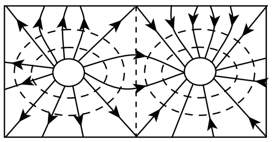
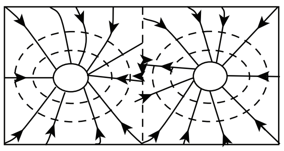
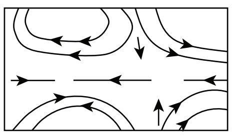
Number of Questions: 25 **Time: 60 min.**

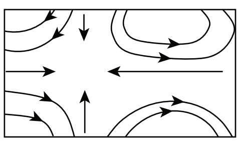
Directions for questions 1 to 25: Select the correct alternative from the given choices.

1. Which one of the following field configuration is for TM_{21} mode?

(A) 

(B) 

(C) 

(D) 

2. The dominant mode in a circular waveguide is a

(A) *TEM* mode (B) TM_{21} mode
(C) TE_{21} mode (D) TE_{11} mode

3. A 50 Ω loss less line has $V_L = 25\, ej^{20}$ V and $Z_L = 50\, e^{j30}$ Ω. The current at $\dfrac{\lambda}{16}$ from the load is

(A) $0.5\, e^{-j10°}$ (B) $0.5\, e^{-j32.5°}$
(C) $0.5\, e^{j12.5°}$ (D) $0.5\, e^{j22.5°}$

4. An air filled cubical cavity operates at a resonant frequency of 8 GHz when exited at the TE_{101} mode then the dimensions of the cavity is

(A) 2.65 cm (B) 0.44 cm
(C) 1.76 cm (D) 0.622 cm

5. A two port network has scattering parameters given by $[S] = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}$. If the port-2 of the two port is open circuited, The S_{11} parameter for the resultant one-port network is $[\Delta S = S_{11}\, S_{22} - S_{12}\, S_{21}]$.

(A) $\dfrac{S_{11} - \Delta S}{1 - S_{22}}$ (B) $\dfrac{S_{11} + \Delta S}{1 + S_{22}}$

(C) $\dfrac{S_{11} + \Delta S}{1 - S_{22}}$ (D) $\dfrac{S_{11} - \Delta S}{1 + S_{22}}$

6. An air filled circular waveguide is to be operated at a frequency of 8 GHz and is to have dimensions such that $f_c = 0.6\, f$ for $T_{E_{11}}$ mode. Then the radius of circular waveguide is

(A) 3.6625 cm (B) 1.83 cm
(C) 2.74 cm (D) 1.373 cm

7. A circular waveguide of internal diameter 4 cm is excited by dominant mode at 10 GHz. Then breakdown power of waveguide is

(A) 1.790 MW (B) 6.429 MW
(C) 3.48 MW (D) 8.629 MW

8. Match List-I (Type of Antenna) with List-II (feature)

	List-I		List-II
(*p*)	Dish Antenna	(1)	end fire
(*q*)	log periodic Antenna	(2)	isotropic
(*r*)	yagi-uda antenna	(3)	Frequency independent
(*s*)	point-electromagnetic source	(4)	highly directional

(A) $p - 4, q - 3, r - 1, s - 2$
(B) $p - 4, q - 2, r - 1, s - 3$
(C) $p - 2, q - 1, r - 3, s - 4$
(D) $p - 1, q - 3, r - 2, s - 4$

9. The constant *x* circles radius and center for a smith chart respectively are

(A) $\dfrac{1}{X}, \left(\dfrac{1}{X}, 1\right)$ (B) $\dfrac{X+1}{X}, \left(\dfrac{1}{X}, 1\right)$

(C) $\dfrac{1}{X}, \left(1, \dfrac{1}{X}\right)$ (D) $\dfrac{x}{x+1}, \left(1, \dfrac{1}{X}\right)$

10. A microwave transmitting antenna is 9 m height. The receiving antenna is 16 m height. Then maximum Transmission distance is

(A) 44 km (B) 24.99 km
(C) 89 km (D) 65 km

11. Evanescent mode attenuation in a waveguide depends upon the

(A) conductivity of the guide walls.
(B) conductivity of the dielectric filling the wave guide.
(C) standing waves in the guide.
(D) operating frequency.

