CLASS TEST - 2016

Electronics Engineering

EC

EMT

Date : 30/07/2016

ANSWERS

1.	(c)	7.	(b)	13.	(c)	19.	(a)	25.	(c)
2.	(b)	8.	(b)	14.	(c)	20.	(a)	26.	(b)
3.	(a)	9.	(d)	15.	(c)	21.	(b)	27.	(b)
4.	(c)	10.	(c)	16.	(b)	22.	(c)	28.	(d)
5.	(c)	11.	(a)	17.	(a)	23.	(a)	29.	(c)
6.	(b)	12.	(c)	18.	(d)	24.	(a)	30.	(a)

Explanation

1. (c)

$$F = \frac{Q_1 Q_2}{4\pi \epsilon_0 \epsilon_r d^2}$$

$$F \propto \frac{1}{\epsilon_r}$$

$$\therefore \quad \frac{F_2}{F_1} = \frac{\epsilon_r}{1}$$

$$\Rightarrow \quad F_2 = \epsilon_r F_1 = 2.25\, F_1$$

2. (b)

$$NA = \sqrt{n_1^2 - n_2^2} = \sqrt{(1.5)^2 - (1.06)^2} = 1.061$$

3. (a)

$$\eta_{TE} = \frac{\eta_0}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$$

$$\eta_{TM} = \eta_0 \sqrt{1-\left(\frac{f_c}{f}\right)^2}$$

$\therefore$ As $f\uparrow \eta_{TE}\downarrow$ and $\eta_{TM}\uparrow$

4. (c)

Directivity, $$D \approx \frac{41{,}000}{\theta_1^\circ \theta_2^\circ}$$

Where, θ_1° is HPBW in one principal plane

θ_2° is HPBW in other principal plane

$$\therefore \quad D \approx \frac{41{,}000}{30^\circ \times 30^\circ} = 45.56$$

$$10 \log D = 10 \log (45.56) = 16.6 \text{ dB}$$

5. (c)

f_c for TE_{02} is $\frac{c}{2}.\frac{2}{b}$ i.e.

$$12 \times 10^9 = \frac{3 \times 10^8}{b}$$

$$\Rightarrow \quad b = \frac{5}{2} \text{ cm}$$

$$\Rightarrow \quad a = 5 \text{ cm}$$

For TE_{01},

$$f_c = \frac{c}{2b} = \frac{3 \times 10^{10}}{2 \times 5/2} = 6 \text{ GHz}$$

6. (b)

$$\nabla \times \vec{A} = \vec{B}$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\nabla \times \vec{E} = -\frac{\partial}{\partial t}\left(\nabla \times \vec{A}\right) = \nabla \times \left(-\frac{\partial \vec{A}}{\partial t}\right)$$

$$\Rightarrow \quad \vec{E} = -\frac{\partial \vec{A}}{\partial t}$$

7. (b)

$$\frac{H_r}{H_i} = \frac{\eta_1 - \eta_2}{\eta_1 + \eta_2}$$

$$\because \quad \eta_1 < \eta_2 \Rightarrow \frac{H_r}{H_i} = \text{negative} \qquad \because \varepsilon_1 > \varepsilon_2$$

$$\Rightarrow 180° \text{ phase shift}$$

8. (b)

$$\vec{E} = -\nabla V$$

B to A satisfies the above expression.

9. (d)

End fire array have wider beams than Broadside array.

10. (c)

$$\eta = \frac{A_{eff}}{A_{phy}} = \frac{2\,\text{m}^2}{A_{phy}} = 0.8$$

$$\therefore \quad A_{phy} = \frac{2}{0.8} = 2.5\ \text{m}^2$$

11. (a)

$\vec{E}$ at (3, –2, 1) due to 10 μC/m^2 is

$$\frac{\rho_s}{2\epsilon_0}\hat{n} = \frac{10}{2\epsilon_0}(\hat{x})\ \mu\text{V/m}$$

$\vec{E}$ due to 20 μC/m^2 is

$$\frac{\rho_s}{2\epsilon_0}\hat{n} = \frac{20}{2\epsilon_0}(-\hat{z})\ \mu\text{V/m}$$

Total, $$\vec{E} = \frac{5\hat{x}}{\epsilon_0} - \frac{10}{\epsilon_0}\hat{z} = \frac{5}{\epsilon_0}(\hat{x} - 2\hat{z})\ \mu\text{V/m}$$

