ANNUAL EXAMINATION - ANSWER KEY -2019

II PUC - PHYSICS

PART - A

I. Answer **all** the following questions: **(10 × 1 = 10)**

1. State Coulomb's Law.

Columb's inverse square law states that force of attraction or repulsion between two static , point charges is directly proportional to the product of magnitudes of charges and inversely proportional to square of the distance between them.

2. Define electrical resistivity of material of a conductor

Resistance of a conductor per unit length and per unit area of cross section is called resistivity. .

3. Write the expression for force acting on a moving charge in a magnetic field.

$F = q(\vec{v} \times \vec{B})$ **or Bqv sin** θ

4. What is magnetic susceptibility?

Ratio of magnetization to magnetic intensity is called magnetic susceptibility.

5. How the self inductance of a coil depends on number of turns in the coil?

Directly proportional to square of number of terms L α n^2

6. For which position of the object magnification of convex lens is -1 (minus one)?

Twice the focal length distance , from the lens.

7. For which angle of incidence reflected ray is completely polarized?

Brewster's angle (polarizing angle)

8. Mention any one type of electron emission.

Thermionic emission (field / photoelectric. Emission)

9. Write the expression for energy of an electron in electron orbit of hydrogen atom.

Energy in nth Bohr orbit, $E_n = \dfrac{-me^4}{8\varepsilon_0^2 n^2 h^2}$

10. Write the relation between Half-Life and Mean-Life of radio active element.

$T_{\frac{1}{2}} = 0.6932\ \mathbf{T_m}$

PART - B

II. Answer **any five** of the following questions: **(5 × 2 = 10)**

11. Write any two basic properties of charge

(i) Charge is quantized

(ii) Charge is conserved

(iii) Charge is additive (any two)

12. Write the expression for drift velocity interms of current, explain the terms used.

$V_d = \frac{I}{nAc}$

I = current

n = no. of electrons per unit volume

A = Area of cross section

c = Charge of electron

13. Define magnetic 'dip' and 'declination' at a place.

The angle between the total magnetic field of earth and horizontal along magnetic meridian

Declaration:

Angle between geographic meridian and magnetic meridian at a given place.

14. Write the expression for speed of light interms of "μ_0" and "ϵ_0", explain the terms used.

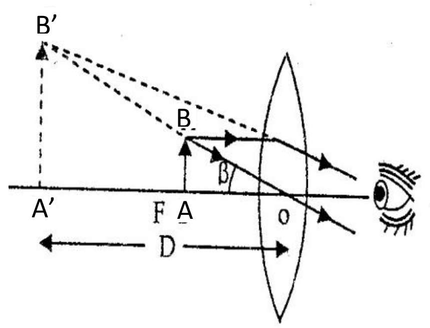
$C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

C = speed of light

μ_0 = magnetic permeability of free space

ε_0 = electric permittivity of free space

15. Write the ray diagram for formation of image in the simple microscope.



16. What is diffraction of light?

The phenomenon of bending of light around the sharp edges of small obstacles or around the edges of narrow slits.

Eg: Colours seen when compact disc is viewed.

17. Write the expression for de-Broglie wave length of electrons in terms of electric potential and explain the terms used.

$$\lambda = \frac{h}{\sqrt{2meV}}$$

λ = de- Broglie wavelength, h = Planck's constant , m=mass of electron V = potential , e =chrge of electron

18. Distinguish between n-type and p-type semi conductors.

n – type	p-type
1) majority carriers are electrons	1) majority carries are holes
2) semiconductor is doped with pentavalent atoms	2) semiconductor is doped with trivalent atoms

PART - C

II. Answer **any five** of the following questions: **(5 × 3 = 15)**

19. Derive an expression for potential energy of electric – dipole placed in an uniform electric field.

Consider an electric dipole placed in a uniform electric field E at an angle θ. Torque experienced by the dipole is $\tau = pE\sin\theta$, where p is the electric dipole moment.

Work done in rotating the dipole further through a small angle $d\theta$ against the torque is $dW = \tau\, d\theta$

$\therefore$ Total work done by external torque in rotating the dipole from angle θ_1 to θ_2 is

$$W = \int_{\theta_1}^{\theta_2} \tau d\theta = \int_{\theta_1}^{\theta_2} pE\sin\theta d\theta$$

$$W = pE\left[-\cos\theta\right]_{\theta_1}^{\theta_2} = -pE\left[\cos\theta\right]_{\theta_1}^{\theta_2}$$

$W = -pE\ (\cos\theta_2 - \cos\theta_1) = pE\ (\cos\theta_1 - \cos\theta_2)$

This work done is stored as the potential energy of the system.