12. At a distance of 6km from a differential antenna, the field strength is 50 μV/m. The field strength at a location 12 km from the antenna is

(A) 10 μV/m (B) 25 μV/m
(C) 14. μV/m (D) 35.5 μV/m

13. A uniform plane wave incident on a sheet whose conductivity is $\sigma_m = 5.8 \times 10^7$ S/m at $f = 2$ GHz then reflection co-efficient is

(A) –1 (B) +1
(C) 0 (D) 0.5

14. A lossless line of $\frac{5\lambda}{4}$ length is terminated with R_o and other short circuited line is connected parallely with a length of $\frac{3\lambda}{4}$ calculate z_{in}?
(A) 0 (B) R_o
(C) ∞ (D) $\frac{R_o}{2}$

15. A rectangular waveguide 2.5 cm × 1.05 cm operates at a frequency of 8 GHz in TE_{20} mode. If the maximum potential gradient of the signal is 6 kV/cm. Then maximum power handing capacity of the waveguide will be
(A) 47.7 kW (B) 123.9 kW
(C) 75.8 kW (D) 93.2 Kw

16. A line has $L = 4$ µH/m and $C = 25$ pF/m distributed constants and load impedance is 300 Ω then find input impedance for $\frac{\lambda}{8}$ length:
(A) 400 Ω (B) $400\angle 53°$ Ω
(C) $400\angle 16°$ Ω (D) $400\angle 45°$ Ω

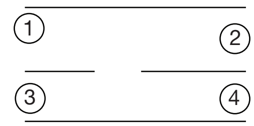
17. Distributed parameters of a 5m co-axial are $R = 10$ Ω/m, $L = 5$ µH/m, $G = 5$ ms/m, $C = 10$ pF/m. The line operates at 5 MHz. Then the end to end propagation delay is
(A) 0.2 µsec (B) 0.1 µsec
(C) 0.4 µsec (D) 0.55 µsec

18. In an air filled rectangular wavelength the cut-off frequencies of TM_{11} and TE_{03} modes are equal to 10 GHz. Then smallest dimension of the waveguide is
(A) 4.5 cm (B) 2.25 cm
(C) 1.6 cm (D) 0.8 cm

19. Which one of the following field patterns represents a TEM wave travelling in the negative x direction?
(A) $E = -8\hat{a}_z$, $H = 2s$
(B) $E = -8\hat{a}_y$, $H = -2\hat{a}_z$
(C) $E = 8\hat{a}_z$, $H = 2\hat{a}_y$
(D) $E = 8\hat{a}_y$, $H = 2\hat{a}_z$

20. The scattering matrix of a two port Network is given by $\begin{bmatrix} 0 & 0.4+j0.8 \\ 0.4+j0.8 & 0 \end{bmatrix}$ find the distance ℓ that the position of port 1 should be shifted to the left so that S_{12} and S_{21} will be real numbers [$\beta = 10\,\pi$]
(A) 2 m (B) 1 m
(C) 4 m (D) 3 m

21. Determine S_{12} scattering parameter for a 10 dB direction coupler. The directivity $D = 20$ dB. Assume that it is loss less and the VSWR at each port is 1 under matched conditions. Two port notation is given as



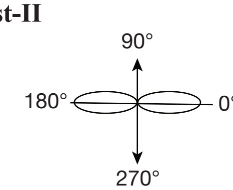
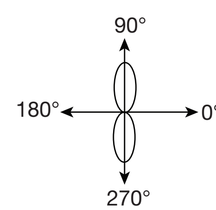
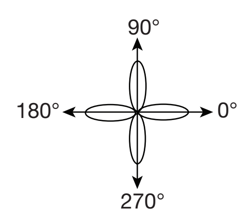
(A) 0.036 (B) 0.3162
(C) 0.948 (D) 0.3462

22. A step-index fiber has a core diameter 100 µm, and accepting angle is 14°. Then find the number of modes that the fiber can propagate at a wavelength of 0.5 µm.
(A) 5780 (B) 11560
(C) 23120 (D) None of the above

23. The radial component of the radiated power density of an infinitesimal linear dipole of length $\ell(\ell << \lambda)$ is given by $W_{avg} = \hat{a}_r\, A_o \frac{\sin\theta}{r^2}\left(\frac{W}{m^2}\right)$ where A_o is the peak value of the power density. Find maximum directivity of the antenna?
(A) $4\pi A_o$ (B) $\frac{A_o}{4\pi}$
(C) $\frac{4}{\pi}$ (D) $\frac{\pi}{4}$