12. (c)

$$\vec{F} = I(\vec{L}\times\vec{B}) = 10\left(2\hat{z}\times 0.02(\hat{y}-\hat{x})\right)$$

$$\frac{\vec{F}}{L} = 0.2\left(\hat{z}\times(\hat{y}-\hat{x})\right) = 0.2\left(-\hat{x}\right) - 0.2\left(\hat{y}\right)$$

$$= -0.2\left(\hat{x}+\hat{y}\right) \text{ N/m}$$

13. (c)

Attenuation constant

$$\alpha = \text{Re}\left[\sqrt{(R+j\omega L)\,(G+j\omega C)}\right]$$

$$= \text{Re}\left[\sqrt{(10\times10^{-3}+2\pi\times10^{4}\times2\times10^{-6})\,(2\times10^{-6}+j2\pi\times10^{4}\times2\times10^{-9})}\right]$$

$\alpha = 2.09 \times 10^{-4}$ Nep/m

$\alpha = 2.09$ Nep/10 kilometers

$\alpha = 2.09 \times 8.686$

$= 18.15$ dB

14. (c)

The characteristic impedance of a co-axial cable with inner diameter d and outer diameter D is given by

$$Z_0 = \frac{138\log\left(\frac{D}{d}\right)}{\sqrt{\epsilon_r}}$$

where $\epsilon_r = 1$ for air and $D = r_2$; $d = r_1$ is given

$$\therefore \qquad Z_0 = 138\log\left(\frac{r_1}{r_2}\right) = -138\log\left(\frac{r_2}{r_1}\right) = -60\ \ln\left(\frac{r_2}{r_1}\right)$$

15. (c)

Microwave antennas work in the range of GHz, where the wavelength (λ) is very small.

Generally the physical length or size of an antenna is proportional to "λ".

λ at Microwave << λ at RF,

So the physical lengths of microwave antennas are smaller than RF antennas.

16. (b)

$$F = \frac{\mu_0 I_1 I_2 l}{2\pi d}$$

Net force on sides parallel to the wire $= \dfrac{\mu_0 I^2 a}{2\pi a} - \dfrac{\mu_0 I^2 a}{2\pi 2a}$

1st term attractive, 2nd term repulsive and repulsion less than attraction.

$$\therefore \qquad F = \frac{\mu_0 I^2}{4\pi} \text{ towards the wire}$$

17. (a)

For dominant mode,

$$f_c = \frac{c}{2a} = \frac{3 \times 10^{10}}{2 \times 2} = 7.5 \text{ GHz}$$

$$v_p = \frac{c}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} = \frac{3 \times 10^8}{\sqrt{1-\left(\frac{7.5}{15}\right)^2}}$$

$$= 3.46 \times 10^8 \text{ m/s}$$

18. (d)

$$\alpha = \omega\sqrt{\mu \in}\sqrt{\left(\frac{f_c}{f}\right)^2 - 1} = \omega\sqrt{\mu_0 \in_0}\sqrt{\in_r}\sqrt{\left(\frac{4}{3}\right)^2 - 1} = 2\pi \times \frac{f}{c} \times 2 \times \frac{\sqrt{7}}{3}$$

$$\alpha = 2\pi \times \frac{3}{4}\frac{f_c}{c} \times 2 \times \frac{\sqrt{7}}{3} = \frac{\pi\sqrt{7}f_c}{c} \qquad \left[f = \frac{3}{4}f_c\right]$$

For TE_{10} mode,

$$f_c = \frac{c}{\sqrt{\in_r}.2a} = \frac{3 \times 10^{10}}{2 \times 2 \times 2.5} = 3 \text{ GHz}$$

$$\Rightarrow \quad \alpha = \frac{\pi\sqrt{7} \times 3 \times 10^9}{3 \times 10^8} = 10\pi\sqrt{7}$$

Now,

$$\frac{E_0}{100} = E_o e^{-\alpha d}$$

$$\Rightarrow \quad d = \frac{1}{\alpha}\ln(100)$$

$$\Rightarrow \quad d = \frac{1}{10\pi\sqrt{7}}\ln 100 = 5.54 \text{ cm}$$

19. (a)

$$\frac{P_r}{P_t} = \left(\frac{\lambda}{4\pi R}\right)^2 G_t G_r$$

Where,

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{9 \times 10^9} = \frac{1}{30}\text{ m},$$

$$P_t = 10 \text{ W},$$

$$P_r = 10^{-5} \text{ W}$$

$$R = 10{,}000 \text{ m}$$

$$G_t = G_r = G$$

$$\frac{P_r}{P_t} = \left(\frac{\frac{1}{30}}{4\pi \times 10000}\right)^2 G^2 = 10^{-6}$$

$$\Rightarrow \quad G = 1200\,\pi$$

$$\Rightarrow \quad 10\log_{10}(1200\,\pi) = 35.76 \text{ dB}$$

20. (a)