If the dipole is initially perpendicular to the field (potential energy=0), and then deflects through θ ($\theta_1=90^\circ$ and $\theta_2=\theta$), the work done in deflecting through θ is

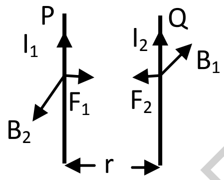
$W = -pE\cos\theta$

Hence Potential energy of the dipole in an electric field is $U=-pE\cos[\theta-0]= -pE\cos\theta$

20. Write the expression for force per unit length between two straight parallel current carrying conductors of infinite length. Hence define SI unit of current 'ampere'.

The expression for force between two long straight, parallel conductors carrying currents

is $\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi r}$



Force is attractive for currents in same direction and repulsive for currents in opposite directions.

One ampere is defined as the identical currents through two long, straight ,parallel conductors placed in vacuum with a separation of 1 metre , when they attract each other with a force per unit length of 2×10^{-7} N/m

21. Distinguish between 'dia' and 'ferro' magnetic materials.

Diamagnetic	**Ferro**
1) Substances which are weakly magnetized in a direction opposite to that of the magnetizing field	1) Substances which are strongly magnetized in the direction of the magnetizing field.
2) Substances are weakly repelled by a strong magnet	2) Substances are strongly attracted by even weak magnet.
3) Susceptibility is low and negative	3) Susceptibility in high and positive

22. Mention the three type's energy loss in a transformer.

1. Loss due to heating of coils
2. Loss due to Eddy currents
3. Hysteresis loss
4. Loss due to flux leakage. (any 3)

23. Write three experimental observations of photoelectric effect.

1. The photoelectric e emission in instantaneous process.
2. Maximum K.E of photoelectron is directly proportional to frequency of incident radiation.

3. For a given metal and frequency of incident radiation saturation current is directly proportional to intensity of incident radiation.

24. Write the three postulates of Bohr's atomic model.

1. An atom has central positively charged nucleus. Electrons revolve round the nucleus in circular orbits called stationary orbits. The necessary centripetal force is provided by the electrostatic force of attraction between the nucleus and the electron.

i.e. $\frac{m v^2}{r} = \frac{1}{4\pi\varepsilon_0} \frac{e \times e}{r^2}$, where m is the mass and v is the velocity of electron and r is the radius of the orbit . Electrons do not radiate in stationary orbits.

2. In stationary orbit ,angular momentum of the electron is equal to integral multiple of $\frac{h}{2\pi}$, where h is Planck's constant.

Angular momentum, $mvr = n\frac{h}{2\pi}$ where n = 1, 2, 3…… (Bohr's quantization rule), where n is called principal quantum number.

3. An electron radiates energy only when it jumps from one orbit of higher energy to another of lower energy.

If E_0 and E_i are the energies of an electron in the outer and inner orbits respectively, then frequency of the emitted radiation v is given by $v = \frac{E_0 - E_i}{h}$ (Bohr's frequency condition) where h is Planck's constant.

25. Explain 'Conduction band' 'Valance band' and 'Energy gap', in semi conductors.

In an isolated atom, like Hydrogen atom, electron has definite energy values, corresponding to different orbits.

In the case of solids, atoms are closely packed and interaction takes place between electrons of outer orbits of different atoms. This results in splitting of energy values.

Valance band is the energy range for valence electrons.

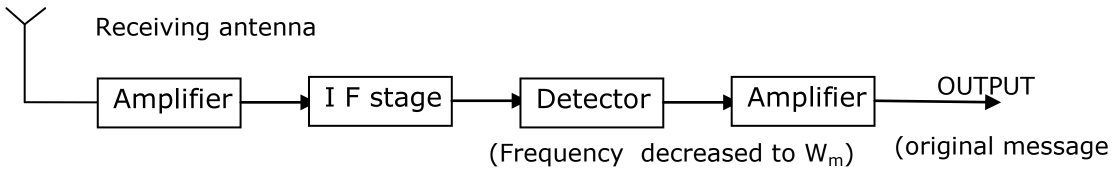
The energy range of conduction or free electrons is called **conduction band**.

