Unit 6

(Introduction of Electromagnetism)

Divergence

$$\text{div}\,\vec{A} = \nabla\cdot\vec{A} = \frac{\delta A}{\delta x} + \frac{\delta A}{\delta y} + \frac{\delta A}{\delta z}$$

$$\text{div}\,\vec{A} = \frac{\oint_s \vec{A}\cdot d\vec{s}}{v}$$

Curl

$$\cdot\ \text{curl}\,\vec{A} = \nabla\times\vec{A}$$

$$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \delta/\delta x & \delta/\delta y & \delta/\delta z \\ A_x & A_y & A_z \end{vmatrix}$$

$$\text{Curl}\,\vec{A} = \nabla\times\vec{A} = \frac{\oint_L \vec{A}\cdot d\vec{l}}{\Delta S}\,\hat{n}$$

Divergence Gauss theorem

$$\int_v (\vec{\nabla}\cdot\vec{A})\,dv = \oint_S \vec{A}\,d\vec{s}$$

$$\left(\text{div}\,\vec{E} = \rho/\epsilon_0\right)$$

Stoke's theorem

$$\oint_L \vec{A}\cdot d\vec{l} = \int_S (\vec{\nabla}\times\vec{A})\,ds$$

Poisson's equation

$$\boxed{\nabla^2\phi = -\rho/\epsilon_0}$$

Laplace equation

$$\boxed{\nabla^2\phi = 0}$$

here $\nabla^2\phi = \left(\frac{\delta^2\phi}{\delta x^2} + \frac{\delta^2\phi}{\delta y^2} + \frac{\delta^2\phi}{\delta z^2}\right)$

Biot-savart law

$$\vec{H} = \frac{1}{4\pi}\oint\frac{I(d\vec{l}\times\vec{R})}{R^3}$$

$$\left(\because\ \vec{B} = \mu_0\vec{H}\right)$$

Faraday's law

$$\text{emf} = -N\frac{d\phi}{dt} \qquad \because \phi = B\cdot ds$$

$$\text{emf} = -N\int\frac{d\vec{B}}{dt}\cdot d\vec{s}$$

Displacement current

$I_d = \frac{dQ}{dt}$: Current between two plates of ~~cond~~ capacitor.

$\oint \vec{H}\cdot d\vec{l} = \frac{dq}{dt} = I_D$

Maxwell's equation

(i) $\boxed{\phi_E = \oint \vec{E}\cdot d\vec{s} = Q/\epsilon_0 = \frac{1}{\epsilon}\int \rho\, dv}$

diff. form $\Rightarrow$ $\text{div } \vec{E} = \vec{\nabla}\cdot\vec{E} = \rho/\epsilon$

(ii) $\boxed{\oint \vec{B}\cdot d\vec{s} = 0}$ $\boxed{\nabla\cdot\vec{B} = \text{div } B = 0}$

(iii) $e = -\frac{d\phi_B}{dt} = \oint \vec{E}\, d\vec{r} = -\oint_S \frac{d\vec{B}}{dt}\cdot d\vec{s}$

$\boxed{\text{Curl } \vec{E} = \vec{\nabla}\times\vec{E} = -\frac{dE}{dt}}$

(iv) $\boxed{\oint B\cdot dr = \mu_0 \Sigma (I_C + I_D)}$

or $\int_C \vec{B}\cdot d\vec{r} = \mu_0 \oint_S \left(\vec{J} + \frac{d\vec{D}}{dt}\right)\cdot d\vec{s}$

or

$\vec{\nabla}\times\vec{B} = \mu\left(\vec{J_f} + \frac{d\vec{D}}{dt}\right) = \left(\mu_0\vec{J_f} + \mu\vec{E}\frac{d\vec{E}}{dt}\right)$

$\underline{\nabla\times\vec{B} = \mu\vec{J_f}}$

Poynting vector $= \frac{\text{energy}}{\text{Area} \times \text{time}} = P/A$

$$\boxed{P = \vec{E} \times \vec{H} = \frac{\vec{E} \times \vec{B}}{\mu}}$$

Unit 5 Semiconductor & material Sci.

Types of bond

- Ionic → High electro negativity diff.
- Covalent → electronegativity ↓ & non metallic
- Metallic → between metal crystal
- Vander wall's

Formation energy bands ⇒ Range of energy possessed by an electron.

Fermi Distribution function

$$\boxed{f(E) = \frac{1}{1 + e^{(E-E_f)/KT}}}$$

K = boltzman constant
T = Temp

Electrical conductivity of semiconductor.

$$\sigma = \frac{J}{E} = e(n\mu_e + p\mu_h)$$

Resistivity

$$\rho = \frac{1}{\sigma}$$

Hall effect

$\boxed{E_H = R_H B J}$ & $\boxed{R_H = -\frac{1}{ne}}$

B = megnetic field
J =

Mobility

$$\boxed{\mu_e = -\sigma_e R_H}$$

Unit 3 Optical Fibre

Coherence Length

$$\boxed{L_c = \frac{c}{\Delta\nu} = \frac{\lambda^2}{\Delta\lambda} = \lambda Q}$$

(here $Q = \frac{\lambda}{\Delta\lambda}$ = Quality factor)

Coherente time

$$\boxed{\tau_c = \frac{L_c}{c}}$$

Acceptance Angle

$$i_{max} = \sin^{-1}\sqrt{n_1^2 - n_2^2}$$

n_1 = Core

n_2 = Cladding

Numerical Aperature

$$\boxed{NA = \sin i_{max} = \sqrt{n_1^2 - n_2^2}}$$

$$\boxed{NA = n_1\sqrt{2\Delta}}$$

here $\Delta = \frac{n_1 - n_2}{n_1}$

Quantum Mechanics Unit 2

Particle Density $|\psi|^2 = \psi\psi^*$ = probability density.

