Previous IPE

SOLVED PAPERS

MARCH-2020 (AP)

PREVIOUS PAPERS

IPE: MARCH-2020(AP)

Time : 3 Hours **SR.PHYSICS** Max.Marks : 60

SECTION-A

I. Answer all questions : $10 \times 2 = 20$

1. Two lenses of power –1.75D and +2.25D respectively, are placed in contact. Calculate the focal length of the combination.
2. What is the importance of Oersted's experiment?
3. Classify the following materials with regard to magnetism : Bismuth, Cobalt, Oxygen, Copper .
4. Define Magnetic inclination or angle of dip.
5. What is transformer ratio?
6. The charging current for a capacitor is 0.6A. What is the displacement current across its plates?
7. What is "Photoelectric effect"?
8. What is the de Broglie wave length associated with an electron, celerated through a potential difference of 100 volts?
9. In which bias can a zener diode can be used as voltage regulator?
10. Mention the frequency range of speech signals.

SECTION-B

II. Answer any six of the following Questions. $6 \times 4 = 24$

11. Explain the formation of a rainbow.
12. Does the principle of conservation of energy hold for interference and diffraction phenomena? Explain briefly.
13. State Gauss's law in electrostatics and explain its importance.
14. Derive an expression for the capacitance of a parallel plate capacitor.
15. State and explain Ampere's law.
16. Obtain an expression for the mutual inductance of two long co-axial solenoids.
17. The wavelength of first member of Balmer series is 6563Å . Calculate the wavelength of second member of Lyman series.
18. Write truth tables of Universal logic gates.

SECTION-C

III. Answer any two of the following Questions. $2 \times 8 = 16$

19. What is Doppler effect ? Obtain an expression for the apparent frequency of sound heard when the source is in motion with respect to an observer at rest.
20. (a) State Kirchhoff's laws for an electrical network. Using these laws deduce the conditions for balance in a Wheatstone bridge.
    (b) The four resistors 20Ω, 40Ω,(20+x)Ω,80Ω respectively form a Wheatstone bridge. Find the value of 'x'.
21. (a)Explain the principle and working of a nuclear reactor with the help of a labelled diagram.
    (b) Compare the radii of the nuclei of mass numbers 27 and 64.

IPE AP MARCH-2020

SOLUTIONS

SECTION-A

1. Two lenses of power –1.75D and +2.25D respectively, are placed in contact. Calculate the focal length of the combination.

A: $P_1 = -1.75$ D, $P_2 = +2.25$ D, P = ? , f = ?

Formula for combined power: $P = P_1 + P_2 \Rightarrow P = -1.75 + 2.25 \Rightarrow P = +0.50$ D

Formula for focal length : $f = 1/P \Rightarrow$ $f = 1/0.50 = 2$ m = **200 cm**

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2. What is the importance of Oersted's experiment ?

A : **1) Oersted's Experiment:** Whenever a current is passed through a conductor, a magnetic field is produced around the conductor carrying current.

2) Importance :

i) The relation between electric current and magnetism is identified with this experiment.

ii) This experiment showed that the origin of magnetic field is due to motion of electric charges.

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3. Classify the following materials with regard to Magnetism. Manganese, Cobalt, Nickel, Bismuth, Oxygen, Copper

A : **1) Para magnetic :** Manganese and Oxygen

2) Dia magnetic : Bismuth and Copper

3) Ferro magnetic : Cobalt and Nickel

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4. Define magnetic inclination or angle of dip.

A : **Magnetic Inclination :** At a given place, the angle between 'total Earth's field' and it's 'horizontal line in magnetic meridian' is called Magnetic inclination.

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5. What is transformer ratio ?

A : **1) Transformer Ratio :** Ratio between number of turns in the secondary coil and the number of turns in the primary coil of a transformer is called transformer ratio.

2) Transformer ratio $= \frac{N_s}{N_p} = \frac{V_s}{V_p}$

6. The charging current for a capacitor is 0.6 A. What is the displacement current across its plates ?

A : The displacement current is equal to charging current at every instant.

So, the displacement current is 0.6 A.

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7. What is photoelectric effect ?

A : 1) Photoelectric Effect: When the surface of a metal is illuminated by electro magnetic radiation of suitable frequency, electrons are emitted from the surface of the metal. This phenomenon is called photoelectric effect.