24. The radiation intensity of the major lobe of an antenna is represented by $U = B_o \cos\theta$. The radiation intensity only in the upper hemisphere. Find beam solid angle
(A) $\frac{\pi}{2}$ steradian (B) π steradian
(C) 2π steradian (D) $\frac{\pi}{4}$ steradian

25. Match List-I (different α, d value) with List-II (field configuration)

List-I	List-II
(p) $\alpha = 0, d = \frac{\lambda}{2}$	(1) 
(q) $\alpha = 0°, d = \lambda$	(2) 
(r) $\alpha = \pi, d = \frac{\lambda}{2}$	(3) 

(A) $p-1, q-2, r-3$ (B) $p-3, q-2, r-1$
(C) $p-2, q-3, r-1$ (D) $p-3, q-1, r-2$

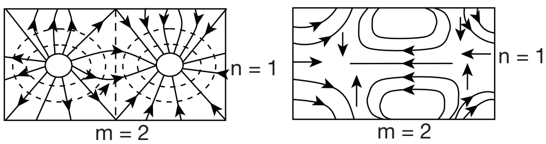
Answer Keys

1. A	**2.** D	**3.** C	**4.** A	**5.** A	**6.** B	**7.** B	**8.** A	**9.** C	**10.** B
11. D	**12.** B	**13.** A	**14.** B	**15.** B	**16.** C	**17.** D	**18.** C	**19.** C	**20.** A
21. C	**22.** B	**23.** C	**24.** B	**25.** C					

Hints and Explanations

Solutions for questions 1 to 25:

1. Field configuration of TM_{21} Mode is



Choice (A)

2. $T_{E_{11}}$ is dominant mode in a circular wave guide.

Choice (D)

3. $\beta l = \dfrac{2\pi}{\lambda} \times \dfrac{\lambda}{16} = \dfrac{\pi}{8} = 22.5^o$

$I_L = \dfrac{V_L}{Z_L} = \dfrac{25\,e^{j20}}{50\,e^{j30^o}}$

$I_L = 0.5\ e^{-j10^o}$ at load

$I_L\left(\dfrac{\lambda}{16}\right)$ from load $= 0.5e^{-j10^o}\ e^{j22.5^o}$

$= 0.5\ e^{j12.5^o}$. Choice (C)

4. For cubical cavity $a = b = c$

$$f_r = \frac{C}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2 + \left(\frac{P}{c}\right)^2}$$

$$8 \times 10^9 = \frac{3\times 10^{10}}{2}\sqrt{\left(\frac{1}{a}\right)^2 + \left(\frac{1}{c}\right)^2}$$

$\Rightarrow\ a = 2.65$ cm. Choice (A)

5. $S_{11} = \Gamma_{in} = S_{11} + \dfrac{S_{12}\,S_{21}\,\Gamma_L}{1 - S_{22}\,\Gamma_L}$

For open circuited $Z_L \to \infty$

i.e., $\Gamma_L = \dfrac{Z_L - Z_O}{Z_L + Z_O} = +1$

$S_{11} = \dfrac{S_{11}(1 - S_{22}) + S_{12}\,S_{21}}{1 - S_{22}}$

$= \dfrac{S_{11} - (\Delta S)}{1 - S_{22}}$. Choice (A)

6. $f_c = 0.6 \times 8$ GHz
$= 4.8$ GHz

$\lambda_c = \dfrac{C}{f_c} = \dfrac{3\times 10^{10}}{4.8\times 10^9} = 6.25$ cms

$\lambda_c = 6.25 = \dfrac{2\pi r}{1.841}$

$\Rightarrow\ r = 1.83$ cm. Choice (B)

7. $(P_{bd})_{T_{E_{11}}} = 1790\, r^2\left[1 - \left(\dfrac{f_{c_{11}}}{f}\right)^2\right]^{\frac{1}{2}}$ kW

$\lambda_{c_{11}} = \dfrac{2\pi r}{1.841} = \dfrac{4\pi}{1.841}$

$f_{c_{11}} = \dfrac{C}{\lambda c_{11}} = 4.4\,\text{GHz}$

$(P_{bd})_{T_{E_{11}}} = 1790 \times \left(\dfrac{4}{2}\right)^2\left[1 - \left(\dfrac{4.4}{10}\right)^2\right]^{\frac{1}{2}}$ kW

$= 6.429$ MW. Choice (B)

8. Choice (A)

9. Center of constant circle is $(1, 1/x)$, radius is $1/x$. Choice (C)

10. $d = 3.57\left[\sqrt{h_t} + \sqrt{h_r}\right]$km

$= 3.57 \times 7 = 24.99$ km. Choice (B)

