Previous IPE

SOLVED PAPERS

MARCH -2026(TG)

PREVIOUS PAPERS

IPE: MARCH-2026 (TG)

Time : 3 Hours

SR. PHYSICS

Max.Marks : 60

SECTION-A

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

1. Define 'Power' of a convex lens. What is its unit?
2. Define magnetic declination.
3. Magnetic lines form continuous closed loops. Why?
4. How do you convert a moving coil galvanometer into an ammeter?
5. What type of transformer is used in a 6V bed lamp?
6. What is the principle of production of electromagnetic waves?
7. What is "work function"?
8. State Heisenberg's Uncertainty Principle.
9. In which bias can a Zener diode be used as voltage regulator?
10. Mention the various parts of the ionosphere.

SECTION-B

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

11. Why does the setting sun appear red?
12. How do you determine the resolving power of your eye?
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. Obtain an expression for the emf induced across a conductor which is moved in a uniform magnetic field which is perpendicular to the plane of motion.
16. Explain the different types of spectral series.
17. Derive an expression for the magnetic dipole moment of a revolving electron.
18. Distinguish between half-wave and full-wave rectifiers.

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 vibrations and obtain relations for their frequencies.

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

IPE TG MARCH - 2026

SOLUTIONS

SECTION-A

1. Define 'power' of a convex lens. What is its unit ?

A : 1) **Power (P) of a Convex Lens :** Reciprocal of focal length (f) of a convex lens is called its power. Thus, $P = 1/f$

2) SI **Units:** dioptre(D)

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2. Define magnetic declination.

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

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3. 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.

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4. How do you convert a moving coil galvanometer into an Ammeter?

A : A galvanometer (G) can be converted into an ammeter (A) by connecting a very **small shunt resistance** (r_s) in **parallel** to it.

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5. What type of transformer is used in a 6 V bed lamp?

A : **Step down** transformer is used in a 6Vbed lamp.

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6. What is the principle of production of electromagnetic waves ?

A : An accelerating charged particle produces an electromagnetic wave.

Visible light and UV rays are produced when electrons move from one energy level to lower energy level in atoms.

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7. 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.

8. 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 $\hbar = h/2\pi$)

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9. In which bias can a Zener diode be used as voltage regulator ?

A : **1)** In voltage regulator, zener diode is used in **Reverse bias.**

2) Because in reverse bias, zener voltage remains constant over a large range of current.

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10. Mention the various parts of the ionosphere.

A : Various Parts of the Ionosphere :

The various parts of the ionosphere are :

1. Troposphere
2. D (Part of Stratosphere)
3. E (Part of Stratosphere)
4. F_1 (Part of Mesosphere)
5. F_2 (Thermosphere)

SECTION-B

11. Why does the setting sun appear red ?

A : Sunset appears Red :

1) Sun light is composed of seven colours (VIBGYOR).
2) Sunlight passes through the atmosphere before it reaches us.
3) In the evenings, when the sun is near the horizon, the rays have to travel longer path in the atmosphere to reach us.
4) The dust, smoke and water vapour present in the atmosphere scatter away these colours differently depending on their wavelengths.
5) Scattering is more if wavelength is less.
6) As red has longer wavelength, it scatters less.
7) Thus red comes to us straight while other colours get scattered into space.
8) That is why, setting sun appears red.

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12. How do you determine the resolving power of your eye ?

A: **1) Resolving Power of Eye:** It is the ability to see the fine details in the viewed objects .

2) We can estimate the resolving power of our eye with a simple experiment.

3) Let us take a pattern of black stripes of equal width (each 5 mm) separated by white stripes of increasing width (0.5mm, 1mm,1.5 mm....)

from left to right as shown in the figure and paste it on a wall of the room.

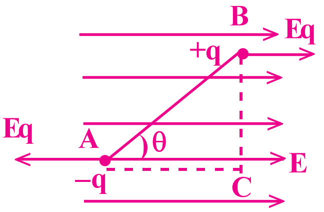
4) Now, let us watch the pattern with one eye. By moving our eye away or closer to the wall, we have to find the white stripe where we can just see some two black stripes as separate stripes. All the black stripes to the left of white stripe would merge into one another and would not be distinguishable.

5) On the other hand, the black stripes on the right of the white stripe would be more and more clearly visible. If d is the width of the white stripe which separates the two regions and D is the distance between the eye and the wall, the resolving power of the eye is given by d/D.