The propagation vector for given electric field

$$\hat{k}_i = 4\hat{a}_x + 3\hat{a}_z$$

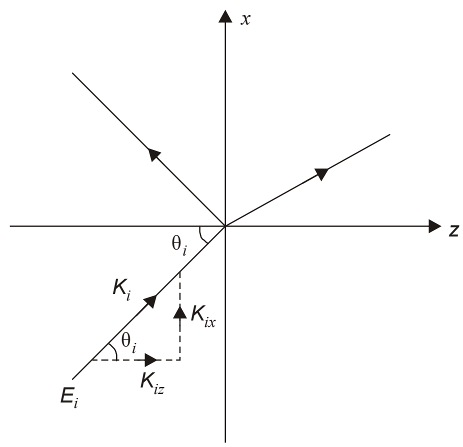
or
$$k_i = 5 = \beta = \omega\sqrt{\mu_o \varepsilon_o} = \frac{\omega}{c}$$

$$\omega = 15 \times 10^8 \text{ rad/sec}$$

A unit vector normal to the interface (z = 0) is $\hat{a}_z$. The plane containing $\hat{k}$ and $\hat{a}_z$ is y constant i.e. xz plane (the plane of incidence)

∵ E_i is normal to this plane

∴ Vertical polarization



Hence,
$$\tan\theta_i = \frac{k_{i_x}}{k_{i_z}} = \frac{4}{3}$$

or
$$\theta_i = \tan^{-1}\left(\frac{4}{3}\right) = 53.13°$$

21. (b)

∵ For a good conducting medium

$$\alpha = \sqrt{\frac{\omega\mu\sigma}{2}} \text{ or } \sqrt{\pi f \mu\sigma}$$

skin depth
$$\delta = \frac{1}{\alpha} = \frac{1}{\sqrt{\pi f \mu \sigma}}$$

given that,

$$e^{-\alpha_1 d_1} = e^{-2}$$

or
$$\alpha_1 d_1 = 2$$

⇒
$$\sqrt{\pi f_1 \mu\sigma} \times d_1 = 2 \quad ...(1)$$

similarly,

$$e^{-\alpha_2 d_2} = e^{-x}$$

or
$$\alpha_2 d_2 = x \quad ...(2)$$

from (1) ÷ (2)

$$\sqrt{\frac{\pi f_1 \mu\sigma}{\pi f_2 \mu\sigma}} \times \frac{d_1}{d_2} = \frac{2}{x}$$

or $$\sqrt{\frac{1}{0.5}} \times \frac{1}{2} = \frac{2}{x}$$

or $$x = 2\sqrt{2}$$

So, the signal will get attenuated by a factor $e^{-2\sqrt{2}}$

22. (c)

$\because$ $R_L >> R_0$

Maxima exists at load end

$\therefore$ first minima is formed $\lambda/4$ away from the load

$\Rightarrow$ $$f = 100 \text{ MHz}, c = 3 \times 10^8 \text{ m/s}$$

$$\lambda = c/f = 3 \text{ m}$$

and $$\frac{\lambda}{4} = 0.75 \text{ m}$$

23. (a)

Near the origin

$$\vec{H}_1 = \frac{1}{\mu_o \mu_{r_1}} \vec{B}_1 = \frac{1}{\mu_o}(1.6\hat{a}_x + 6.67\hat{a}_z) \text{ A/m}$$

$$\vec{H}_2 = \frac{1}{\mu_o \mu_{r_2}} \vec{B}_2 = \frac{1}{\mu_o}(5.15\hat{a}_x - 3.54\hat{a}_y + 2.0\hat{a}_z) \text{ A/m}$$

Then the sheet current at the interface $\vec{K}$ is given by

$$\vec{K} = (\vec{H}_1 - \vec{H}_2) \times \hat{a}_{n_{12}}$$

$$\vec{K} = \frac{1}{\mu_o}(-3.55\hat{a}_x + 3.54\hat{a}_y + 4.67\hat{a}_z) \times \hat{a}_z$$

$$\vec{K} = \frac{5.0}{\mu_o}\left(\frac{\hat{a}_x + \hat{a}_y}{\sqrt{2}}\right) \text{ A/m}$$