The gap between conduction band and valence band is called forbidden gap or **energy gap.**

26. What is modulation? Write the block diagram of the receiver.

Production of amplitude modulated wave

The Process of mixing low frequency signal with high frequency carrier wave is called modulation.



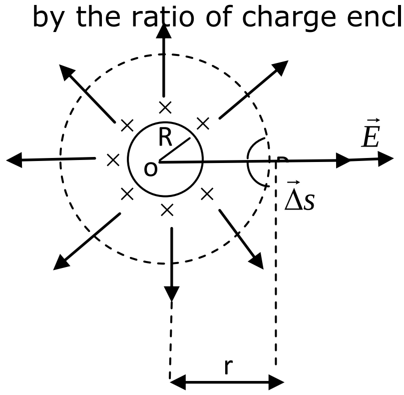
Block diagram of receiver

PART-D

IV. Answer **any two** of the following questions: **(2 × 5 = 10)**

27. State Gauss's law. Derive an expression for electric intensity at a point outside the uniformly charged shell.

Gauss law states that electric flux through any surface enclosing charge completely is given by the ratio of charge enclosed to the absolute permittivity of space.



Consider a spherical shell of radius R , carrying charge q., with centre O.

Let P be a point at a distance r from centre O. Consider a Gaussian sphere with centre O and radius r. The total electric flux through this surface is

$\phi = \Sigma$ (E cos θ) Δs, (electric field at all points on the Gaussian surface is same in Magnitude)

$= \Sigma$ E Δs (∵ $\theta = 0°$, E is normal to the surface.)

ϕ = E(4 πr^2) ....(1) (∵ $\Sigma \Delta s = 4\pi r^2$, area of the Gaussian sphere)

By Gauss theorem, the total electric flux through the Gaussian surface is

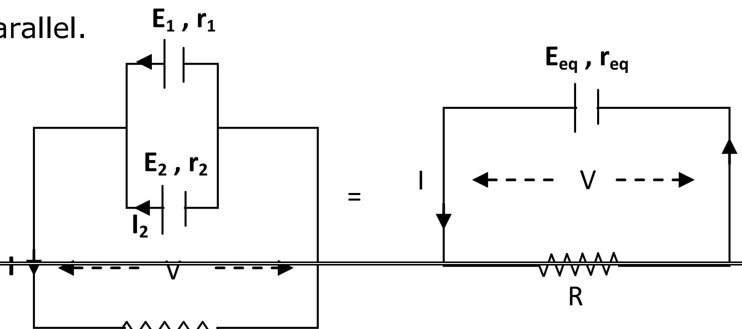
$$\phi = \frac{1}{\varepsilon_0}(q) \text{.........(2)}$$

From (1) & (2), $$E(4\pi r^2) = \frac{1}{\varepsilon_0}(q)$$

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

28. Two cells of emf E_1 and E_2 and internal resistance r_1 and r_2 are connected in parallel such that they send current in same direction. Derive an expression for equivalent resistance and equivalent emf of the combination.

The expression for equivalent emf and equivalent internal resistance for two cells connected in parallel.



Cells are said to be in parallel if negative terminals of all the cells are connected together to one terminal and positive terminals are connected to the other terminal. Consider two cells having emf's E_1, E_2 and internal resistances r_1, r_2 respectively connected in parallel.

Let I_1 and I_2 are the currents through the cells respectively, then the main current is

$$I = I_1 + I_2 \text{ …….(1)}$$

If V is the terminal p.d across each cell then for the first cell, $V = E_1 - I_1 r_1$

$$\text{or } I_1 = \frac{E_1 - V}{r_1}$$

And for the second cell, $V = E_2 - I_2 r_2$ or $I_2 = \frac{E_2 - V}{r_2}$

Substituting I_1 and I_2 in eqn. (1) $I = \frac{E_1 - V}{r_1} + \frac{E_2 - V}{r_2}$

$$I = \frac{E_1}{r_1} + \frac{E_2}{r_2} = V\left(\frac{1}{r_1} + \frac{1}{r_2}\right) ----(2)$$

Let the parallel grouping of cells be replaced with a single cell of emf E_{eq} and internal resistance r_{eq} then, $V = E_{eq} - I\, r_{eq}$

