Section Title : One Mark Questions
Total Questions: 10
Max Marks : 1
-ve Marks :0.33

Question No: 1

Analysis

Which of the following values can be greater than intrinsic impedance of free space?

(A) TE wave impedance in rectangular wave guides

(B) TM wave impedance in cylindrical wave guides

(C) TEM wave impedance in parallel plane wave guides

(D) TM wave impedance in rectangular wave guides

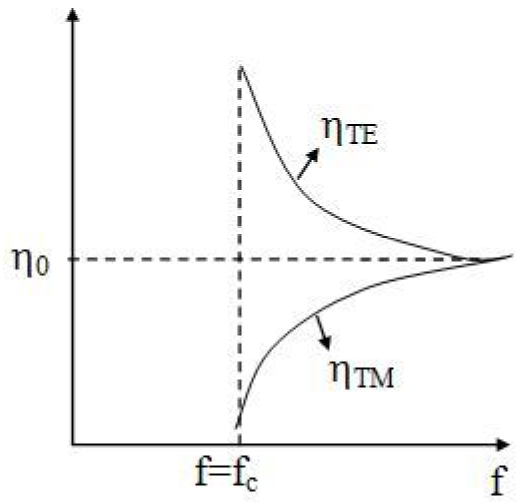
Not Attempted -- Correct Answer : A

Solution :

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

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

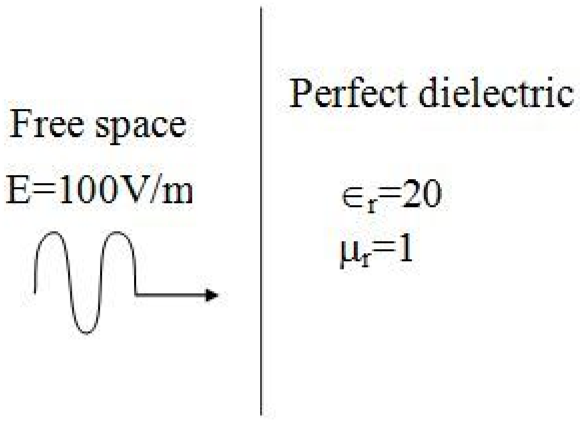
$\eta_{TM} \leq \eta_0 \leq \eta_{TE}$



Question No: 2

Analysis

A uniform plane wave traveling through the free space having the electric field amplitude 100V/m incident normally on a perfect dielectric as shown in figure. The magnitude of magnetic field (in A/m) in the dielectric is _____.



Not Attempted -- Correct Answer : 0.43 & Valid Answer Range :0.37,0.46

Solution :

$$\tau = \frac{E_{0t}}{E_{0i}} = \frac{2\eta_2}{\eta_2 + \eta_1}$$

$$\eta_1 = 120\pi\Omega, \eta_2 = \frac{120\pi}{\sqrt{20}} = 84.2\Omega$$

$$E_{0t} = \frac{2 \times 84.2}{120\pi + 84.2} \times 100 = 36.5 V/m$$

$$H_{0t} = \frac{36.5}{84.2} = 0.43349A$$

Question No: 3

Analysis

Pick up the right statement regarding the end fire array when comparing with broad side array

(A) Directivity is always along the normal to the axis of the array

(B) Directivity is at 60° between the axis and normal to the axis

(C) The beam angles are undefined for any spacing and number of elements

(D) They have wider beams than broad side array.

Not Attempted -- Correct Answer : D

Solution :

$(\text{Beam width})_{\text{end fire}} > (\text{Beam width})_{\text{broad side}}$

Question No: 4

Analysis

A silica fiber has a refractive index of 1.5 and it is surrounded by cladding material with a refractive index of n_2 .If the critical angle is 60° then n_2 is ________.

Not Attempted -- Correct Answer : 1.3 & Valid Answer Range :1.26,1.37

Solution :

$$\theta_C = \sin^{-1}\left(\frac{n_2}{n_1}\right)$$

$$\sin\theta_C = \frac{n_2}{n_1}$$

$$n_2 = n_1 \sin\theta_c = 1.5 \times \sin 60° = 1.5 \times \frac{\sqrt{3}}{2} = 1.3$$

$n_2 = 1.3$

Question No: 5

Analysis

A transmission line with characteristic impedance 100Ω is terminated with a load Z_L.The VSWR calculated on the line is 3.If the load is replaced with an open circuit, the voltage minima is shifted by $\frac{\lambda}{4}$ away from the load. The value of load impedance Z_L (in Ω) is _____.

Not Attempted -- Correct Answer : 33.33 & Valid Answer Range :33,34
Solution :

When the load is open circuited, V_{max} will at the load so, previously V_{min} will be at the load, so the impedance $Z_L = \frac{Z_0}{3} = 33.33\Omega$

Question No: 6
Analysis

For an antenna the aperture efficiency is 80% and maximum effective area is $2m^2$. The physical area of the antenna is ____m^2.

