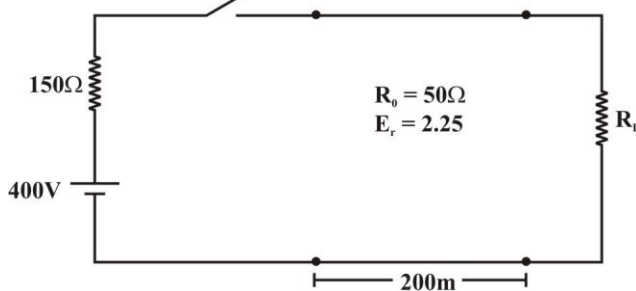


EMT Conventional Solution (ESE-2015 Test Series Dated 17.04.2015)

Sol.1 (a)

$$V = \frac{C}{\sqrt{\epsilon_r}} = \frac{3 \times 10^8}{\sqrt{2.25}} = \frac{3 \times 10^8}{3} \times 2$$

$$= 2 \times 10^8 \text{ m/sec}$$



$$t_1 = \frac{d}{v} = \frac{200\text{m}}{2 \times 10^8} = 1\mu\text{sec}$$

$$V_o(t = t_1) = V_o(t = 0) + k_1 V_o(t = 0)$$

At $t = 2\mu\text{sec}$, wave will return to input

$$V_o(t = t_2) = V_o(t = 0) + k_1 V_o(t = 0) + k_1 k_2 V_o(t = 0)$$

$$62.5 = 100[1 + k_1 + k_1 k_2]$$

$$k_2 = \frac{150 - 50}{150 + 50} = 0.5$$

$$0.625 = 1 + k_1 + 0.5k_1 \Rightarrow k_1 = -0.25$$

$$k_1 = -0.25 = \frac{R_L - 50}{R_L + 50} \quad \boxed{R_L = 30\Omega} \quad \text{ANS}$$

Sol.1.(b)

$$\tan \delta = \frac{\sigma}{\omega \epsilon} \quad \text{so} \quad \sigma = 0.001 \times 2\pi f \times \epsilon = 2.22 \times 10^{-6} \text{ mho/met}$$

Average power dissipated is : $P = \sigma E^2 = 2.22 \times 10^{-6} \times (10^3)^2 = 2.22 \text{ (W/m}^3\text{)} \quad \text{ANS}$

Sol.1(c) 25π

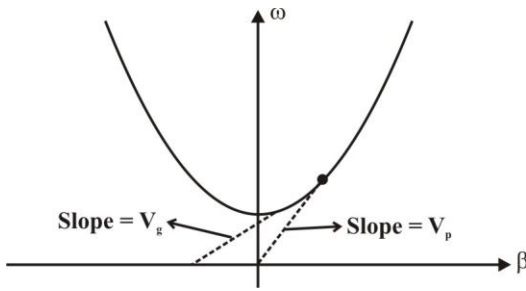
$$\iiint_V \vec{D} \cdot d\vec{s} = \int_V (\nabla \cdot \vec{D}) \cdot dV$$

Where $\vec{D} = 2p^2 \vec{a}_p + z \vec{a}_z$

$$\nabla \cdot \vec{D} = 6p + 1 \quad \& \quad dV = p dp d\phi dz$$

$$\int_V (\nabla \cdot \vec{D}) dV = \int_{z=0}^5 \int_{\phi=0}^{2\pi} \int_{p=0}^2 (6p+1) p dp d\phi dz = 25 \pi \quad \text{ANS}$$

Sol.1 (d)



Sol.2 (a)



$$\frac{q}{4\pi\epsilon_0 x^2} = \frac{q}{2 \times 4\pi\epsilon_0 (a-x)^2} \quad x = (2 \pm \sqrt{2})a$$

Only $x = (2 + \sqrt{2})a$ is taken. **ANS**

Sol.2 (b)

$$V_1 = \frac{2\lambda}{2\pi\epsilon_0} \ln\left(\frac{R_1}{r_1}\right) \quad \left\{ \vec{E} = \frac{\lambda}{2\pi\epsilon_0 r} \right\}$$

$$V_2 = \frac{-\lambda}{2\pi\epsilon_0} \ln\left(\frac{R_2}{r_2}\right)$$

$$V_3 = \frac{-\lambda}{2\pi\epsilon_0} \ln\left(\frac{R_3}{r_3}\right)$$

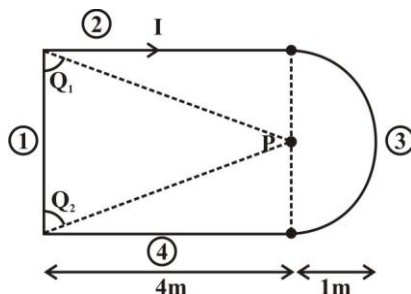
$$V = \frac{\lambda}{2\pi\epsilon_0} \left[\ln \frac{r_2 r_3}{r_1^2} + k \right]$$

