac{Q}{\epsilon_0 A} \left[\because E = \frac{V}{d} \right] \Rightarrow \frac{V}{d} = \frac{CV}{\epsilon_0 A} \quad [\because Q = CV] \Rightarrow C = \frac{\epsilon_0 A}{d}$$

\therefore Capacitance of the parallel plate capacitor is given by $C = \frac{\epsilon_0 A}{d}$

15. Find the magnetic induction due to a long current carrying conductor.

A: Magnetic Induction due to a Long Conductor carrying current :

1) Consider a long straight conductor carrying a current i . Let P be a point at a distance r from the conductor. Let r be the radius of the circle passing through the point P. The circumference of the circle is $2\pi r$. Magnetic induction is same at all points on the circle.

2) Consider a small element of length $d\vec{l}$.

$$\text{Now, } \oint \vec{B} \cdot d\vec{l} = \oint B dl \cos \theta = B \oint dl \cos \theta$$

3) Angle between B and $d\vec{l}$ is zero $\Rightarrow \theta = 0 \Rightarrow \cos \theta = \cos 0 = 1$

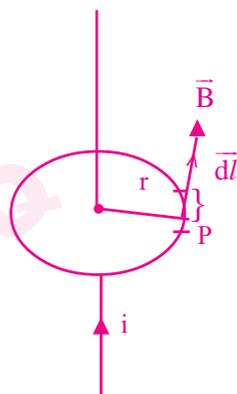
$$\therefore \oint \vec{B} \cdot d\vec{l} = B \oint dl$$

$$\oint \vec{B} \cdot d\vec{l} = B(2\pi r) \dots (1) \quad (\because \oint dl = 2\pi r)$$

4) From Ampere's law $\oint \vec{B} \cdot d\vec{l} = \mu_0 i \dots (2)$

$$\text{From (1) \& (2); } B2\pi r = \mu_0 i \Rightarrow B = \frac{\mu_0 i}{2\pi r}$$

$$\therefore B = \frac{\mu_0 i}{2\pi r}$$



16. Describe the ways in which Eddy currents are used to advantage.

A: 1) **Eddy Currents** : When large pieces of conductors are subjected to changing magnetic fluxes, induced currents are produced in them. Such induced currents are called eddy currents

2) Advantages of Eddy Currents :

i) **Magnetic Brakes to Trains**: When the strong electromagnets are activated, the eddy currents induced in the rails oppose the motion of the train. As a result, **smooth braking effect** comes into play.

ii) **Electromagnetic Damping**: In galvanometers, electromagnetic damping brings the coil to rest quickly. This happens due to eddy currents produced in the core.

iii) **Induction Furnace** : A high frequency alternating current is passed through a coil which surrounds the metals to be melted. Then the eddy currents generated in the metals produce high temperatures.

iv) **Electric power meters**: The shiny **metal disc** in the 'electric power meter' **rotates** due to eddy currents.

17. Explain the different types of spectral series of hydrogen atom.

A: Hydrogen atom consists of five spectral series. They are

1) Lyman series 2) Balmer series 3) Paschen series 4) Brackett series 5) Pfund series.

1) Lyman series: When an electron jumps from any outer orbits to the first orbit, we get Lyman series. It is observed in the **UV** region. Here $n_1=1$ and $n_2=2,3,4,5,\dots$

$$\therefore \nu = R \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right] = R \left[\frac{1}{1^2} - \frac{1}{n_2^2} \right]$$

2) Balmer Series: When an electron jumps from any outer orbits to the second orbit, we get Balmer series. It is observed in the **Visible** region. Here $n_1=2$ and $n_2=3,4,5,\dots$

$$\therefore \nu = R \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right] = R \left[\frac{1}{2^2} - \frac{1}{n_2^2} \right]$$

3) Paschen Series : When an electron jumps from any outer orbits to the third orbit, we get Paschen series. It is observed in the **near infrared** region. Here $n_1=3$ and $n_2=4,5,6,\dots$

$$\therefore \nu = R \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right] = R \left[\frac{1}{3^2} - \frac{1}{n_2^2} \right]$$

4) Brackett Series : When an electron jumps from any outer orbits to the fourth orbit, we get Brackett series. It is observed in the **infrared** region. Here $n_1=4$ and $n_2=5,6,7,\dots$

$$\therefore \nu = R \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right] = R \left[\frac{1}{4^2} - \frac{1}{n_2^2} \right]$$

5) Pfund Series : When an electron jumps from any outer orbits to the fifth orbit, we get Pfund series. It is observed in the **far infrared** region. Here $n_1=5$ and $n_2=6,7,8,\dots$

