CLASS TEST

Sl.: 01DLSKEC_ABCDEFGH_18526

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ELECTROMAGNETICS THEORY

ELECTRONICS ENGINEERING

Date of Test : 18/05/2026

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (a)

$$\eta_{TE} = \frac{120\pi}{\cos\theta} > 120\pi$$

$$\eta_{TM} = 120\pi \times \cos\theta < 120\pi$$

$$\eta_{TEM} = 120\pi$$

2. (a)

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

$$\nabla \times \vec{A} = \mu\vec{H}$$

$$\Rightarrow \quad \vec{H} = \frac{1}{\mu}\left(\nabla \times \vec{A}\right)$$

3. (c)

The phase shift between X component and Y component is 90° and X component lags Y component hence it is left hand circular polarization.

4. (b)

Electrical length of the line, $\theta = \beta l$

$$v_p = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10 \times 10^{-6} \times 0.1 \times 10^{-12}}} = 10^9 \text{ m/s}$$

$$\lambda = \frac{v_p}{f} = \frac{10^9}{10^6} = 1000 \text{ m}$$

$$\theta = \frac{2\pi}{\lambda} \times l = \frac{2\pi}{1000} \times 250 = \frac{\pi}{2} = 90°$$

5. (b)

$$\beta = \sqrt{6^2 + 8^2} = \sqrt{36 + 64} = 10$$

$$f = \frac{c}{\lambda} = \frac{c}{2\pi} \times \beta$$

$$= \frac{3 \times 10^8}{2\pi} \times 10$$

$$= 0.477 \times 10^9 \text{ Hz}$$

6. (a)

$$Z_{in} = Z_0 \frac{Z_L + jZ_0 \tan\beta l}{Z_0 + jZ_L \tan\beta l} = 50 \frac{150 + j50\tan 72°}{50 + j150\tan 72°} \simeq 18.2 - j14.3\ \Omega$$

7. (a)

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

$$\Rightarrow \quad f = \frac{1}{\delta^2 \pi \mu \sigma} = \frac{1}{36 \times 10^{-6} \times \pi \times 4\pi \times 10^{-7} \times 10^6} = 7036.2 \text{ Hz} \simeq 7 \text{ kHz}$$

8. (a)

The cutoff wave number for the dominant mode of rectangular waveguide is '$\frac{\pi}{a}$' where 'a' is the broader dimension of the waveguide.

$$\therefore \quad \text{Wave number} = \frac{\pi}{3.14\times10^{-2}} = 100$$

9. (d)

From Maxwell's equation

$$\vec{\nabla}\cdot\vec{B} = 0$$

$$\frac{\partial}{\partial x}8x - \frac{\partial}{\partial y}2ky + \frac{\partial}{\partial z}4z = 0$$

$$8 - 2k + 4 = 0$$

or,
$$k = \frac{12}{2} = 6$$

10. (a)

Magnetic energy density,

$$W = \frac{1}{2}\mu\left|\vec{H}\right|^2$$

$$= \frac{1}{2}\times4\times4\pi\times10^{-7}\left|\sqrt{2^2+4^2+8^2}\right|^2$$

$$= \frac{1}{2}\times4\times4\pi\times10^{-7}[4+16+64]$$

$$= 672\pi\times10^{-7}$$

$$\therefore \quad W \approx 211\ \mu\text{J/m}^2$$

11. (c)

We have,
$$\frac{m\pi x}{a} = \frac{2\pi x}{a}, \quad m = 2$$

$$\frac{n\pi x}{b} = \frac{3\pi y}{b}, \quad n = 3$$

$\therefore$ it is TE_{23} node

Cut off frequency,
$$f_c = \frac{u}{2}\sqrt{\left(\frac{m}{a}\right)^2+\left(\frac{n}{2}\right)^2} = \frac{3\times10^8}{2}\sqrt{\left(\frac{2}{286}\right)^2+\left(\frac{3}{1.016}\right)^2}\times100$$

$$= 46.19\text{ GHz}$$

$\omega = 10\pi\times10^{10}$,
$$f = 50\text{ GHz}$$

$$\beta = \frac{2\pi f}{c}\sqrt{1-\left(\frac{f_c}{f}\right)^2} = \frac{2\pi\times50\times10^9}{3\times10^8}\sqrt{1-\left(\frac{46.19}{50}\right)^2} = 400.68\text{ rad/m}$$