2) The electrons emitted in photoelectric effect are called photoelectrons.

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8. What is the de Broglie wave length associated with an electron, accelerated through a potential difference of 100 volts?

Sol: Given V= 100 V, λ=?

Formula: $\lambda = \frac{1.227}{\sqrt{V}}\ \text{nm} = \frac{1.227}{\sqrt{100}} = \frac{1.227}{10} = 0.1227\,\text{nm}$

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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 of zener diode, zener voltage remains constant over a large range of current.

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10. Mention the frequency range of speech signals.

A : Frequency Range of Audio Signals:

The frequency range of audio signals is from 300 Hz to 3100 Hz. (Its band width is 2800 Hz)

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.

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12. Does the principle of conservation of energy hold for interference and diffraction phenomena? Explain briefly.

A : 1) Yes. The principle of conservation of energy 'holds good' for both 'interference and diffraction'.

2) Patterns of bright and dark fringes are formed in interference and diffraction.

3) These patterns obey the principle of conservation of energy.

4) In interference and diffraction, light energy is redistributed.

5) If it reduces in one region producing a dark fringe, it increases in another region producing bright fringe.

6) Thus there is no gain or loss of energy.

7) Hence, total energy remains constant.

13. State Gauss' law in electrostatics and explain its importance.

A : 1) Gauss' Law: The total electric flux (ϕ) through any closed surface is equal to $\frac{1}{\varepsilon_0}$ times the net charge (q) enclosed by the closed surface. Thus $\phi = \frac{1}{\varepsilon_0}(q)$

2) Importance of Gauss' Law:

i)Gauss' law is true for any closed surface (of any shape and any size).

ii)Gauss law gives the relation between the electric field and the charge.

iii)Gauss' law is valid for stationary charges as well as for rapidly moving charge.

iv)Gauss' law is based on Coulomb's law. Gauss' law is valid as long as Coulomb's law is valid.

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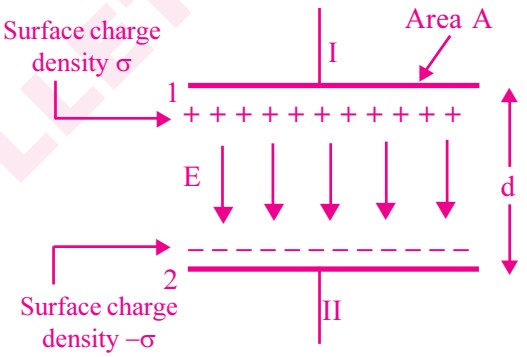
14. Derive an expression for the capacitance of a parallel plate capacitor.

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

Electric field between two charged plates is

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

But $\sigma = Q/A$

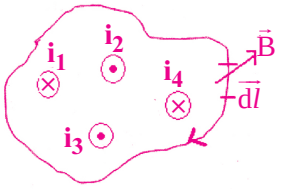
$\therefore$ The field inside the capacitor is $E = \frac{Q}{\varepsilon_0 A}$ .....(1)

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

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

15. State and explain Ampere's law.

A: 1) Ampere's Law: The line integral of the intensity of magnetic induction field ($\oint \vec{B}.d\vec{l}$) around a closed curve is equal to μ_0 times the net current (i) bounded by the curve.



2) Thus, $\oint \vec{B}.d\vec{l} = \mu_0 i$

where $d\vec{l}$ = small element of the path,

μ_0 = permeability of free space.

3) Explanation:

i) Consider a closed curve as shown in the figure. d*l* is a small length element on the curve.

ii) Let B is the resultant magnetic field of the position of d*l*.

iii) Currents i_1, i_4 are directed into the plane of paper and are positive.

iv) Currents i_2, i_3 are directed outward to the plane of paper and are negative.

v) So, the total current crossing the area bounded by the closed curve is $i = i_1 - i_2 - i_3 + i_4$

Hence, $\oint \vec{B}.d\vec{l} = \mu_0 (i_1 - i_2 - i_3 + i_4)$ $\therefore \oint \vec{B}.d\vec{l} = \mu_0 i$

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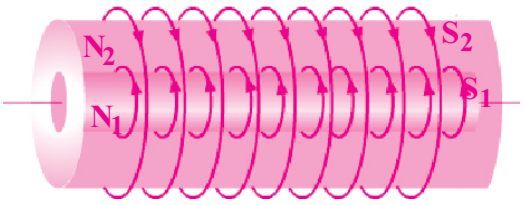
16. Obtain an expression for the mutual inductance of two long coaxial solenoids.

