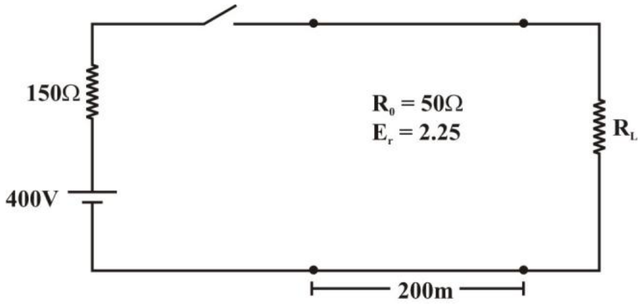
EMT Conventional Solution (ESE-2015 Test Series Dated 17.04.2015)

Sol.1 (a) $V = \frac{C}{\sqrt{\in_r}} = \frac{3\times10^8}{\sqrt{2.25}} = \frac{3\times10^8}{3}\times 2$

$= 2\times10^8 \text{m/sec}$



$t_1 = \frac{d}{v} = \frac{200\text{m}}{2\times10^8} = 1\mu\text{sec}$

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

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

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

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

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

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

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

Sol.1.(b) $\tan s = \frac{\sigma}{\omega \in}$ so $\sigma = 0.001\times 2\pi f \times \in = 2.22\times10^{-6}\text{mho/met}$

Average power dissipated is : $P = \sigma E^2 = 2.22\times10^{-6}\times(10^3)^2 = 2.22(\text{W/m}^3)$ **ANS**

Sol.1(c) 25π

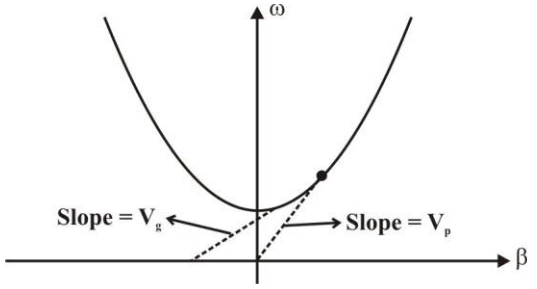
$\oiint \vec{D}\cdot d\vec{s} = \int_v (\nabla\cdot\vec{D})\cdot dv$

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

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

$\int_v (\nabla\cdot\vec{D})dv = \int_{z=0}^{5}\int_{\varphi=0}^{2\pi}\int_{p=0}^{2}(6p+1)p\,d_p d_\varphi d_z = 25\pi$ **ANS**

Sol.1 (d)



Sol.2 (a)

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

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

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

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

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

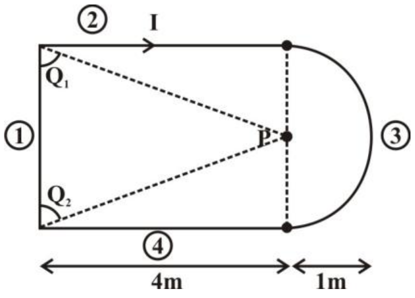
$$V = \frac{\lambda}{2\pi\epsilon_0}\left[\ln\frac{r_2 r_3}{r_1^2} + k\right]$$

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

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

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

Sol. 3(a)



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

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

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

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

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

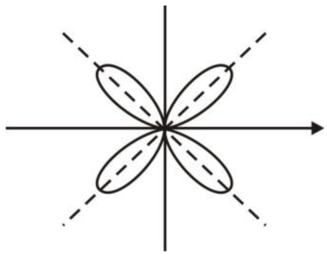
Sol.4 (a)(i) $d = \lambda \ \& \ \delta = \pi$

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

$$AF = 2\cos\left(\pi/2 + \pi\cos\phi\right)$$

Maxima: $\phi = 60^o, 120^o, 240^o, 300^o ...$

Minima: $\phi = 0, 90^o, 180^o, 270^o ...$



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

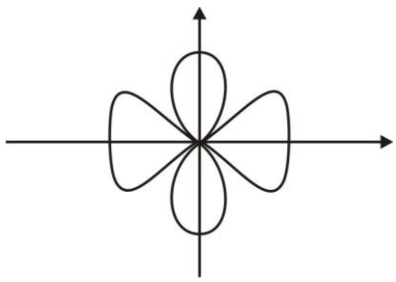
$$\psi = \beta d\cos\phi + \delta \ = \frac{2\pi}{\lambda}\times\lambda\cos\phi + 0 = 2\pi\cos\phi$$