Not Attempted -- Correct Answer : 2.5 & Valid Answer Range :2.5,2.5
Solution :

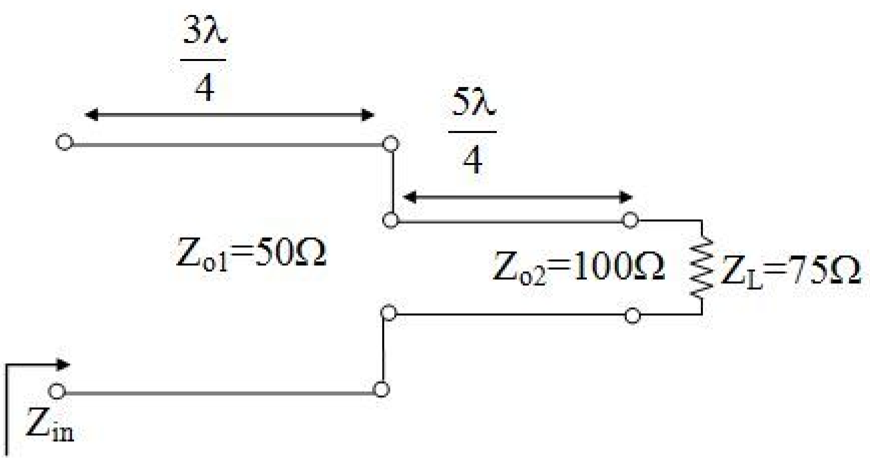
A_e=k A_p

$$A_P = \frac{A_e}{k} = \frac{2}{0.8}$$

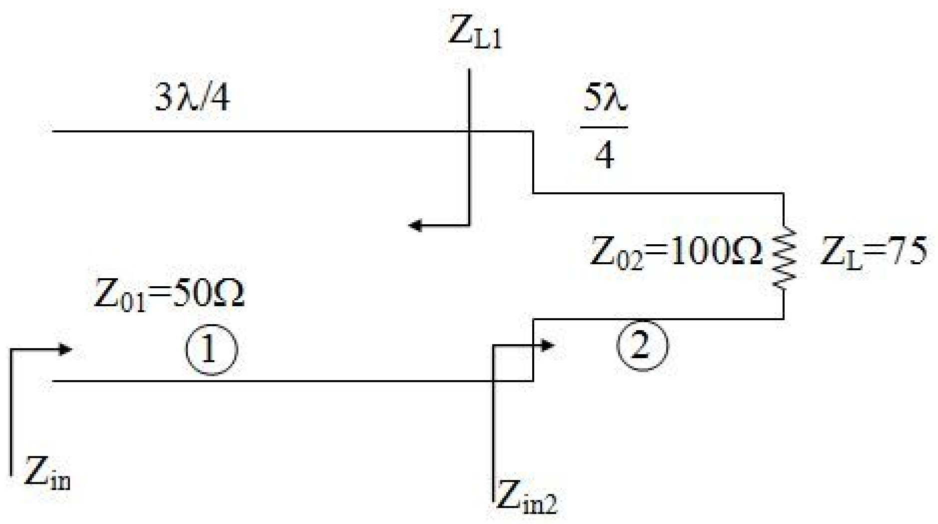
A_p =2.5 m^2

Question No: 7
Analysis

Consider the lossless transmission line shown in figure. The input impedance Z_{in} _______Ω.



Not Attempted -- Correct Answer : 18.75 & Valid Answer Range :18.6,18.8
Solution :



$$Z_{in2} = \frac{Z_{02}^2}{Z_L} = \frac{100\times100}{75}$$

$Z_{in2}=133.3\Omega$

$$Z_{L_1} = Z_{in_2} = 133.3\Omega$$

$$Z_{in} = \frac{Z_{0_1}^2}{Z_{L_1}} = \frac{50\times50}{133.3}$$

$Z_{in} = 18.75\Omega$

Question No: 8

Analysis

If the magnetic flux density $\vec{B} = \left(\frac{2}{\rho}\right)\hat{a}_\phi \text{mT}$, then the net magnetic flux crossing the plane surface described by $0.5 \le \rho \le 2.5$ m and $0 \le z \le 2$ m is _______. (where ρ,ϕ,Z are cylindrical coordinates)

(A) 0.8 mWb

(B) 3.2 mWb

(C) 3.2 μWb

(D) 6.4 mWb

Not Attempted -- Correct Answer : D

Solution :