11. Choice (D)

12. field $\alpha\, \dfrac{1}{r}$

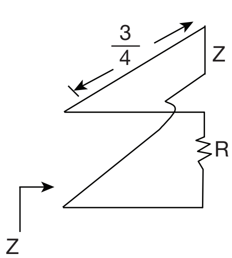
field$_1 \times r_1 =$ field$_2\, r_2$
$\Rightarrow\ 6 \times 50 = 12 \times f_2$
$\Rightarrow\ f_2 = 25$ μv/m. Choice (B)

13. $\dfrac{\sigma}{\omega\varepsilon} >> 1$ so it is conductor, it acts as a short circuit

$Z_L = 0$

$\Gamma = \dfrac{Z_L - Z_O}{Z_L + Z_O} = -1$. Choice (A)

14.



From short circuit side $z_L = 0$

$$\beta l = \frac{2\pi}{\lambda} \times 3\frac{\lambda}{4} = 3\frac{\pi}{2}$$

Then $Z_{in} = Z_o \left[\frac{Z_L + jZ_o \tan\beta l}{Z_o + jZ_L \tan\beta l}\right] = \frac{Z_0^2}{Z_L} = \infty$

$\Rightarrow \quad Z_{in} = \infty \,//\, R_o = R_o$. Choice (B)

15. $P = \dfrac{\sqrt{1-\left(\dfrac{f_c}{f_o}\right)^2}}{2\eta} E_{max}^2 .a.b$ kW

$f_o = 8$ GHz

$$f_c = \frac{C}{\lambda_C} = \frac{3\times10^{10}}{2.5} = 1.2\,\text{GHz}$$

$$P = \frac{\sqrt{1-\left(\frac{1.2}{8}\right)^2}}{2\times120\pi} \times 36\times10^6 \times 2.5\times1.05$$

$= 123.916$ kW. Choice (B)

16. $Z_{in} = Z_o \left[\dfrac{Z_L + jZ_o \tan\beta l}{Z_o + jZ_L \tan\beta l}\right] \left[Z_o = \sqrt{\dfrac{L}{C}} = \dfrac{2}{5}\times10^3 = 400\,\Omega\right]$

$$= 400\left[\frac{300 + j\,400}{400 + j\,300}\right]$$

$$= 400\left[\tan^{-1}\left(\frac{4}{3}\right) - \tan^{-1}\left(\frac{3}{4}\right)\right]$$

$= 400\angle16°\,\Omega$. Choice (C)

17. $\gamma = \sqrt{(R + j\omega L)(G + j\omega C)}$

$$= \sqrt{(10 + j50\pi)(5\times10^{-3} + j\,\pi\times10^{-4})} = \propto + j\beta$$

$= 0.55 + j0.55$/m

$\Rightarrow \quad \beta = 0.55\ \text{m}^{-1}$

$\Rightarrow \quad t = \dfrac{\beta\,\ell}{\omega} = \dfrac{0.55\times5}{5\times10^6} = 0.55\,\mu\,\text{sec}$. Choice (D)

18. $\dfrac{2\pi}{\sqrt{\left(\dfrac{\pi}{a}\right)^2 + \left(\dfrac{\pi}{b}\right)^2}} = \dfrac{2\pi\times a}{3\pi}$

$$\Rightarrow \left(\frac{a}{b}\right)^2 = 8$$

Given that f_c of $T_{E_{03}}$ is 10 GHz

$$\lambda_C = \frac{3\times10^{10}}{10^{10}} = 3\,\text{cm}$$

$$\Rightarrow \frac{2\pi\times a}{3\pi} = 3 \Rightarrow a = 4.5\,\text{cm}$$

$b = 1.6$ cm. Choice (C)

19. Wave is travelling on negative x axis

$\Rightarrow \quad E \times H\left(-\hat{a}_x\right)$

i.e., $E = 8\,\hat{a}_z$

$H = 2\,\hat{a}_y$. Choice (C)

20. Given that $[S] = \begin{bmatrix} 0 & 0.89\,e^{j63.43^o} \\ 0.89\,e^{j63.43^o} & 0 \end{bmatrix}$

If the wave is travelled ℓ distance phase of wave is changed by ϕ_1 then new scattering matrix is