For Equipotential surface total voltage remains constant so V will remain constant.

$$\ln \frac{r_2 r_3}{r_1^2} = K \quad \text{So } \frac{r_2 r_3}{r_1^2} = K$$

Sol.2 (c) $V_1 = 12.5V$ & $V_2 = 187.5V$ **ANS**

Sol. 3(a)



$$B_4 = \frac{\mu_0 I}{4r} = \frac{\mu_0 I}{4}$$

$$B_1 = \frac{\mu_0 I}{4\pi r} (\cos \theta_1 + \cos \theta_2)$$

$$= \frac{\mu_0 I}{4\pi \times 4} (\cos \theta_1) \times 2 = 2 \times \frac{1}{\sqrt{17}} \frac{\mu_0 I}{16\pi}$$

$$B_2 = \frac{\mu_0 I}{4\pi \times 1} \times \frac{4}{\sqrt{17}} = B_3$$

$$\vec{B} = B_1 + B_2 + B_3 + B_4 = 5.2 \mu T \quad \text{ANS}$$

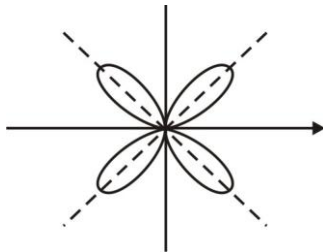
Sol.4 (a)(i) $d = \lambda$ & $\delta = \pi$

$$\psi = \frac{2\pi}{\lambda} \cdot \lambda \cos \phi + \pi$$

$$AF = 2 \cos\left(\frac{\pi}{2} + \pi \cos \phi\right)$$

Maxima: $\phi = 60^\circ, 120^\circ, 240^\circ, 300^\circ \dots$

Minima: $\phi = 0, 90^\circ, 180^\circ, 270^\circ \dots$



(ii) $AF = 2 \cos(\psi/2)$

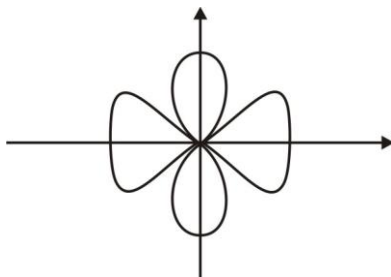
$$\psi = \beta d \cos \phi + \delta = \frac{2\pi}{\lambda} \times \lambda \cos \phi + 0 = 2\pi \cos \phi$$

$$AF = 2 \cos(\pi \cos \phi)$$

Maxima: $\phi = 0, \pi/2, \pi, 3\pi/2$

Minima: $\phi = 60^\circ, 129^\circ, 240^\circ, 300^\circ \dots$

For HPBW: $\pi \cos \phi = \pm \pi/4 \quad \therefore \cos \phi = (\pm 1/4)$



Sol.4 (b) $G = \frac{4\pi}{\lambda^2} \times A_e, \quad \lambda = \frac{3 \times 10^8}{4 \times 10^9}$

$$G = \frac{4\pi}{(0.075)^2} \times 0.5 \times \frac{\pi d^2}{4} = \frac{\pi^2 \times 0.5}{(0.075)^2} \times (20)^2 = 55.45 \text{ dB} \quad \text{ANS}$$

Sol.4 (c) $D = \frac{4\pi \times (57.3)^2}{30^\circ \times 35^\circ} = \frac{4\pi}{\lambda^2} \times A_e$

$$\therefore A_e = \frac{(57.3)^2}{(30^\circ \times 35^\circ)} \lambda^2 = 3.126 \lambda^2 \quad \text{ANS}$$