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

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.



Electric Dipole

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 × Perpendicular distance between the forces.........(1)

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

From Δ ABC, $\sin\theta = \dfrac{BC}{2a} \Rightarrow BC = 2a\sin\theta$.........(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 $\vec{E}$.

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

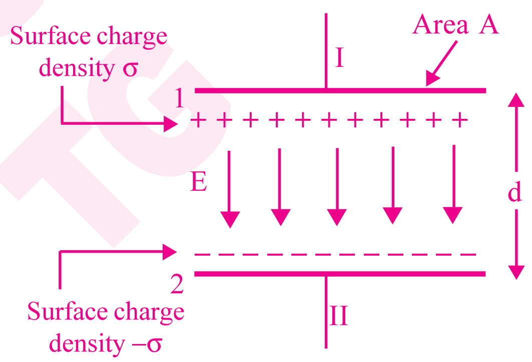
A: Capacitance of a parallel plate capacitor :

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 $\dfrac{\sigma}{2\varepsilon_0}$. The electric field due to plate 2 is $-\dfrac{\sigma}{2\varepsilon_0}$.

Electric field between two charged plates is

$$E = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \cancel{2}\frac{\sigma}{\cancel{2}\varepsilon_0} = \frac{\sigma}{\varepsilon_0}$$

But $\sigma = Q/A$

$\therefore$ The field inside the capacitor is $E = \dfrac{Q}{\varepsilon_0 A}$ ....(1)

$$\Rightarrow \frac{V}{d} = \frac{Q}{\varepsilon_0 A} \left[\because E = \frac{V}{d}\right]$$

$$\Rightarrow \frac{V}{d} = \frac{CV}{\varepsilon_0 A} \quad [\because Q = CV]$$

$$\Rightarrow C = \frac{\varepsilon_0 A}{d}$$

$\therefore$ Capacitance of the parallel plate capacitor is given by $C = \dfrac{\varepsilon_0 A}{d}$

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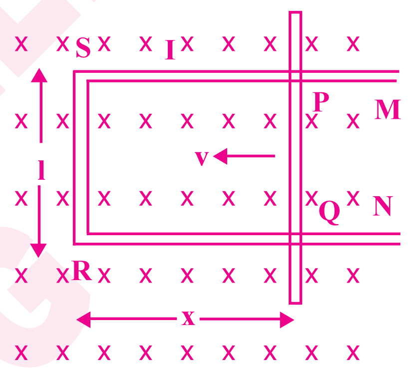
15. Obtain an expression for the <u>emf induced across a conductor</u> which is moved in a <u>uniform magnetic field</u> which is <u>perpendicular to the plane of motion.</u>

A : Induced emf due to motion of a conductor in a magnetic field:



1) Let us suppose that PQRS is a rectangular conductor.

It is placed in a uniform magnetic field B which is perpendicular to the plane of the system.

2) The conductor PQ is free to move. Suppose, the conductor PQ is moved towards left with velocity v.

3) Let RQ = x and RS = l.

4) Then the magnetic flux enclosed by the loop PQRS is $\phi_B = B\, l\, x$

5) The induced emf is $\varepsilon = -\dfrac{d\phi_B}{dt} = -\dfrac{d}{dt}(B\, l\, x) \Rightarrow \varepsilon = -B\, l \dfrac{dx}{dt}$

But $\dfrac{dx}{dt} = -v$

6) $\therefore$ Induced emf $\varepsilon = B\, l\, v$

16. 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....

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

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....

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

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,........

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

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,..........

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

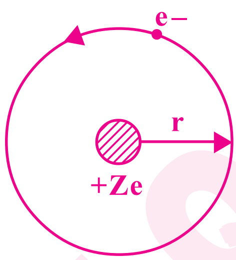
5) **Pfund Series :** When an electron jumps from any outer orbits to the fifth orbit, we get Pfund series. It is observed in the **far infrared** region. Here n_1=5 and n_2=6,7,8,..........

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

17. Derive an expression for the magnetic dipole moment of a revolving electron.

A: Magnetic Dipole Moment due to Revolving Electron:

Let us suppose that an electron is revolving in a circular orbit of radius r with a speed v and time period T.



Formula: $v = \frac{2\pi r}{T} \Rightarrow T = \frac{2\pi r}{v}$

Current $i = \frac{e}{T} \Rightarrow i = \frac{ve}{2\pi r}$

Magnetic dipole moment $M = iA = \frac{ve(\pi r^2)}{2\pi r}$

Magnetic dipole moment due to revolving electron is $M = \frac{evr}{2}$

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18. Distinguish between half-wave and full wave rectifiers.