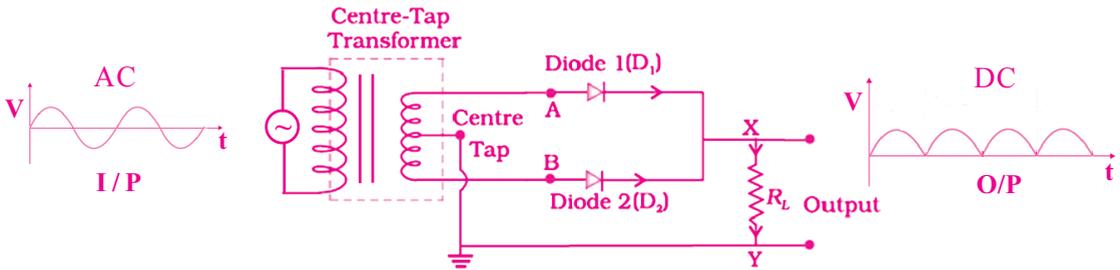
$$\therefore \nu = R \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right] = R \left[\frac{1}{5^2} - \frac{1}{n_2^2} \right]$$

18. What is rectification ? Explain the working of a full wave rectifier.

A: 1) Rectification: The process of converting alternating current (AC) into directed current (DC) is called rectification.

2) Full Wave Rectifier: The circuit which rectifies both half cycles of an a.c wave is called Full Wave Rectifier.

3) Working: Two diodes D_1, D_2 are connected to the Load Resistance (R_L) as shown in the figure.



i) As the current is AC, the direction of the current in the secondary winding of the transformer changes after every half cycle.

ii) During the first half cycle, D_1 is forward biased and D_2 is reverse biased.

Hence, current passes to R_L through D_1 and no current passes through D_2 .

iii) During second half cycle, D_2 is forward biased and D_1 is reverse biased.

Hence, current passes to R_L through D_2 and no current passes through D_1 .

iv) Thus the full wave is rectified using two diodes.

4) Efficiency of full wave rectifier is $\eta = \frac{0.812 \times R_L}{r_f + R_L}$

Where r_f = diode forward resistance, R_L = load resistance.

SECTION-C

19. How are stationary waves formed in closed pipes ? Explain the various modes of vibration and obtain relations for their frequencies.

A: 1) Closed pipe: A pipe closed at one end is called closed pipe.

2) Formation of Stationary waves : When a sound wave is sent to a closed pipe, the wave reflects back at the closed end of the pipe. These incident wave and reflected wave travelling in opposite directions super impose each other to produce Stationary waves.

3) A node (N) is formed at the closed end and an antinode (A) is formed at open end .

4) Notation: l = length of air column,

V = Velocity of sound in air, $\lambda_1, \lambda_3, \lambda_5$ are the wave lengths of waves in respective harmonics.

5) First Harmonic: Here, 1 node and 1 antinode is formed.

$$\text{Length of the air column } l = \frac{\lambda_1}{4} \Rightarrow \lambda_1 = 4l$$

$$\therefore \text{ Frequency of first harmonic } n_1 = \frac{V}{\lambda_1}$$

$$\therefore n_1 = \frac{V}{4l} \dots\dots\dots(i)$$



6) Third Harmonic: Here, 2 nodes and 2 antinodes are formed.

$$\text{Length of air column } l = \frac{\lambda_3}{4} + \frac{\lambda_3}{4} + \frac{\lambda_3}{4} = \frac{3\lambda_3}{4}$$

$$\therefore l = \frac{3\lambda_3}{4} \Rightarrow \lambda_3 = \frac{4l}{3}$$

$$\therefore \text{ Frequency of third harmonic } n_3 = \frac{V}{\lambda_3} = V \left(\frac{3}{4l} \right) = 3 \left(\frac{V}{4l} \right) = 3n_1 \dots\dots\dots(ii)$$



7) Fifth Harmonic: Here, 3 nodes and 3 antinodes are formed.

$$\text{Length of air column } l = \frac{\lambda_5}{4} + \frac{\lambda_5}{4} + \frac{\lambda_5}{4} + \frac{\lambda_5}{4} + \frac{\lambda_5}{4} = \frac{5\lambda_5}{4}$$

$$\therefore l = \frac{5\lambda_5}{4} \Rightarrow \lambda_5 = \frac{4l}{5}$$

$$\therefore \text{ Frequency of fifth harmonic } n_5 = \frac{V}{\lambda_5} = V \left(\frac{5}{4l} \right) = 5 \left(\frac{V}{4l} \right) = 5n_1 \dots\dots\dots(iii)$$



8) From (i), (ii) & (iii) we have $n_1 : n_3 : n_5 : \dots = n_1 : 3n_1 : 5n_1 : \dots = 1 : 3 : 5 : \dots$

A closed organ pipe 70cm long is sounded. If the velocity of sound is 331m/s, what is the fundamental frequency of vibration of the air column?

Sol: Given length of closed pipe $l=70$ cm = 0.7 m , $V = 331$ m/s, $n=?$

$$\text{Fundamental frequency } n = \frac{V}{4l} = \frac{331}{4 \times 0.7} = 118.2 \text{ Hz}$$

20. State Kirchoff's law for an electrical network. Using these laws deduce the condition for balance in a Wheatstone bridge.