24. (a)

For a conducting material we have $\alpha = \beta$

skindepth $$\delta = \frac{1}{\alpha} = \frac{1}{\beta}$$

$$\delta = \frac{1}{\beta}$$

$$\delta = \frac{1}{\frac{2\pi}{\lambda}}$$

$$\delta = \frac{\lambda}{2\pi}$$

$\therefore$ $$\lambda = 2\pi\delta$$

25. (c)

Wave is travelling in $+z$-direction and E_x leads E_y component by 90°. Also $|E_x| = |E_y|$

Therefore Right circular.

26. (b)

$$\frac{\sigma}{\omega \in} = \tan 2\theta_\eta = \tan 60° = 1.732$$

$$|\eta| = 240 = \frac{\sqrt{\dfrac{\mu}{\in}}}{\left[1+\left(\dfrac{\sigma}{\omega \in}\right)^2\right]^{1/4}} = \frac{\dfrac{120\pi}{\sqrt{\in_r}}}{(1+3)^{1/4}}$$

$$\Rightarrow \quad \in_r = \frac{\pi^2}{8} = 1.234$$

Complex permittivity $\quad \in_c = \in\left(1-j\dfrac{\sigma}{\omega \in}\right) = 1.234 \times \dfrac{10^{-9}}{36\pi}(1-j1.732)$

$$= (10.91 - j18.9) \times 10^{-12} \text{ F/m}$$

$\therefore \quad x = 10.91$

$y = -18.9$

27. (b)

28. (d)

$$\beta = \omega\sqrt{LC} = 2\pi \times 3 \times 10^3 \sqrt{\frac{200 \times 10 \times 10^{-9}}{10^6}}$$

$$= 0.02664 \text{ rad/m}$$

given, $\quad \Gamma_l = \rho_L e^{j\theta_L}$

$$= 0.67\, e^{-j42°}$$

towards the source end of the line the reflection coefficient is given by

$$\Gamma_s = \rho_s\, e^{j\theta_s}$$

where, $\quad \rho_s = \rho_L$ (Because the line is lossless)

and $\quad \theta_s = -2 \times \beta \times l + \theta_L$

$\therefore \quad \theta_s = -69.488$

29. (c)

$$\Rightarrow \quad |\vec{H}| = \frac{I_0 \cos\left(\dfrac{\pi}{2}\cos\theta\right)}{2\pi r \sin\theta}$$

$$\Rightarrow \quad 5 \times 10^{-6} = \frac{I_0 \times 1}{2 \times \pi \times \left(2 \times 10^3\right).1}$$

or $\quad I_0 = 20\,\pi$ mA

$$\therefore \quad P_{rad} = \frac{1}{2} I_0^2 R_{rad} = \frac{1}{2} \times (20\pi)^2 \times 36.56 \times 10^{-6}$$

$$= 72 \text{ mW}$$

30. (a)

$$\beta = \frac{2\pi}{\lambda} = \frac{2\pi}{c/f_0} = 2\pi f_0 \sqrt{\mu \in}$$

also the phase difference is

$$\beta l = \frac{2\pi}{\lambda} \times \frac{\lambda}{4} = \frac{\pi}{2}$$

$$\therefore \quad \beta l = 2\pi f_0 \sqrt{\mu\varepsilon} \times l = \frac{\pi}{2}$$

For airfilled length the phase difference

$$\beta l_1 = 2\pi f_0 \times \sqrt{4\pi \times 10^{-19} \times 8.854} \times 0.05 \quad \text{.........(1)}$$

Dielectric filled length, the phase difference

$$\beta l_2 = 2\pi f_0 \times \sqrt{4\pi \times 10^{-19} \times 2.5 \times 8.854} \times 0.05 \quad \text{..........(2)}$$

from (1) & (2)

$$\beta l_1 + \beta l_2 = \beta l = \frac{\pi}{2}$$

$$\therefore \quad f_0 = \frac{1}{4\left(\sqrt{4\pi \times 10^{-19} \times 8.854} + \sqrt{4\pi \times 10^{-19} \times 2.5 \times 8.854}\right) \times 0.05}$$

$$\simeq 581 \text{ MHz}$$

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