$\because f > f_c$
$$\alpha = 0$$

$\gamma = \alpha + j\beta = j400.7$ rad/m

12. (a)

Propagation constant given by

$$\tau = \sqrt{(R + j\omega L)(G + j\omega C)}$$

$$= \sqrt{(0.03 + j2\pi \times 10^3 \times 10^{-4})(0 + j2\pi \times 10^3 \times 20 \times 10^{-9})}$$

$$= 2.121 \times 10^{-4} + j8.88 \times 10^{-3} \text{ /m}$$

$\therefore$ $$r = \alpha + j\beta$$

$\therefore$ $$\alpha = 2.121 \times 10^{-4} \text{ Np/m} = 0.21 \times 10^{-3} \text{ Np/m}$$

A distortion less line operating at 120 MHz has $R = 20\ \Omega$/m, $L = 0.3\ \mu$H/m, $C = 63$ pF/m

13. (d)

Given, $$H_z = 5\cos(10^9 t - 4y)\hat{a}_z \text{ A/m}$$

$$J_d = \nabla \times H = \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 0 & 0 & H_z \end{vmatrix}$$

$$= \frac{\partial H_z}{\partial y}\hat{a}_x = \frac{\partial}{\partial y}(5\cos(10^9 t - 4y))\hat{a}_x$$

$$J_d = 20\sin(10^9 t - 4y)\hat{a}_x \text{ A/m}$$

But, $$J_d = \frac{\partial D}{\partial t}$$

$$D = \int J_d dt = -\frac{20}{10^9}\cos(10^9 t - 4y)\hat{a}_x$$

$$D = -20\cos(10^9 t - 4y)\hat{a}_x \text{ nC/m}^2$$

14. (a)

At junction input impedance of $\frac{\lambda}{2}$ line

$$\tan\beta l = \tan\left(\frac{2\pi}{\lambda}\frac{\lambda}{2}\right) = 0$$

$$Z_{\text{in } L} = Z_o\left(\frac{Z_L + jZ_o\tan\beta l}{Z_o + jZ_L\tan\beta l}\right) = Z_L = 100\ \Omega$$

For input impedance of S.C. stub

As we know for SC stub, $Z_L = 0$

$$\tan\beta l = \tan\left(\frac{2\pi}{\lambda}\frac{\lambda}{8}\right) = 1$$

$$Z_{\text{in } S} = Z_o\left(\frac{Z_L + jZ_o\tan\beta l}{Z_o + jZ_L\tan\beta l}\right) = jZ_o = j50\ \Omega$$

At junction, $$Y = \frac{1}{Z} = \frac{1}{j50} + \frac{1}{100} = 0.01 - j0.02$$

15. (c)

From boundary condition of dielectric - dielectric medium.

$$E_{t_1} = E_{t_2}$$

and $$D_{n_1} = D_{n_2}$$

$$\varepsilon_{r_1} E_{n_1} = \varepsilon_{r_2} E_{n_2}$$

or $$E_{n_2} = \frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} E_{n_1} = \frac{2}{8} \times 100 = 25$$

$\therefore$ $$\vec{E}_2 = 25\hat{a}_x + 200\hat{a}_y - 50\hat{a}_z$$

16. (a)

Given: $Z_L = 80 + j40$; $Z_o = 50\ \Omega$

$$\Gamma = \frac{Z_L - Z_o}{Z_L + Z_o} = \frac{80 + j40 - 50}{80 + j40 + 50}$$

$$= \frac{30 + j40}{130 + j40} = \frac{50\angle 53.13°}{136\angle 17.10°} = 0.367\angle 36.03°$$

$$P_{\text{load}} = P_{\text{incid}} - P_{\text{reflected}} = P_{\text{incid}}\left[1 - |\Gamma|^2\right]$$

$$P_{\text{load}} = 30\,[1 - (0.367)^2] = 25.9\text{ W}$$

17. (a)

The cut-off frequency for the TE_{mn} mode is,

$$f_c = \frac{C}{2\sqrt{\epsilon_r}}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

We need the frequency lie between the cut-off frequencies of the TE_{10} and TE_{01} modes.