A : 1) **Kirchoff's First Law** : At any junction in an electric circuit, the sum of currents entering the junction is equal to the sum of currents leaving the junction.

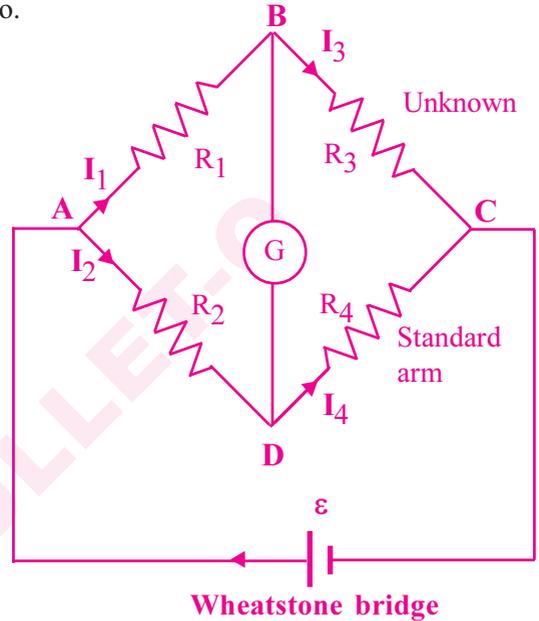
2) **Kirchoff's Second Law** : The algebraic sum of changes in potential around any closed loop involving resistors and cells in the loop is zero.

3) **Wheatstone's Bridge** :

The circuit shown in the figure is called Wheatstone's bridge. It has four resistors R_1 , R_2 , R_3 and R_4 . AC is battery arm, BD is galvanometer arm.

The galvanometer G detects the current.

If the resistors are adjusted such that the galvanometer current $I_g = 0$, the bridge is said to be balanced.



Applying Kirchoff's junction rule at B, we get $I_1 = I_3$ (1)

Applying Kirchoff's junction rule at D, we get $I_2 = I_4$ (2)

Applying Kirchoff's loop rule to closed loop ABDA, we get $I_1 R_1 + 0 - I_2 R_2 = 0$

$$\Rightarrow I_1 R_1 = I_2 R_2 \Rightarrow \frac{I_1}{I_2} = \frac{R_2}{R_1} \text{(3)}$$

Applying Kirchoff's loop rule to closed loop CBDC, we get $I_4 R_4 + 0 + -I_3 R_3 = 0$

$\Rightarrow I_3 R_3 = I_4 R_4$ From (1) & (2) $I_3 = I_1$ and $I_4 = I_2$

$$\therefore I_1 R_3 = I_2 R_4 \Rightarrow \frac{I_1}{I_2} = \frac{R_4}{R_3} \text{(4)}$$

Equating the RHS of equ (3) and equ (4), we get $\frac{R_2}{R_1} = \frac{R_4}{R_3} \Rightarrow \frac{R_1}{R_2} = \frac{R_3}{R_4}$

This is the **balance condition of Wheatstone's bridge** to make $I_g = 0$.

21. a) Explain the principle and working of a nuclear reactor with the help of a labelled diagram.

A: 1) **Principle:** Nuclear reactor works on the principle of **controlled chain reaction.**

2) **Main parts of Nuclear reactor:**

- (i) Fuel
- (ii) Moderator
- (iii) Control rods
- (iv) Protective Shielding
- (v) Coolant

3) **Fuel:** The material which undergoes fission is called fuel. **Ex:** U^{235} .

4) **Moderator:** The material which slows down the fast moving neutrons is called moderator. **Ex:** D_2O , Graphite

5) **Control rods:** The rods which absorb neutrons to control the chain reaction are called control rods.
Ex: Cd, B

6) **Protective Shielding:** The construction with cement and lead(Pb) around the reactor which protects from harmful radiations is called protective shielding.

7) **Coolant:** The liquid which removes the heat generated by the reactor is called circulating coolant. **Ex:** Water at high pressure, molten sodium.

8) **Working:**

- i) Uranium fuel rods are arranged in the A/ cylinders.
- ii) The graphite moderator is placed in between the fuel cylinders.
- iii) When U^{235} undergo fission, fast neutrons are released.
- iv) These neutrons pass through the surrounding graphite moderator and loose their energy.
- v) The heat generated here is used to produce steam.
- vi) This steam is used to rotate steam turbine then electric power is produced.

b) **If one microgram of ${}_{92}U^{235}$ is completely destroyed in an atom bomb, how much energy will be released ?**

Sol: Given that $m = 10^{-6}g = 10^{-9}kg$, $c = 3 \times 10^8ms^{-1}$, $E = ?$

Formula: $E = mc^2$

$$\therefore E = 10^{-9} (3 \times 10^8)^2 \Rightarrow E = 9 \times 10^{-9+8+8} \quad \therefore E = 9 \times 10^7 J$$

