PART - I

1. (a)
2. (c)
3. (c)
4. (a)
5. (c)
6. (a)
7. (a)
8. (d)
9. (b)
10. (a)
11. (d)
12. (d)
13. (a)
14. (a)
15. (c)

PART - II

16. Hysteresis: -

It is the lagging of magnetization M behind the applied magnetic field H in a magnetic material. The magnetization depends on the history of the applied field.
Key points:
- Shows a hysteresis loop when H is cycled.
- Energy loss occurs in each cycle.
- Retentivity and coercivity are characteristics of hysteresis.

17. The intensity I of plane-polarized light transmitted through a polarizer is related to the angle θ between the light's vibration direction and the polarizer's axis by:

$I = I_0 \cos^2 \theta$
Where:
I_0 = initial intensity of the polarized light
θ = angle between light's polarization and polarizer axis.

18. Electrostatic Potential: -

It is the work done per unit positive charge in bringing a small test charge from infinity to a point in an electric field without acceleration.

19. Step (1): Formula for induced emf

$$\mathcal{E} = \frac{\Delta\Phi}{\Delta t}$$

Where:
$\Delta\Phi$ = change in magnetic flux
Δt = time
Step (2): Substitute values
$\Delta\Phi = 4\text{mWb} = 4 \times 10^{-3}$ Wb, $\Delta t = 0.4$ s

$$\mathcal{E} = \frac{4 \times 10^{-3}}{0.4} = 0.01 \text{ V}$$

20. Applications of Seebeck Effect: -

- Thermocouples: Used to measure temperature in industries and laboratories.
- Temperature sensors: Detect temperature differences in electronic devices.
- Thermoelectric generators: Convert heat energy into electrical energy.
- Infrared detectors: Measure radiation based on heat-induced voltage.

21. Decay constant λ is related to half-life $T_{1/2}$ by:

$$\lambda = \frac{\ln 2}{T_{1/2}}$$

Given $T_{1/2} = 5.01$ days:

$$\lambda = \frac{0.693}{5.01} \approx 0.138\text{day}^{-1}$$

22. Electromagnetic Waves: -

Electromagnetic waves are waves consisting of mutually perpendicular electric and magnetic fields that oscillate in phase and propagate through space at the speed of light without the need for a medium.

In short: They are self-propagating electric and magnetic fields.

23. Biasing: -

Biasing is the process of applying a DC voltage or current to a transistor or diode to set its operating point in the desired region of its characteristic curve.

Types of Biasing: -

(i) Fixed bias – DC voltage applied directly to the base.
(ii) Collector-to-base bias – Base connected to collector through a resistor.
(iii) Voltage-divider bias – Uses a resistor network to set base voltage.
(iv) Emitter bias – Combines fixed bias with emitter resistor for stability.

24. Given: Focal length $f = 150 \text{ cm} = 1.5 \text{ m}$

Formula for lens power:

$$P = \frac{100}{f(\text{ cm})} \text{ or } P = \frac{1}{f(\text{ m})}(\text{ in diopters , D})$$

Using meters:

$$P = \frac{1}{f(\text{ m})} = \frac{1}{1.5} \approx 0.67\text{D}$$

PART - III

25. β^+Decay (Beta Plus Decay):

- Process: A proton → neutron + positron (β^+) +neutrino (ν_e)
- Effect: Atomic number decreases by 1 , mass number unchanged

Example:

$${}^{11}_{6}C \rightarrow {}^{11}_{5}B + \beta^+ + \nu_e$$

26. Given:

$I = 0.2 \text{ A}, A = 0.5 \text{ mm}^2 = 0.5 \times 10^{-6} \text{ m}^2$
$n = 8.4 \times 10^{28} \text{ m}^{-3}, e = 1.6 \times 10^{-19}\text{C}$

Formula:

$$v_d = \frac{I}{neA}$$

Calculation:

$$v_d = \frac{0.2}{8.4 \times 10^{28} \cdot 1.6 \times 10^{-19} \cdot 0.5 \times 10^{-6}} \approx 3 \times 10^{-5} \text{ m/s}$$

Drift velocity: $v_d \approx 3 \times 10^{-5} \text{ m/s}$

27. Given: Two thin lenses in contact with focal lengths f_1 and f_2. Let f be the effective focal length.

Lens formula:

$$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u}, \frac{1}{f_2} = \frac{1}{v_2} - \frac{1}{u_2}$$

For lenses in contact: $u_2 = v_1$ and $v_2 = v$ (final image).

$$\frac{1}{v} - \frac{1}{u} = \left(\frac{1}{v_1} - \frac{1}{u}\right) + \left(\frac{1}{v_2} - \frac{1}{v_1}\right) = \frac{1}{f_1} + \frac{1}{f_2}$$

Hence, effective focal length:

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

28. Current Sensitivity:

- It is the deflection produced in a galvanometer per unit current.

$$\text{Current sensitivity } = \frac{\text{deflection}}{\text{current}}$$

Factors increasing current sensitivity:

(i) Increase the number of turns (N) of the coil.
(ii) Increase the area (A) of the coil.