These will be, $$f_{c,\,10} = \frac{C}{2\sqrt{\epsilon_r}\,a} = \frac{3\times 10^8}{2\sqrt{\epsilon_r}(0.06)} = \frac{2.5\times 10^9}{\sqrt{\epsilon_r}}$$

$$f_{c,\,01} = \frac{C}{2\sqrt{\epsilon_r}\,b} = \frac{3\times 10^8}{2\sqrt{\epsilon_r}(0.04)} = \frac{3.75\times 10^9}{\sqrt{\epsilon_r}}$$

$\therefore$ The range of frequencies over which single mode operation will occur is

$$\frac{2.5}{\sqrt{\epsilon_r}}\text{ GHz} < f < \frac{3.75}{\sqrt{\epsilon_r}}\text{ GHz}$$

18. (a)

For dominant mode, $$f_c = \frac{c}{2a} = \frac{3\times 10^{10}}{2\times 4} = 3.75\text{ GHz}$$

and $$\eta_{TE} = \frac{\eta_0}{\sqrt{1 - \left(\frac{f_c}{f}\right)^2}} = \frac{377}{\sqrt{1 - \left(\frac{3.75}{10}\right)^2}} = 406.7\ \Omega$$

$\therefore$ $$P_{avg} = \frac{E_0^2 ab}{4\eta_{TE}} = \frac{(65)^2 \times 4 \times 2 \times 10^{-4}}{4 \times 406.7} = 2.078\text{ mW}$$

19. (d)

From the $\vec{E}$ field, propagation vector is

$$\vec{k}_1 = 3a_x + \sqrt{3}a_z$$

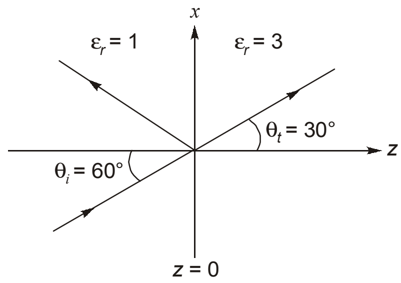
$$\Rightarrow \quad k_1 = \sqrt{12} = \frac{\omega}{c}$$

$$\omega = 3\sqrt{12} \times 10^8 \text{ m/s}$$

A unit vector normal to the interface ($z = 0$) is a_z. The plane containing K and a_z is y = constant, Which is XZ plane, the plane of incidence. Since E_1 is normal to the plane, it is perpendicular polarization.

$$\tan\theta_i = \frac{k_{ix}}{k_{iz}} = \frac{3}{\sqrt{3}} = \sqrt{3}$$

$$\theta_i = 60°$$



$$\sqrt{\varepsilon_r}\cdot\sin 60° = \sqrt{3}\cdot\sin\theta_t$$

$$1\times\frac{\sqrt{3}}{2} = \sqrt{3}\cdot\sin\theta_t$$

$$\theta_t = 30°$$

$$\theta_i = 60°$$

$$\Gamma_1 = \frac{E_{ro}}{E_{io}} = \frac{\eta_2\cos\theta_i - \eta_1\cos\theta_t}{\eta_2\cos\theta_i + \eta_1\cos\theta_t}$$

$$\eta_1 = \eta_0 = 377\ \Omega$$

$$\eta_2 = \frac{377}{\sqrt{3}}$$

$$\Gamma_1 = \frac{\frac{377}{\sqrt{3}}\cdot\frac{1}{2} - \frac{377\sqrt{3}}{2}}{\frac{377}{\sqrt{3}}\cdot\frac{1}{2} + \frac{377\sqrt{3}}{2}} = \frac{\frac{377}{2}\left(\frac{1}{\sqrt{3}} - \sqrt{3}\right)}{\frac{377}{2}\left(\frac{1}{\sqrt{3}} + \sqrt{3}\right)}$$

$$\Gamma_1 = \frac{1-3}{1+3} = \frac{-2}{4} = -0.5$$

$$\Gamma_1 = -0.5 = \frac{E_{ro}}{10}$$

$$E_{ro} = -5$$

$$\vec{E}_r = -5\cos(\omega t - 3x + \sqrt{3}z)\, a_y \text{ V/m}$$

20. (c)

$$P_{avg} = \frac{1}{2}\frac{|E|^2}{\eta} = \frac{1}{2}\frac{(100+400)}{120\pi}\ \text{W/m}^2$$

$$\text{Power} = P_{avg} \times \text{Area} = \frac{1}{2}\times\frac{500}{120\pi}\times\pi\times 36 = \frac{500}{240}\times 36 = \frac{50}{2}\times 3 = 75\ \text{W}$$