→ probability. $p = \boxed{\int |\psi|^2 dv = 1}$

→ Normalized function ψ when

$$\langle O(x) \rangle = \int_{-\infty}^{\infty} O |\psi|^2 dx$$

Time Dependent wave equation.

$$i\hbar \frac{\delta \psi(x,t)}{\delta t} = -\frac{\hbar^2}{2m} \frac{\delta^2 \psi(x,t)}{\delta x^2} + U\psi(x,t)$$

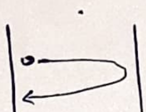
~~for 3D~~ Hamiltonian operator (Total energy)

$$H = \left[-\frac{\hbar^2}{2m} \nabla^2 + U\right]$$

→ Time independent

$$\frac{\delta^2 \psi}{\delta x^2} + \frac{2m}{\hbar^2}[E - U(x)]\psi(x) = 0$$

Free Particle in 1-D Box



$x=0$ $x=a$

limit 0 to a

general solution

$\psi(x) = A \sin kx + B \cos kx$ (B=0)

~~ψ~~ A.

$$P = \int_{-\infty}^{\infty} \psi\psi^* dx = 1$$

find A by this

Eigen Energy

$$\boxed{E_n = \frac{n^2 h^2}{8 m a^2}}$$

(for zero point energy $n = 1$)

for 3-D

$$E = \frac{h^2}{8ma^2}(n_x^2 + n_y^2 + n_z^2)$$

$$\left(\psi(x,y,z) = \left(\frac{2}{a}\right)^{3/2} \sin\left(\frac{n_x \pi}{a}\right)x \, \sin\left(\frac{n_y \pi}{b}\right)y \, \sin\left(\frac{n_z \pi}{c}\right)z \right)$$

→ for Degenerecy.

$$\boxed{E_a = E_b}$$

Unit 1 Optical fibre

wave optics

Michelson interference

$2d\cos\theta = (n-\frac{1}{2})\lambda$

(for Bright fringes)

$2d\cos\theta = n\lambda$

for dark fringes

by $2d = N\lambda$

$$\boxed{\lambda = 2x/N}$$

So

$$\boxed{N_2 - N_1 = \frac{2x(\lambda_1 - \lambda_2)}{\lambda_1 \lambda_2}}$$

$\Rightarrow \left(\lambda_1 - \lambda_2 = \frac{\lambda_{avg}^2}{2x}\right)$ **

fringe shift

* $\boxed{x = (\mu - 1)t}$

(t = thickness)

Newton's Ring

dark

$2\mu t = n\lambda$

&

$D_n = \sqrt{\frac{4Rn\lambda}{\mu}}$

bright

$2\mu t = (n+\frac{1}{2})\lambda$

$D_n = \sqrt{\frac{2(2n-1)\lambda R}{\mu}}$

fringe width

$\beta = r_{n+1} - r_n$

$\beta = \frac{1}{2}[D_{n+1} - D_n]$

wavelength by Newton's Ring

$$\boxed{\lambda = \frac{D_{n+p}^2 - D_n^2}{4pR}}$$

n = order.

Diffraction

phase diff $= \frac{2\pi}{\lambda} e \sin\theta$

path diff $= e \sin\theta = \Delta x = \delta$

* $\boxed{I = I_0 \left(\frac{\sin^2\alpha}{\alpha^2}\right)}$ Intensity

here $\alpha = \delta/2 = \frac{e \sin\theta}{2}$

**
$$\boxed{\text{Resolving Power} = \lambda/d\lambda = \frac{1}{\text{Resolution limit}}}$$

$a+b \sin\theta_n = n\lambda$ — i for 1

$(a+b) \sin(\theta_n + d\theta_n) = n(\lambda + d\lambda)$ ii for 2

**
Resolving power $\boxed{\frac{\lambda}{d\lambda} = nN}$ Here N = number of lines per inch.

& $n = \frac{(a+b)\sin\theta}{\lambda}$

$\boxed{w = N(a+b)}$ grating width.

** $\frac{\lambda}{d\lambda} = \frac{N(a+b)\sin\theta}{\lambda} = \frac{w \sin\theta}{\lambda}$

Bragg's Condition

$\sin\theta \leq 1$

$\frac{\lambda}{2d} \leq 1 \Rightarrow \boxed{\lambda \leq 2d}$

Constructive interference b/w diffracted rays.