A: 1) Mutual Inductance: As long as the current in one of the two adjacent coils changes, a current is induced in the other coil. This phenomenon is called mutual induction.

2) Mutual induced emf $\varepsilon = -M\frac{di}{dt}$

where M is mutual inductance of the coils.



3) Expression for Mutual Inductance of two co-axial Solenoids: Let us consider two coaxial solenoids S_1,S_2 each of length *l*. Let r_1 and r_2 be the radii, n_1 and n_2 be the number of turns per unit length, N_1 and N_2 be the total number of turns of the solenoids S_1 and S_2 respectively.

4) When a current i_2 is set up in S_2, it sets up a magnetic flux ϕ_1 through S_1.

Then $N_1 \phi_1 = M_{12} i_2$ .....(i),where M_{12} is mutual inductance of S_1 with respect to S_2.

5) The magnetic field due to current i_2 in S_2 is $\mu_0 n_2 i_2$.

$\therefore N_1 \phi_1 = (n_1 l)(\pi r_1^2)(\mu_0 n_2 i_2) = \mu o\, n_1 n_2 \pi r_1^2 l\, i_2$ ..... (ii)

6) From (i) and (ii), we get $M_{12} = \mu_0 n_1 n_2 \pi r_1^2 l$ .....(iii)

7) In a similar way, considering the reverse case of flux through S_2 due to current I_1 through S_1, we get $M_{21} = \mu_0 n_1 n_2 \pi r_1^2 l$ .....(iv)

8) From equ (iii) and (iv), we get $M_{12} = M_{21} = M$ and hence $M = \mu_0 n_1 n_2 \pi r_1^2 l$

17. The wavelength of first member of Balmer series is 6563Å. Calculate the wavelength of second member of Lyman series.

Sol: Wavelength equation for Balmer series is $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

For first member of Balmer Series, $\frac{1}{6563} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) \Rightarrow \frac{1}{6563} = \frac{5R}{36}$ ....(1)

For second member of Lyman Series, $\frac{1}{\lambda^1} = R\left(\frac{1}{1^2} - \frac{1}{3^2}\right) \Rightarrow \frac{1}{\lambda^1} = \frac{8R}{9}$ .....(2)

$$\frac{(1)}{(2)} \Rightarrow \frac{\lambda^1}{6563} = \frac{5R}{36} \times \frac{9}{8R}$$

$$\lambda^1 = \frac{5}{32} \times 6563 = 1025.5\text{Å}$$

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18. Write truth tables of Universal logic gates.

A:

NAND gate-Truth Table

Input		Output
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

AND gate-Truth Table

Input		Output
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

In NAND gate, the output becomes zero only when both the inputs are 1. It is opposite to AND gate.

In AND gate the output becomes 1 only when both the inputs are 1.

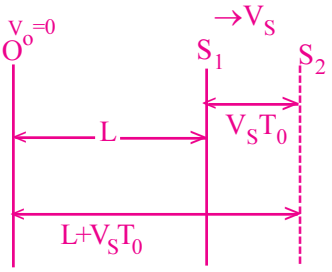
The symbol of NAND gate is 

The symbol of AND gate is 

SECTION-C

19. What is Doppler effect ? Obtain an expression for the apparent frequency of sound heard when the source is in motion with respect to an observer at rest.

A: **1) Doppler Effect:** The phenomenon of apparent change in frequency received by the observer due to relative motion between source and observer is known as doppler effect.



2) Apparent frequency when the Source is in motion w.r.t. an Observer at rest: Suppose observer is rest at O, the source (S_1) is moving away from the observer, with a velocity V_S.