(iii) Use a stronger magnetic field (B).
(iv) Reduce the restoring torque (make the suspension or spring weaker).
Higher N, A, B and lower restoring torque ⟶ higher current sensitivity.a

29. Given:

- Power of laser, $P = 50 \text{ mW} = 50 \times 10^{-3}$ W
- Wavelength, $\lambda = 640 \text{ nm} = 640 \times 10^{-9}$ m
- Planck's constant, $h = 6.63 \times 10^{-34}$Js
- Speed of light, $c = 3 \times 10^{8}$ m/s

Energy of one photon:
$$E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \cdot 3 \times 10^{8}}{640 \times 10^{-9}} \approx 3.11 \times 10^{-19} \text{ J}$$
Number of photons per second:
$$n = \frac{P}{E} = \frac{50 \times 10^{-3}}{3.11 \times 10^{-19}} \approx 1.61 \times 10^{17} \text{ photons } /s$$

30. Inductance of a Solenoid (Short):

- Magnetic field inside: $B = \mu_0 \frac{N}{l} I$
- Flux through one turn: $\Phi = BA = \mu_0 \frac{N}{l} I \cdot A$
- Flux linkage: $\Lambda = N\Phi = \mu_0 \frac{N^2 A}{l} I$
- Inductance:
$$L = \frac{\Lambda}{I} = \mu_0 \frac{N^2 A}{l}$$

31. Differences between Interference and Diffraction (Short):

Feature	Interference	Diffraction
Cause	Superposition of light from two or more coherent sources	Bending of light around obstacles or slits
Source	Requires two or more sources	Can occur with single source
Fringe pattern	Bright and dark fringes at regular intervals	Central maximum and decreasing side maxima
Dependence	Depends on path difference	Depends on aperture size and shape
Observation	Two or more overlapping waves	Single wave spreading

32. Coulomb's Law: Electric field due to point charge q at distance r :
$$\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \hat{r}$$
Flux through a spherical surface of radius r :
$$\Phi_E = \oint \vec{E} \cdot d\vec{A} = E \cdot 4\pi r^2 = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \cdot 4\pi r^2 = \frac{q}{\epsilon_0}$$
Gauss's Law:

$\boxed{\oint \vec{E} \cdot d\vec{A} = \frac{q_{\text{enclosed}}}{\epsilon_0} 3}$

33. Given:

Energy gap: $E_g = 1.875\text{eV} = 1.875 \times 1.6 \times 10^{-19}$ J $= 3.0 \times 10^{-19}$ J

Planck's constant: $h = 6.6 \times 10^{-34}$Js

Speed of light: $c = 3 \times 10^8$ m/s

Wavelength formula:

$$\lambda = \frac{hc}{E_g}$$

Calculation:

$$\lambda = \frac{6.6 \times 10^{-34} \cdot 3 \times 10^8}{3.0 \times 10^{-19}} \approx 6.6 \times 10^{-7} \text{ m} = 660 \text{ nm}$$

Colour: Red (since 620-750 nm corresponds to red light)

PART - IV

34. (a) Simple Microscope: Single convex lens used to magnify small objects.

Magnification: -

Normal focus (eye relaxed): $M = \frac{D}{f}$

Near point focus (eye accommodated): $M = 1 + \frac{D}{f}$

(D = least distance of distinct vision, f = focal length of lens)

OR

(b) Determination of Unknown Resistance using Metre Bridge (Short): -

(i) Setup: Connect unknown resistance R and known resistance S in the two gaps of the bridge wire (forming a Wheatstone bridge).

(ii) Galvanometer Connection: Connect a galvanometer at the sliding jockey on the metre bridge wire.

(iii) Adjust Jockey: Slide the jockey until the galvanometer shows zero deflection (null point). Let lengths on the wire be l_1 and l_2.

