**II/IV B.Tech(Regular) DEGREE EXAMINATION**

**DEPARTMENT OF ECE**

Subject Name: **Electromagnetic Field Theory**

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set-I.

1 a Gauss's law:
net Electric flux out of a closed surface is equal to the charge enclosed by it

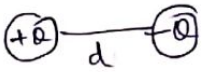
$$\oint_s \bar{D} \cdot \bar{ds} = Q_{enc}$$

$$\nabla \cdot \bar{D} = \rho_v$$

1.b. potential;
Workdone in moving 1C - positive charge from infinity to a particular point

potential due to a point charge $= \dfrac{Q}{4\pi\epsilon_0 r}$

1.c A dipole is formed when a positive charge and equal amount of negative charge separated by small distance



1.d polarization: is defined as net dipole moment per unit volume

$$\bar{P} = \lim_{\Delta v \to 0} \frac{\sum_{i=1}^{n} Q_i \bar{d_i}}{\Delta v}$$

1.e Dielectric breakdown:
Dielectric breakdown is said to have occured when a dielectric starts conducting due to excessive applied electric field

1.f Ampere's law: States that the line integral of $\bar{H}$ about any closed path is exactly equal to the direct current enclosed by it

$$\oint_l \bar{H} \cdot \bar{dl} = I_{enc}$$

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1.g Magnetization, is the magnetic dipole moment per unit Volume

1.h. unit of magnetic flux density: wb/m$^2$ (or) Tesla

1.i whenever a Closed circuit is placed in a time Varying magnetic field then emf will be induced in the circuit

1.j Skin depth:$\rightarrow$ is a measure of the penetration of of a plane electromagnetic wave into a material

$$\delta = \frac{1}{\alpha} = \frac{1}{\sqrt{\pi f \mu \sigma}} \quad (\text{for a Conductor})$$

2 a

Statement → 1M

Explanation → 4M

2.b $Q_1 = 10\mu C$ $P_1(-1\ -2\ 5)$

$Q_2 = -20\mu C$ $P_2(-3\ -2\ 3)$

$\bar{E}$ at $P(1\ -2\ 3) = \bar{E}_1 + \bar{E}_2$

$$= \frac{Q_1}{4\pi\epsilon_0 |R_1|^3}\bar{R}_1 + \frac{Q_2}{4\pi\epsilon_0}\frac{\bar{R}_2}{|R_2|^3} \rightarrow 2M$$

$$= \frac{10\times10^{-9}}{4\pi\times\left(\frac{10^{-9}}{36\pi}\right)} \cdot \frac{(2a_x + 0a_y - 2a_z)}{(\sqrt{4+0+4})^3} + \frac{-20\times10^{-9}}{4\pi\times\frac{10^{-9}}{36\pi}}\frac{(4a_x+0a_y+0a_z)}{(\sqrt{42})^3}$$

$$= \frac{90}{(\sqrt{8})^3}(2a_x - 2a_z) - 180 \cdot \frac{4a_x}{(4)^3}$$

$$= \frac{90}{16\sqrt{2}}(2a_x - 2a_z) - \frac{180}{16}a_x$$

$$= 7.95a_x - 7.95a_z - 11.25a_x$$

$$= -3.3a_x - 7.95a_z \ \text{V/m}$$

$\rightarrow$ 3M

3.a $\quad w_0 = \frac{1}{2}\epsilon_0 E^2$

Figure → 1M

derivation → 4M

3.b

$Q_1 = 10^{-9}c$ at $P_1(0,0,0.1)$

$Q_2 = -10^{-9}c$ at $P_2(0,0,-0.1)$

free space ⇒ $\epsilon_0$

$V(0.3,0,0.4) = ?$

$$V = V_1 + V_2$$

$$= \frac{Q_1}{4\pi\epsilon_0 R_1} + \frac{Q_2}{4\pi\epsilon_0 R_2} \rightarrow 2M$$

$$= \frac{10^{-9}}{4\pi \times \frac{10^{-9}}{36\pi}\,|(0.3,0,0.4)-(0,0,0.1)|} + \frac{-10^{-9}}{4\pi \times \frac{10^{-9}}{36\pi}\,|(0.3,0,0.4)-(0,0,-0.1)|}$$

$$= \frac{9}{\sqrt{0.3^2+0.2^2}} - \frac{9}{\sqrt{0.3^2+0.5^2}}$$

$$= 9\left[\frac{1}{\sqrt{0.13}} - \frac{1}{\sqrt{0.34}}\right] = 9.526 \text{ Volts.}$$

3M

4.a → Derivation → 5M

4.b Given $\quad V = \frac{4y^2 z}{x^2+1}$

$$V \text{ at } (1,2,3) = \frac{4(2)^2 3}{(1^2+1)} = 24 \text{ volt} \rightarrow 1M$$

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laplace's equation $\nabla^2 V = -\frac{\rho_v}{\epsilon_0}$ → 3M

$\rho_v = -\epsilon_0 (\nabla^2 V)$

$= -\epsilon_0 \left( \frac{d^2 V}{dx^2} + \frac{d^2 V}{dy^2} + \frac{d^2 V}{dz^2} \right)$

$= -106.2 \ pC/m^3$

5.a Figure + Discription → 2M

Derivation → 3M

5.b Figures → 2M

Derivation → 3M

6.a Statement → 1M

Explanation with necessary expressions → 4M

6.b Derivation → 5M

7.a Derivation $\rightarrow$ 5M

7.b $\bar{H} = y^2z\, a_x + 2(x+1)yz\, a_y + (x+1)z^2\, a_z$ A/m

$\bar{J}$ at $(1,1,1) = ?$

$\bar{J} = \nabla \times \bar{H}$ $\rightarrow$ 2m

$$= \begin{vmatrix} a_x & a_y & a_z \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ y^2z & 2(x+1)yz & (x+1)z^2 \end{vmatrix}$$

$$= a_x\left[0 - 2(x+1)y\right] - a_y\left[z^2 - y^2\right] + a_z\left[2y\cancel{z} - 2y\cancel{z}\right]$$

$$= a_x\left[-2(1+1)(1)\right] - a_y\left[1-1\right] + 0\,a_z \rightarrow 3m$$

$$= -6\,a_x \quad A/m^2$$

8.a

Maxwell's equations in point form $\rightarrow$ 2.5M

Maxwell's equations in integral form $\rightarrow$ 2.5M

8.b: Given $\bar{E} = 2\sin(\omega t - 50z)\, a_x$ V/m

No medium specified so consider free space

$\bar{D} = \epsilon_0 \bar{E}$

$= 2\epsilon_0 \sin(\omega t - 50z)\, a_x$ V/m $\longrightarrow$ 2M

$\frac{E_0}{H_0} = \eta_0 \Rightarrow H_0 = \frac{E_0}{\eta_0} = \frac{2}{120\pi} \longrightarrow$ 1M

Now

$$\bar{H} = \frac{2}{120\pi} \sin(\omega t - 50z)\, a_y$$

$$\bar{B} = \mu_0 \bar{H} \rightarrow 2m$$

$$= \frac{2\mu_0}{120\pi} \sin(\omega t - 50z)\, a_y.$$

9.a

Helmholtz equations → 2m

Expressions of $\alpha, \beta, \eta$ → 2m

Expressions of $E, \bar{H}$ → 1m

9.b

inconsistency of ampere's circuital law → 2m

modification → 3m