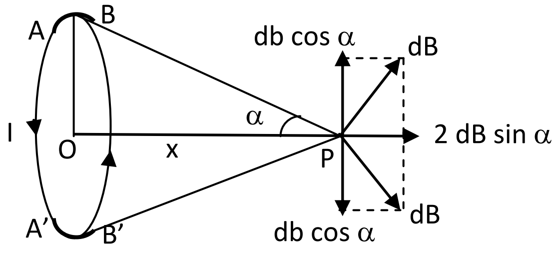
$$\text{or } I = \frac{E_{eq}}{r_{eq}} = \frac{V}{r_{eq}} \text{.............(3)}$$

Comparing (2) and (3), $\frac{E_{eq}}{r_{eq}} = \frac{E_1}{r_1} + \frac{E_2}{r_2}$ *and* $\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2}$ *or* $r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$

$$E_{eq} = \left[\frac{E_1}{r_1} + \frac{E_2}{r_2}\right] r_{eq} = \left[\frac{E_1 r_2 + E_2 r_1}{r_1 r_2}\right]\left[\frac{r_1 r_2}{r_1 + r_2}\right] = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}.$$

29. Derive an expression for the intensity of magnetic field at any point on the axis of a circular current loop.

Consider a circular coil having N turns with mean radius r and carrying current I. Let P be a point on the axis, at distance x from the centre O.



The magnetic field at P due to AB is, $dB = \left(\frac{\mu_0}{4\pi}\right)\frac{Id\ell\sin\theta}{a^2}$ *along* PM…….(1)

where 'a' is the distance between the point and the element AB.

$$dB = \left(\frac{\mu_0}{4\pi}\right)\frac{Id\ell}{a^2}$$

$(\because \theta = 90)$. Similarly magnetic field at P due to the element A'B' is

$dB = \left(\frac{\mu_0}{4\pi}\right)\frac{Id\ell}{a^2}$ along PN …..(2)

The magnetic field dB is resolved into horizontal and vertical components, dBsinα and dBscosα respectively, where α is the angle between line joining the point to the element and axis of the coil.

The vertical components of magnetic fields being equal and opposite cancel each other and horizontal components add up.

Hence magnetic field at P due to two current elements = 2dBsinα

$\therefore$The resultant magnetic field at P due to one turn of the coil = Σ 2dB sin α

$= \sum 2\left(\frac{\mu_o}{4\pi}\right)\frac{Idl}{a^2}\sin\alpha$ from (1)

$= \left(\frac{\mu_o}{4\pi}\right)\frac{2I}{a^2}\sum d\ell \sin\alpha$

$= \left(\frac{\mu_o}{4\pi}\right)\frac{2I}{a^2}\pi r \sin\alpha$ Since the field is due to 2 elements , $\sum dl = \frac{Circumference}{2} = \pi r$

$= \left(\frac{\pi_o}{4\pi}\right)\frac{2\pi I r^2}{a^3}$ From ΔROP, $\sin\alpha = \frac{r}{a}$

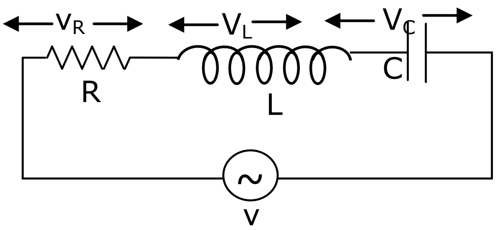
$= \left(\frac{\pi_o}{4\pi}\right)\frac{2\pi I r^2}{(r^2 + x^2)^{3/2}}$ From ΔAOP, $a = (r^2 + x^2)^{1/2}$ or $a^3 = (r^2 + x^2)^{3/2}$

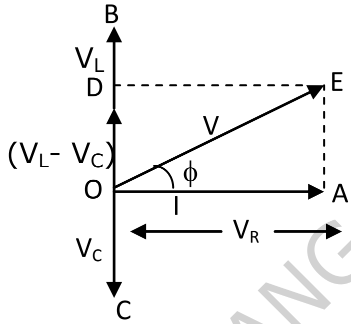
For N turns of the coil $B = \left(\frac{\pi_o}{4\pi}\right)\frac{2\pi N I r^2}{(r^2+x^2)^{3/2}}$.

The direction of the magnetic field is along the axis of coil.

V. Answer **any two** of the following questions: **(2 × 5 = 10)**

30. Derive an expression for the impedance of a series LCR circuit, when an AC voltage is applied to it.





Consider a wire of resistance 'R', coil of inductance 'L' and capacitor of capacitance 'C' connected in series with a sinusoidal AC source.