3) If L is the distance between O and S_1, V is Velocity of sound then time taken by the 'first wave' to reach the observer is $t_1 = \frac{L}{V}$ .....(i)

4) Time taken by the 'second wave' to reach the observer is $t_2 = T_0 + \frac{(L + V_S T_0)}{V}$ .....(ii)

5) From (i) & (ii) apparent time period $T = t_2 - t_1$

$$= \left(T_0 + \frac{L + V_s T_0}{V} \right) - \frac{L}{V}$$

$$= T_0 + \frac{\cancel{L}}{\cancel{V}} + \frac{V_s T_0}{V} - \frac{\cancel{L}}{\cancel{V}}$$

$$= T_0 + \frac{V_s T_0}{V}$$

$$= T_0 \left(1 + \frac{V_s}{V} \right)$$

$$T = T_0 \left(\frac{V + V_s}{V} \right)$$

$$\frac{1}{T} = \frac{1}{T_0} \left(\frac{V}{V + V_s} \right)$$

6) But we know $\frac{1}{T} = n$ and so $\frac{1}{T_0} = n_0$

7) $\therefore$ Apparent frequency heard by the observer $n = n_0 \left(\frac{V}{V + V_s} \right)$

8) Similarly, when the source is approaching the observer, we replace V_s by $-V_s$

$\therefore$ Apparent frequency $n = n_0 \left(\frac{V}{V - V_s} \right)$

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.

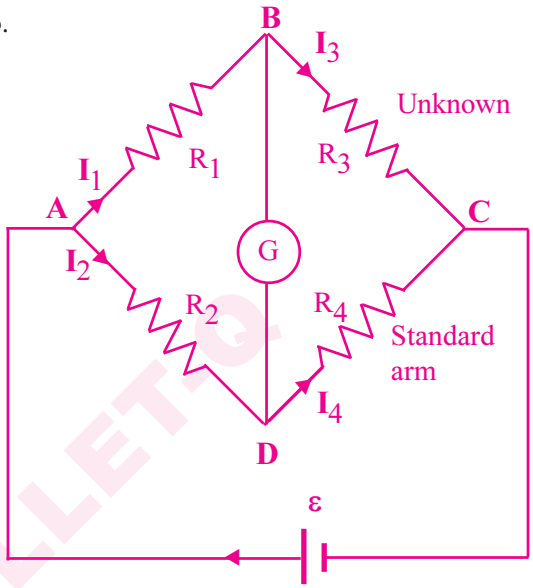
2) Kirchoff's Second Law : The algebraic sum of changes in potential around any closed loop involving resistors and cells in the loop is zero.

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 $I_1 R_1 + 0 - I_2 R_2 = 0$

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

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 $I_4 = I_2$

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

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

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

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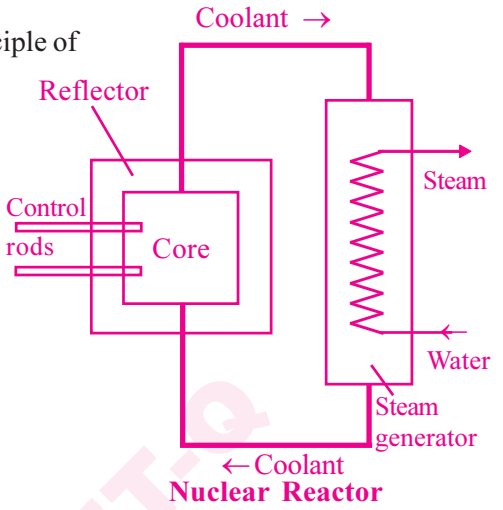
b) The four resistors 20Ω, 40Ω, (20+x)Ω, 80Ω respectively form a wheatstone bridge. Find the value of 'x'.

Sol: From balanced Wheatstone bridge Principle

$$\frac{P}{Q} = \frac{R}{S} \Rightarrow \frac{20}{40} = \frac{(20+x)}{80} \Rightarrow 20 + x = 40 \Rightarrow x = 20$$

21. 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.**



Nuclear Reactor

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

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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.

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b) Compare the radii of the nuclei of mass numbers 27 and 64.

Sol: Given $A_1 = 27, A_2 = 64, \frac{R_1}{R_2} = ?$

Nuclear radius $R = R_0 A^{1/3}$ or $R \propto A^{1/3} \Rightarrow \frac{R_1}{R_2} = \frac{\sqrt[3]{A_1}}{\sqrt[3]{A_2}} = \frac{\sqrt[3]{27}}{\sqrt[3]{64}} = \frac{3}{4}$

$\therefore R_1 : R_2 = \mathbf{3 : 4}$