21. (b)

$$Y_L = 0.01 + j0.02\ \mho$$

$$Z_L = \frac{1}{Y_L} = 20 - j40\ \Omega$$

$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{20 - j40 - 300}{20 - j40 + 300} = 0.877\angle -164.7°$$

$$\Gamma_L(l) = \Gamma_L e^{-j2\beta l} = \Gamma_L e^{\frac{-j2\pi}{\lambda}\cdot 0.1\lambda}$$

$$= \Gamma_L e^{-j36°} = 0.877\angle -200.7°$$

22. (a)

For a distortionless transmission line,

$$Z_0 = \sqrt{\frac{R}{G}} \quad \text{...(i)}$$

and

$$\alpha = \sqrt{RG} \quad \text{...(ii)}$$

From equations (i) and (ii), $\alpha = \frac{R}{Z_0} = \frac{0.5}{100} = 0.005\ \text{Np/m}$

23. (d)

$$\frac{P_t}{P_i} = \left(1 - |\Gamma|^2\right)$$

Where,

$$\Gamma = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} = \frac{\frac{120\pi}{3} - \frac{120\pi}{2}}{\frac{120\pi}{3} + \frac{120\pi}{2}} = -\frac{1}{5}$$

∴

$$\frac{P_t}{P_i} = \left(1 - \frac{1}{25}\right) = \frac{24}{25} = 0.96$$

24. (a)

For short circuited transmission line,

$$Z_{in} = jZ_0 \tan\beta l$$

where,

$$\beta = \frac{2\pi}{\lambda} = \frac{2\pi}{c/f} = \frac{2\pi}{\frac{3\times 10^{10}}{3\times 10^{10}}}\ \text{rad/cm}$$

$$\beta = 2\pi\ \text{rad/cm}$$

and $\beta l = 4\pi$ rad

$\therefore$ $Z_{in} = jZ_0 \tan(4\pi)$

$Z_{in} = 0$

25. (c)

We know that; phase constant,

$$\beta = \omega\sqrt{\mu_0 \mu_r \epsilon_0 \epsilon_r} \text{ (for lossless dielectric)}$$

$$\beta = \omega\sqrt{4\pi\times10^{-7}\times\frac{10^{-9}}{36\pi}\times1\times9}$$

$$= 2\pi \times 10.5 \times 10^6 \times 10^{-8}$$

$\therefore$ $$\beta = 0.21\pi \text{ rad/m}$$

26. (c)

For a good conductor,

$$\beta = \sqrt{\frac{\omega\mu\sigma}{2}}$$

Also, $$\frac{\partial\beta}{\partial\omega} = \frac{1}{2}\left(\frac{\omega\mu\sigma}{2}\right)^{-1/2}\frac{\mu\sigma}{2}$$

or $$\frac{\partial\beta}{\partial\omega} = \frac{1}{2}\sqrt{\frac{\mu\sigma}{2\omega}} = \frac{1}{v_g}$$

$\because$ $$v_p = \frac{\omega}{\beta} = \frac{\omega}{\sqrt{\frac{\omega\mu\sigma}{2}}} = \sqrt{\frac{2\omega}{\mu\sigma}}$$

$$\frac{v_g}{v_p} = \frac{2\sqrt{\frac{2\omega}{\mu\sigma}}}{\sqrt{\frac{2\omega}{\mu\sigma}}}$$

$\therefore$ $$\frac{v_g}{v_p} = 2$$

27. (a)