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

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

Minima: $\phi = 60^o, 129^o, 240^o, 300^o ...$

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



Sol.4 (b) $G = \frac{4\pi}{\lambda^2} \times A_e$, $\lambda = \frac{3\times10^8}{4\times10^9}$

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

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

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

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

$\sigma = 0$

$P = j\omega\sqrt{\mu\in} = j\omega(1-2j)\sqrt{\mu_0 \in_0}$

$\alpha = 2\omega\sqrt{\mu_0 \in_0} = \frac{2\times2\pi\times1.1\times10^9}{3\times10^8} = 46.02 \text{ Np/m}$

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

$= 10e^{-46.02\times01} = 0.098 = 0.1 \text{ V/m}$ **ANS**

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

$z > 0 \rightarrow \eta_2 = \sqrt{\frac{j\omega\mu}{\sigma + j\omega\varepsilon}} = 4\times10^{-4}\underline{|45^\circ}$

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

So $H_t = \frac{2\eta_1}{\eta_1+\eta_2} \times \frac{E_1}{\eta_1} = \frac{2}{\eta_1+\eta_2}\frac{E_1}{\eta_1} = 0.011\sin(3\pi\times10^6 t - 4.7\times10^{-5})$ **ANS**

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

Then $E_z = 0$

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

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

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

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

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

$$\boxed{E/H=\sqrt{\frac{\mu}{\varepsilon}}}$$

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

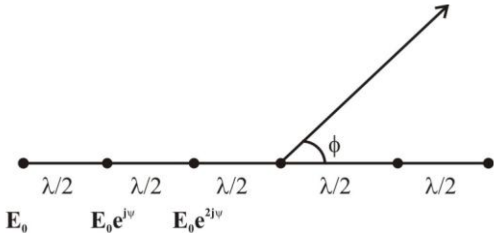
$$P_{rad}=\iint u(\theta,\phi)\sin\theta\, d\theta\, d\varphi$$

$$u(\theta,\phi)\ \alpha\ \sin^2\theta\ \sin^2\varphi$$

$$P_{rad}=\iint \sin^3\theta \sin^2\theta\, d\theta\, d\varphi$$

Putting all values D=6 **ANS**

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

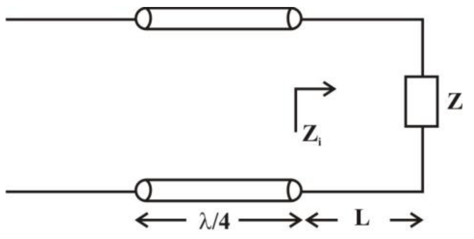


$$\psi=\beta d\cos\phi+\delta$$

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

$$\delta=-\pi/2=-90^o$$ **ANS**

Sol. 6(c)



$$Z_L=250-j150$$

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

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

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

$I_m(Z_i)=0 \quad \Rightarrow \quad \ell=0.14\lambda$ **ANS**

Calculate $\quad Re(z_i)=0.57$

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

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

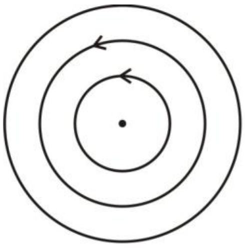
$\lambda_c = 2a$ for TE_{10} f_c

And here next higher mode is TE20 mode:

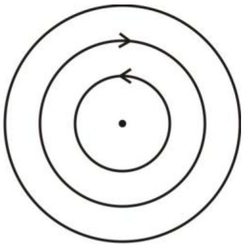
For Single mode operation $f_c\,(TE_{10}) < f < f_c\,(TE_{20})$

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

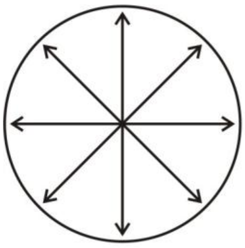
Sol.7 (b)



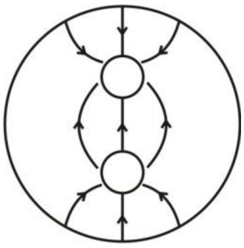
TE_{01}



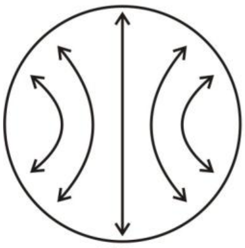
TE_{02}



TM_{01}



TM_{11}



TE_{11}