A :

Half wave rectifier	Full wave rectifier
1) A **single diode** is used in half wave rectifier.	1) **Two diodes** are used in full wave rectifier.
2) A **transformer without centre tap** is used in it.	2) A **transformer with centre tap** is used in it.
3) Half wave rectifier converts only one half of AC into DC.	3) Full wave rectifier converts both the half cycles of AC into DC.
4) Its maximum efficiency is 40.6%.	4) Its maximum efficiency is 81.2 %.

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.

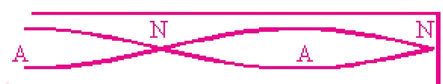
5) **First Harmonic:** Here, 1 node and 1 antinode is formed.

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

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

$$\therefore \ n_1 = \frac{V}{4l} \quad \text{....................(i)}$$

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



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

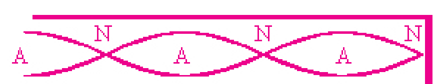
$$\therefore l = \frac{3\lambda_3}{4} \Rightarrow \lambda_3 = \frac{4l}{3}$$

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

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

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

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



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

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

TAG P) 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=?

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

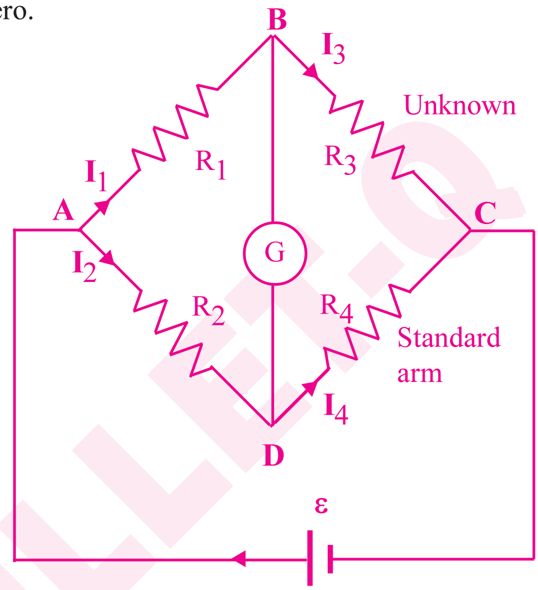
2) Kirchoff's Second Law : The algebraic sum of changes in potential around any closed loop involving resistors and cells in the loop is zero.

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.



Wheatstone bridge

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 $I_1 R_1 + 0 - I_2 R_2 = 0$

$\Rightarrow I_1 R_1 = I_2 R_2 \Rightarrow \dfrac{I_1}{I_2} = \dfrac{R_2}{R_1}$ ....(3)

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

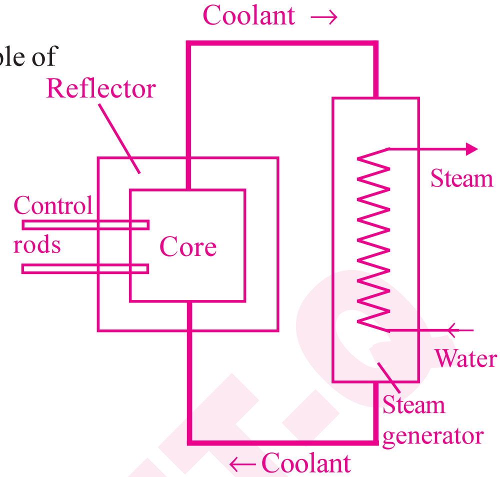
$\Rightarrow I_3 R_3 = I_4 R_4$ From (1) & (2) $I_3 = I_1$ and $I_4 = I_2$

$\therefore I_1 R_3 = I_2 R_4 \Rightarrow \dfrac{I_1}{I_2} = \dfrac{R_4}{R_3}$ ....(4)

Equating the RHS of equ (3) and equ (4), we get $\dfrac{R_2}{R_1} = \dfrac{R_4}{R_3} \Rightarrow \dfrac{R_1}{R_2} = \dfrac{R_3}{R4}$

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

21. Explain the principle and <u>working of a nuclear reactor</u> with the help of a labelled diagram.



Nuclear Reactor

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 Sheilding

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*l* 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.