$V = V_0 \sin \omega t$ ....(1)

Let, $I = I_0 \sin(\omega t - \phi)$ -----(2) be the current, which is same through the circuit elements at any time.

Where ϕ is the phase difference between the voltage and current in the circuit.

If V_R, V_L and V_C are the p.d across R, L and C respectively, then we have,

$V_R = IR$, $V_L = IX_L$ and $V_C = IX_C$. V_R is in phase with current I, V_L leads I by $\pi/2$ and V_C lags behind current I by $\pi/2$.

If V is the p.d across the combination, (applied voltage) then V is the phasor sum of V_R, V_L and V_C as shown in the figure. V_R, V_L and V_C are represented by the vectors OA, OB and OC respectively. If $V_L > V_C$, the resultant of these two values is ($V_L - V_C$) represented by the vector OD.

From the phasor diagram,

$$V^2 = V_R^2 + (V_L - V_C)^2$$

$$V^2 = (IR)^2 + (IX_L - IX_C)^2$$

$$V = \sqrt{(IR)^2 + (IX_L - IX_C)^2}$$

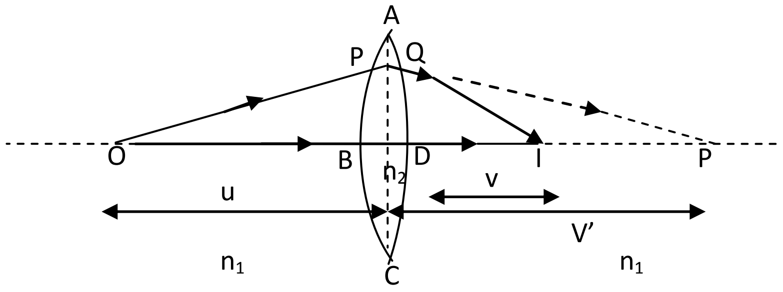
$$V = I\sqrt{R^2 + (X_L - X_C)^2}$$

$$V = I \times Z$$

Impedance $Z = \sqrt{R^2 + (X_L - X_C)^2}$ which is the effective opposition offered by the circuit for the flow of AC through it. Also $\tan\phi = \frac{V_L - V_C}{V_R} = \frac{IX_L - IX_L}{IR} = \frac{X_L - X_C}{R}$

$$\phi = \tan^{-1}\left[\frac{X_L - X_C}{R}\right].$$

31. Derive "Lensmaker's" formula



Consider a thin convex lens of focal length f of refractive index n_2, surrounded by medium of R. I n_1 such that $n_2 > n_1$.

Let R_1 and R_2 be the radii of curvature of the surfaces ABC and ADC.

O is a luminous point object on the principal axis at a distance u from the optic centre. A ray incident along OB proceeds undeviated.

Another ray OP incident at P after refraction through the lens emerges along QI.

Refraction through a single spherical surface is given by

$$-\frac{R.I.of\ object\ space}{object\ distance} + \frac{R.I\ of\ image\ space}{image\ distance} = \frac{R.\ I\ of\ image\ space - R.\ I.of\ object\ space}{Radius\ of\ curvature}$$

….(1)

The refraction through the lens is considered in two steps.

1. Refraction at the surface ABC :

In the absence of the second surface ADC, the refracted rays from a real image I' at a distance v'.

For refraction at this surface, $-\frac{n_1}{u} + \frac{n_2}{v'} = \frac{n_2 - n_1}{R_1}$ ……… (2) using eqn (1)

2. Refraction at the surface ADC:

For refraction at this surface, the image I' acts as a virtual object forming a real image I at a distance V.