Given, $$E_y = 10\sin\left(\frac{2\pi x}{6}\right)\cos\left(\frac{3\pi y}{2}\right)\sin(\omega t - 4z) \text{ V/cm}$$

$$\frac{m\pi}{a} = \frac{2\pi}{6} \qquad \therefore \quad m = 2$$

$$\frac{n\pi}{b} = \frac{3\pi}{2} \qquad \therefore \quad n = 3$$

$\therefore$ The propagating mode is TE_{23} mode,

$\therefore$ $$f_c = \frac{3\times10^8}{2\pi\times10^{-2}}\sqrt{\left(\frac{2\pi}{6}\right)^2+\left(\frac{3\pi}{2}\right)^2} = 23.05 \text{ GHz}$$

Given, $f = 40$ GHz

Since, $f > f_c;\quad \eta = \eta_0 \Big/ \sqrt{1-\left(\frac{f_c}{f}\right)^2}$

$\therefore \quad \eta = 377 \Big/ \sqrt{1-\left(\frac{23.05}{40}\right)^2}$

$\therefore \quad \eta = 461.29\ \Omega$

28. (c)

Given, loss tangent, $\frac{\sigma}{\omega \in} = 1498.97 >> 1$

Hence, the medium is a good conductor,

$$\therefore \quad \alpha = \beta = \omega\sqrt{\frac{\mu \in}{2} \times \frac{\sigma}{\omega \in}} \quad \left(\because \frac{\sigma}{\omega \in} >> 1\right)$$

$$= 10\pi\sqrt{\frac{10\mu_0 \in_0}{2} \times 1498.98} = 9.066 \times 10^{-6}$$

Skin depth in a good conductor is

$$\delta = \frac{1}{\beta} = \frac{1}{\alpha} = 1/9.066 \times 10^{-6} = 1.103 \times 10^{5}\ \text{m}$$

29. (b)

At dominant mode, TE_{10}

$$f_c = \frac{v_p}{2\pi}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2}$$

$$f_c = \frac{v_p}{2\pi}\sqrt{\left(\frac{\pi}{a}\right)^2}$$

here, $v_p = \frac{c}{\sqrt{\varepsilon_r}} = \frac{3 \times 10^8}{\sqrt{1.44}} = 2.5 \times 10^8\ \text{m/s}$

$$8.5 \times 10^9 = \frac{2.5 \times 10^8}{2 \times a}$$

or $a = 0.0147\ \text{m} = 1.47\ \text{cm}$

30. (d)

By using boundary conditions, normal component will be $E_{N1} = E_1 \cdot n$. Taking $f = x - y + 2z$, the unit vector that is normal to the surface is

$$n = \frac{\nabla f}{|\nabla f|} = \frac{1}{\sqrt{6}}[\hat{a}_x - \hat{a}_y + 2\hat{a}_z]$$

$$\therefore \quad E_{N1} = E_1 \cdot n = (100\hat{a}_x + 200\hat{a}_y - 50\hat{a}_z) \cdot \frac{1}{\sqrt{6}}(\hat{a}_x - \hat{a}_y + 2\hat{a}_z)$$

$$= \frac{1}{\sqrt{6}}[100 - 200 - 100]$$

$$E_{N1} = -81.65\ \text{V/m}$$

$\therefore$ The normal component points into region 1 from the surface

Then,
$$E_{N1} = -81.65\left(\frac{1}{\sqrt{6}}\right)\left[\hat{a}_x - \hat{a}_y + 2\hat{a}_z\right]$$
$$E_{N1} = -33.33\hat{a}_x + 33.33\hat{a}_y - 66.67\hat{a}_z \text{ V/m}$$

The tangential component will be
$$E_{T1} = E_1 - E_{N1}$$
$$E_{T1} = 133.3\hat{a}_x + 166.7\hat{a}_y + 16.67\hat{a}_z$$

From the boundary conditions,
$$E_{T2} = E_{T1}\ ;\ E_{N2} = \frac{\epsilon_{r1}}{\epsilon_{r2}} \cdot E_{N1} = \frac{1}{4}E_{N1}$$
$$E_2 = E_{T2} + E_{N2} = E_{T1} + \frac{1}{4}E_{N1}$$

$\therefore$
$$E_2 = 133.3\hat{a}_x + 166.7\hat{a}_y + 16.67\hat{a}_z - 8.3\hat{a}_x + 8.3\hat{a}_y - 16.67\hat{a}_z$$

$\therefore$
$$E_2 = 125\hat{a}_x + 175\hat{a}_y \text{ V/m}$$

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