(iv) Use Wheatstone Relation:

$$\frac{R}{S} = \frac{l_1}{l_2}$$

(v) Solve for Unknown Resistance:

$$R = S \cdot \frac{l_1}{l_2}$$

35. (a) Magnetic Field on the Axis of a Circular Coil (Short):

(i) Along the axis (distance x from center):

- For a circular coil of radius R carrying current I :

$$B = \frac{\mu_0 I R^2}{2(R^2 + x^2)^{3/2}}$$

where x is the distance along the axis from the center.

(ii) At the center of the coil (x = 0):

$$B_{\text{center}} = \frac{\mu_0 I}{2R}$$

Equation obtained using Biot-Savart law.

OR

(b) (i) Relation at minimum deviation ($\delta = \delta_m$)

- Light is symmetric inside prism: $i_1 = i_2 = i_1, r_1 = r_2 = r$

$$r_1 + r_2 = A \Rightarrow 2r = A \Rightarrow r = \frac{A}{2}$$

(ii) Deviation: $\delta_m = i_1 + i_2 - A = 2i - A \Rightarrow i = \frac{A+\delta_m}{2}$

(iii) Snell's Law at prism surface:

$$\mu = \frac{\sin i}{\sin r} = \frac{\sin \frac{A+\delta_m}{2}}{\sin \frac{A}{2}}$$

Refractive index of prism material:

$$\mu=\frac{\sin\frac{A+\delta_m}{2}}{\sin\frac{A}{2}}$$

36. (a) (i) Photon energy:

$E_{\text{photon}}=h\nu$

(ii) Energy spent to overcome work function (ϕ) :

K.E. of ejected electron $=E_{\text{photon}}-\phi$

$\frac{1}{2}mv_{\max}^2=h\nu-\phi$

Einstein's Photoelectric Equation:

$K_{\max}=h\nu-\phi$

OR

(b) Phase Relationship in a Pure Inductive Circuit (Short):

- Voltage across inductor: $V_L=L\frac{dI}{dt}$
- Current: $I=I_0\sin\omega t$
- Then: $V_L=L\frac{dI}{dt}=\omega LI_0\cos\omega t=\omega LI_0\sin(\omega t+90^\circ)$
- Conclusion:

Voltage leads current by 90° in a pure inductor.

Phasor Diagram:

- Voltage V vector ahead of current I vector by 90°.

37. (a) Frequency Modulation (FM) – Short:

Advantages: -

(i) Less affected by noise and interference.

(ii) Better sound quality and fidelity.

(iii) Wider bandwidth allows high-frequency transmission.

Limitations: -

(i) Requires larger bandwidth than AM.

(ii) More complex and expensive transmitter and receiver.

(iii) Not suitable for long-distance communication using small antennas.

OR

(b) Maxwell's Modification of Ampere's Law (Short):

- Original Ampere's Law:

$\oint\vec{B}\cdot d\vec{l}=\mu_0I_{\text{conduction}}$

- Problem: Fails for time-varying electric fields (e.g., charging capacitor).
- Maxwell's Addition: Introduced displacement current $I_d=\epsilon_0\frac{d\Phi_E}{dt}$.
- Modified Law:

$$\oint\vec{B}\cdot d\vec{l}=\mu_0\left(I_{\text{conduction}}+\epsilon_0\frac{d\Phi_E}{dt}\right)$$

38. (a) Electric Field of a Dipole on Axial Line (Short):

Dipole: Charges $+q$ and $-q$ separated by $2a$.

Axial point: Distance r from center along dipole axis.

Field due to $+q$ and $-q$:

$$E=\frac{1}{4\pi\epsilon_0}\left[\frac{q}{(r-a)^2}-\frac{q}{(r+a)^2}\right]$$

For $r\gg a$, approximate:

$$E\approx\frac{1}{4\pi\epsilon_0}\frac{2qa}{r^3}=\frac{1}{4\pi\epsilon_0}\frac{2p}{r^3}$$

where $p=q\cdot 2a$ is the dipole moment.

Result:

$$\boxed{E_{\text{axial}}=\frac{1}{4\pi\epsilon_0}\frac{2p}{r^3}}$$

OR

(b) Nuclear Reactor (Short): -

A device in which controlled nuclear fission takes place to produce energy, usually in the form of heat.
(i) Moderator: -
- Slows down fast neutrons to thermal neutrons to sustain the chain reaction.
- Examples: Graphite, Heavy water (D_2O), Light water (H_2O)
(ii) Control Rods: -
- Absorb excess neutrons to control or stop the fission reaction.
- Made of Boron, Cadmium, or Hafnium
(iii) Cooling System: -
- Removes heat from the reactor core and transfers it to generate steam.
- Coolants: Water, Liquid sodium, Gas (CO_2).