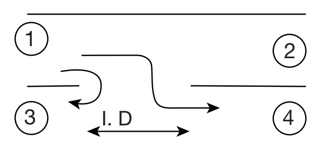
$$[S] = \begin{bmatrix} 0 & 0.89\,e^{j(63.43-\varphi_1)} \\ 0.89\,e^{j(63.43^o-\varphi_1)} & 0 \end{bmatrix}$$

Given that S_{12} and S_{21} are real so $\phi_1 = 63.43^o$

$\Rightarrow \quad \beta l = \phi_1$

$l = \dfrac{63.43}{10\pi} = 2$ m. Choice (A)

21. $[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{bmatrix}$



Coupling $= 10\log\dfrac{P_4}{P_1} = 10$

$$\Rightarrow \frac{P_4}{P_1} = 10 = \frac{P_1}{P_4} = \left|S_{41}^2\right| = \frac{1}{10}$$

$\Rightarrow \quad S_{41} = 0.3162 = S_{14}$

$\Rightarrow \quad D = 10\log\dfrac{P_4}{P_3}$

$\Rightarrow \quad 20 = 10\log\dfrac{|S_{14}|^2}{|S_{13}|^2}$

$\Rightarrow \quad \dfrac{|S_{14}|^2}{|S_{13}|^2} = 100$

$\Rightarrow \quad \sqrt{\dfrac{(0.3612)^2}{10^2}} = S_{13} = 0.036 = S_{31}$

Given that $VSWR = 1$

$$S_{11} = S_{22} = S_{33} = S_{44} = \frac{VSWR-1}{VSWR+1} = 0$$

$$\Rightarrow \quad [S]=\begin{bmatrix} 0 & S_{12} & 0.036 & 0.3162 \\ S_{21} & 0 & S_{23} & S_{24} \\ 0.036 & S_{23} & 0 & S_{34} \\ 0.3162 & S_{24} & S_{34} & 0 \end{bmatrix}$$

$\Rightarrow$ $[S]\,[S]^* = I$

So $|S_{12}|^2 + |S_{13}|^2 + |S_{14}|^2 = 1$

$\Rightarrow$ $S_{12} = 0.948.$ Choice (C)

22. $N = \dfrac{V^2}{2} = \dfrac{1}{2}\left(\dfrac{\pi dNA}{\lambda}\right)^2$

$NA = \sin\theta_a$

$\Rightarrow$ $\sin 14^\circ = 0.242$

$$N = \frac{1}{2}\left(\frac{\pi\times 100\times 10^{-6}\times 0.242}{0.5\times 10^{-6}}\right)^2 = 11560.$$

Choice (B)

23. $D_{max} = \dfrac{4\pi U_{max}}{P_{rad}}$

$U = r^2\, W_{av} = A_o \sin\theta$

U_{max} occurs at $\theta = \dfrac{\pi}{2} \Rightarrow U_{max} = A_o$

$$P_{rad} = \oint\!\!\oint_S U.ds = A_o \int_0^{2\pi}\int_0^{\pi} \frac{\sin\theta}{r^2}\times r^2 \sin\theta\, d\theta\, d\varphi = A_o\,\pi^2$$

$$\Rightarrow D_{max} = \frac{4\pi\times A_o}{A_o\,\pi^2}$$

$D_{max} = \dfrac{4}{\pi}.$ Choice (C)

24. Beam Solid angle

$$(\Omega_A) = \frac{1}{F(\theta,\varphi)_{max}}\int_0^{2\pi}\int_0^{\pi} F(\theta,\varphi)\sin\theta\, d\theta\, d\phi$$

Given that radiation intensity is only for upper hemisphere.

$\phi \in (0, 2\pi)$, $\phi \in (0, \pi/2)$

$$\Omega_A = \frac{1}{2}\int_0^{2\pi}\int_0^{\pi/2} 2\cos\theta \sin\theta\, d\theta\, d\phi$$

$= \dfrac{1}{2}\times 2\pi\times 1 = \pi.$ Choice (B)

25. $\Psi = (\beta d\cos\theta + \alpha)$

For $\alpha = 0$, $d = \dfrac{\lambda}{2}$

$\Psi = \dfrac{K}{s(s+9)}$

$= \pi\cos\theta$

$E = 2E_o \cos(\Psi/2)$

E_{max} at $\theta = 90^\circ$ and 270°

E_{min} at

$\Rightarrow$ $\theta = 0^\circ$ and 180°

$p - 2$, $q - 3$, $r - 1$.

Choice (C)