For refraction at this surface , $-\frac{n_2}{v'} + \frac{n_1}{v} = \frac{n_1 - n_2}{R_2}$ using eqn (1)

$$-\frac{n_2}{v'} + \frac{n_1}{v} = \frac{n_2 - n_1}{R_2}$$ …….. (3)

Adding eqn (2) and eqn(3) $= -\frac{n_1}{u} + \frac{n_1}{v} = \frac{n_2 - n_1}{R_1} - \frac{n_2 - n_1}{R_2}$

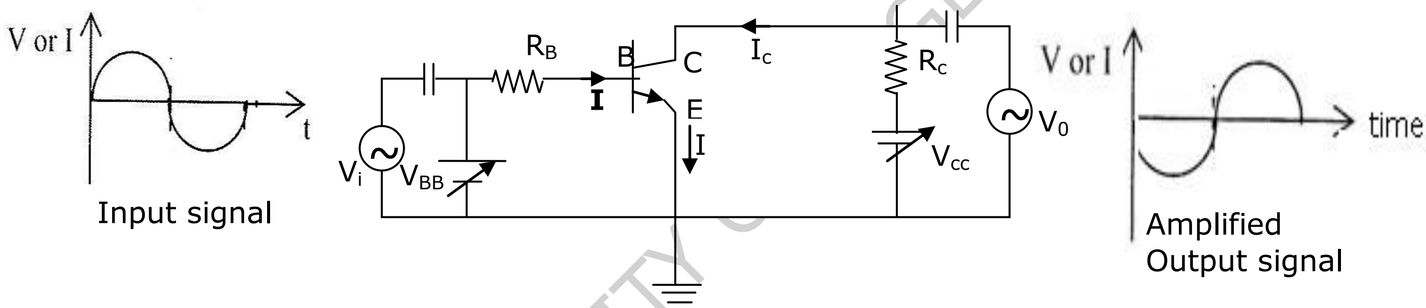
$$n_1\left[-\frac{1}{u}+\frac{1}{v}\right] = (n_2 - n_1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

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

$$\frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$ (using lens formula $\frac{1}{f} = -\frac{1}{u} + \frac{1}{v}$)

This is known as lens maker's formula.

32. Explain the working of a n-p-n transistor in CE mode as an amplifier.



In CE – amplifier circuit, EB junction is forward biased and CB junction is reversed biased. The input AC signal to be amplified is applied between the base and the emitter. The output is taken across the load resistance R_C included in the collector circuit.

When $V_i = 0$, the output voltage $V_0 = V_{CE} - I_C R_C$ ……(1) (Using KVL)

When V_i is not zero and during positive half cycle of ac, the input circuit is forward biased and the base current I_B increases. As I_B increases, I_C increases β times ($\because I_C = \beta I_B$).

As I_C increases, $I_C R_C$ increases which makes V_0 negative. During negative half cycle of ac, the base current I_B decreases. As I_B decreases, I_C decreases β times. As I_C decreases, $I_C R_C$ decreases which makes V_0 becomes positive. Thus input signal is amplified in opposite direction.

In the input region $V_{BB} = V_{BE} + I_B R_B$ ------ (1)

time

In the output region $V_{CC} = V_{CE} + I_C R_L$ ------- (2)

When input voltage V_i is applied $v_{BB} + V_i = (V_{BE} + \Delta V_{BE}) + (I_B + \Delta I_B) R_B$ - -(3) time

Also $V_{CC} = (V_{cE} + \Delta V_{CE}) + (I_c + \Delta I_c) R_C$ ……..(4)

(3) – (1) gives $V_i = (\Delta V_{BE}) + (\Delta I_B) R_B$ ($\Delta v_{BE} = r_i \times \Delta I_B$)

$V_i = \Delta I_B (R_B + r_i) = \Delta I_B \times r$ ($R_B + r_i = r$ ......(5)

(4)-(2) gives $0 = \Delta V_{CC} + \Delta I_C R_c \Rightarrow \Delta V_{ce} = -\Delta I_C R_c$ ....(6)

(6) /(5) $\Rightarrow$ $\dfrac{\Delta V_{CE}}{V_i} = \dfrac{V_o}{V_i} = voltage \;\; gain, A_v = -\dfrac{\Delta I_c R_c}{\Delta I_B \times r} = -\beta_{AC} \times \dfrac{R_C}{r}$

Output is amplified , but out of phase with input signal

Power gain = Voltage gain × current gain. $P_{gain} = A_V \times \beta$

VI. Answer **any three** of the following questions: **(3 × 5 = 15)**

33. In a circular parallel plate capacitor radius of each plate is 5 cm and they are separated by a distance of 2 mm. Calculate the capacitance and the energy stored, when it is charged by connecting the battery of 200 V

(given $\in_0 = 8.854 \times 10^{-12}$ Fm^{-1})

Solution:

Radius $r = 5$ cm $= 5 \times 10^{-2}$ m

$d = 2 \times 10^{-3}$ m : voltage applied = 200 v

$\varepsilon_0 = 8.8754 \times 10^{-12}$ Fm^{-1}

$A = \pi r^2 = 3.142 \times (5 \times 10^{-2}) = 0.007855 m^2$

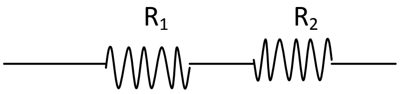
$$C = \frac{\varepsilon_0 A}{d}$$

$$C = \frac{8.854 \times 10^{-12} \times 0.007855}{2 \times 10^{-3}} = 34.8 \times 10^{-12} \text{ F}$$

$U = \frac{1}{2} \times 34.8 \times 10^{-12} \times (200)^2 = 6.96 \times 10^{-7}$ J

34. Two resistors are connected in series with 5V battery of negligible internal resistance. A current of 2A flows through each resistor. If they are connected in parallel with the same battery a current of $\frac{25}{3} A$ flows through combination.

Calculate the value of each resistance.



Solution:

E = 5V I = $\frac{E}{R_s}$

I = 2A (series)

$I = \frac{25}{3} A(parallel)$

$R_s = R_1 + R_2 = \frac{E}{I} = \frac{5}{2} = 2.5 \ \Omega$ ------------ (1)

$R_p = \frac{R_1 R_2}{(R_1 + R_2)} = \frac{E}{I} = \frac{5 \times 3}{25} = \frac{15}{25} = 0.6 \ \Omega$

$R_P = \frac{R_1 R_2}{R_1 + R_2} = \frac{R_1 R_2}{R_s} = 0.6 \Omega$ $R_1 R_2 = 1.5\Omega$

$(R_1 - R)^2 = (R_1 + R_2)^2 - 4R_1 R_2$

$(R_1 - R_2)^2 = (2.5)^2 - 4 \times 1.5 = 6.25 - 6 = 0.25$

$(R_1 - R_2)^2 = 0.25$ $R_1 - R_2 = 0.5 \ \Omega$ ---------- (2)

From (1) and (2)

$R_1 = \frac{3}{2} = 1.5\Omega$

$R_1 + R_2 = 2.5$ $1.5 + R_2 = 2.5$

$R_2 = 1\Omega$

35. A conductor of length 3m moving in a uniform magnetic field of strength 100 T . It covers a distance of 70 m in 5 sec. Its plane of motion makes an angle of 30° with direction of magnetic field. Calculate the emf induced in it.

Solution: L = 3m

B = 100 T

$E = Blv \sin\theta$ $v = \frac{70}{5} = 14$ m/s

$= 100 \times 3 \times 14 \times \frac{1}{2}$

E = 2100 V

36. In a Young's double slit experiment wave length of light used is 5000 Å and distance between the slits is 2 mm, distance of screen from the slits is 1m. Find fringe width and also calculate the distance of 7th dark fringe from central bright fringe.

Solution: $\lambda = 5000 \times 10^{-10}$ m

$d = 2 \times 10^{-3}$ m

$D = 1$ m

Fringe width $\beta = \dfrac{\lambda D}{d} = \dfrac{5000 \times 10^{-10} \times 1}{2 \times 10^{-3}} = 2.5 \times 10^{-4} m$

Distance of n^{th} dark band , $X_n = (2n - 1)\dfrac{\beta}{2} = (14-1) \times \dfrac{2500 \times 10^{-7}}{2} = 13 \times 1250 \times 10^{-7}$

$X_n = 1.625 \times 10^{-3}$m

37. Half life of U-238 undergoing α - decay is 4.5×10^9 years. What is the activity of one gram of U-238 sample?

Solution:

$T_{1/2} = 4.5 \times 10^9$ years

$T_{1/2} = 4.5 \times 10^9 \times 365 \times 24 \times 60 \times 60 = 1.42 \times 10^{17}$ s

Mass of sample , m = 1g   238 gram contains 6.023×10^{23} nuclei. Hence

no. of nuclei in 1 gram sample $N = \dfrac{6.023 \times 10^{23} \times 1}{238} = 2.53 \times 10^{21}$

Decay rate

$$R = \frac{dN}{dt} = \lambda N = \frac{0.693}{T_{1/2}} = \frac{0.693 \times 2.53 \times 10^{21}}{1.42 \times 10^{17}}$$

$= 1.23 \times 10^4\ s^{-1}$ or 1.23×10^4 becquerel

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