Sol. 5(a) $P = \sqrt{j\omega\mu(\sigma + j\omega\epsilon)}$

$$\sigma = 0$$

$$P = j\omega\sqrt{\mu\epsilon} = j\omega(1-2j)\sqrt{\mu_0\epsilon_0}$$

$$\alpha = 2\omega\sqrt{\mu_0\epsilon_0} = \frac{2 \times 2\pi \times 1.1 \times 10^9}{3 \times 10^8} = 46.02 \text{ Np/m}$$

$$E_{t0} = E_{i0} e^{-\alpha z} \times T \quad \{T=1\}$$

$$= 10e^{-46.02 \times 0.1} = 0.098 = 0.1 \text{ V/m} \quad \text{ANS}$$

Sol.5(b) For $z < 0 \rightarrow \eta_1 = \eta_0$

$$z > 0 \rightarrow \eta_2 = \sqrt{\frac{j\omega\mu}{\sigma + j\omega\epsilon}} = 4 \times 10^{-4} \angle 45^\circ$$

$$T = \frac{2\eta_1}{\eta_1 + \eta_2}$$

So $H_t = \frac{2\eta_1}{\eta_1 + \eta_2} \times \frac{E_1}{\eta_1} = \frac{2}{\eta_1 + \eta_2} \frac{E_1}{\eta_1} = 0.011 \sin(3\pi \times 10^6 t - 4.7 \times 10^{-5}) \quad \text{ANS}$

Sol.5(c) If wave is propagating in z-direction

Then $E_z = 0$

$$\frac{\partial}{\partial x}(E_x \& H_y) = 0 \quad \text{or} \quad \frac{\partial}{\partial x}(E_y \& H_x) = 0$$

$$\frac{\partial}{\partial y}(E_x \& H_y) = 0 \quad \text{or} \quad \frac{\partial}{\partial y}(E_x \& H_y) = 0$$

$$\text{Energy stored in electric field} = \frac{1}{2} \epsilon E^2$$

$$\text{Energy stored in electric field} = \frac{1}{2} \mu H^2$$

$$\text{If both are equal} \quad \frac{1}{2} \epsilon E^2 = \frac{1}{2} \mu H^2$$

$$E/H = \sqrt{\frac{\mu}{\epsilon}}$$

Sol.6 (a) $D = \frac{4\pi \times U(\theta, \phi)_{\max}}{P_{\text{rad}}}$

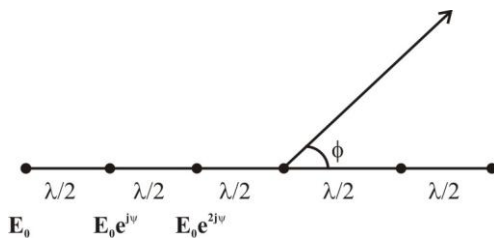
$$P_{\text{rad}} = \iint u(\theta, \phi) \sin \theta d\theta d\phi$$

$$u(\theta, \phi) \propto \sin^2 \theta \sin^2 \phi$$

$$P_{\text{rad}} = \iint \sin^3 \theta \sin^2 \phi d\theta d\phi$$

Putting all values $D=6$ **ANS**

Sol.6 (b) whenever main beam is formed, the phase shift over total electric field becomes zero.

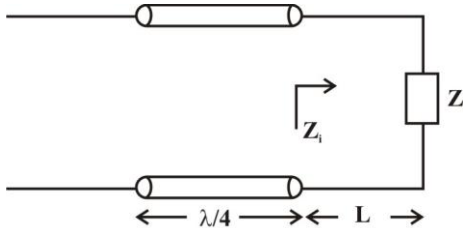


$$\psi = \beta d \cos \phi + \delta$$

$$0 = \frac{2\pi}{\lambda} \cdot \frac{\lambda}{2} \cos 60^\circ + \delta$$

$$\delta = -\frac{\pi}{2} = -90^\circ \quad \text{ANS}$$

Sol. 6(c)



$$Z_L = 250 - j150$$

$$Z_i = \frac{Z_0 \times (Z_L + jZ_0 \tan \beta \ell)}{(Z_0 + jZ_L \tan \beta \ell)}$$

$\therefore \lambda/4$ is used only for purely resistive load

$$Z_i = \frac{Z_0 \left((250 - j150) + j300 \tan \beta \ell \right)}{(300 + j(250 - j150) \tan \beta \ell)}$$

$$I_m(Z_i) = 0 \quad \Rightarrow \quad \ell = 0.14\lambda \quad \text{ANS}$$

Calculate $\text{Re}(z_i) = 0.57$

Now required $z_o = 300 \times \sqrt{0.57} = (227\Omega) \quad \text{ANS}$

Sol.7 (a) Single mode operation means only dominant mode will propagate:

$$\lambda_c = 2a \text{ for } TE_{10} \quad f_c$$

And here next higher mode is TE₂₀ mode:

$$\text{For Single mode operation } f_c (TE_{10}) < f < f_c (TE_{20})$$

$$\text{For decay rate: } \alpha = \sqrt{w^2 - w_c^2}$$

Sol.7 (b)