Given $\vec{B} = \frac{2}{\rho}\hat{a}_\phi \times 10^{-3}$ Tesla

$$\phi = \int_s \underset{(\phi=\text{constant})}{\vec{B}.\vec{ds}} = 10^{-3}\int_{\rho=0.5}^{2.5}\int_{z=0}^{2}\frac{2}{\rho}\hat{a}_\phi.d\rho dz\hat{a}_\phi$$

$$= 2\times10^{-3}\left[\ln\left(\frac{2.5}{0.5}\right)\right]\times2$$

$$= 6.437\times10^{-3}$$

$\therefore \phi = 6.43\text{mWb}$

Question No: 9

Analysis

A lossless transmission line is short circuited at one end has electrical path length of $\frac{\pi}{4}$ radians. If its input impedance is j80Ω, then characteristic impedance of the line is

(A) j80Ω (B) j40Ω

(C) 80Ω (D) j∞Ω

Not Attempted -- Correct Answer : C

Solution :

given:

Short circuited transmission line

Electrical length $\beta\ell = \frac{\pi}{4}$ radians

$Z_{in} = Z_{sc} = jZ_0 \tan\beta\ell$

$j80 = jZ_0 \tan\frac{\pi}{4}$

$\therefore Z_0 = 80\Omega$

Question No: 10

Analysis

If a point charge of 10nC is located at the centre of the sphere of radius 'r', then electric field intensity of any point on the surface of the sphere, will have

(A) both θ & ϕ components

(B) only radial component

(C) only θ- component

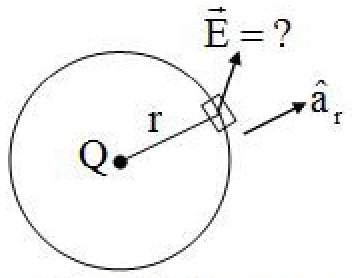
(D) only ϕ - component

Not Attempted -- Correct Answer : B

Solution :

$\vec{E} = \frac{Q}{4\pi\varepsilon r^2}\hat{a}_r$ (or)

$\vec{E} = E_r\hat{a}_r$



Therefore field intensity has only radial component

Section Title : Two Marks Questions

Total Questions: 20

Max Marks : 2

-ve Marks :0.66

Question No: 11

Analysis

A proton of mass 1.67×10^{-27} kg and charge 1.6×10^{-19}C is projected with a speed of 2×10^{6} m/s at an angle of 60° to the x-axis. If a uniform magnetic field of 0.104 Tesla is applied along y- axis, the path of proton is

(A) a circle of radius 0.2m and time period $\pi\times10^{-7}$ sec

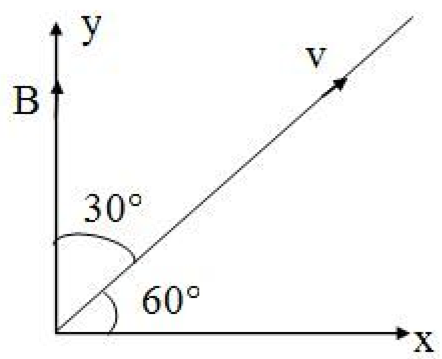
(B) a circle of radius 0.1m and time period $2\pi\times10^{-7}$ sec

(C) a helix of radius 0.1 m and time period $2\pi\times10^{-7}$ sec

(D) a helix of radius 0.2 m and time period $4\pi\times10^{-7}$ sec

Not Attempted -- Correct Answer : C

Solution :



Angle between the B and v is 30°, so the path of the particle is helix.

$$T = \frac{2\pi m}{Bq} = \frac{2\pi\times1.67\times10^{-27}}{0.104\times1.6\times10^{-19}} = 2\pi\times10^{-7}\text{ sec}$$

$$r = \frac{mv\sin\theta}{Bq} = \frac{1.67\times10^{-27}\times2\times10^{6}}{1.6\times10^{-19}\times0.104}\times\sin30^{\circ} = 0.1\text{m}$$

Question No: 12

Analysis

A lossless antenna is operating at 100 MHz and its maximum effective aperture is 0.7162 m^2 at this frequency. The input impedance of this antenna is 75Ω and it is attached to a 50Ω transmission line.If the polarization is matched ,then the directivity of the antenna , is _____.

(A) 1.04

(B) 0.4924

(C) 3

(D) 3.54

Not Attempted -- Correct Answer : A

Solution :

A_{emax}=0.7162 m^2

$$A_{emax} = \frac{\lambda^2}{4\pi} e_{cd}\, e_r\, e_p\, D$$

Radiation efficiency (e_{cd})= 1 (lossless)

Reflection (mismatch) efficiency $e_r = (1-\Gamma^2) = \left(1-\left(\frac{75-50}{75+50}\right)^2\right)$

$$= (1-0.2^2) = 0.96$$

Polarization efficiency (e_P) =1

$$D = \frac{0.7162}{\frac{9}{4\pi}(1)(0.96)(1)} \quad \left(\because \lambda = \frac{3\times10^8}{100\times10^6} = 3\text{m}\right)$$

D=1.0417

Question No: 13

Analysis

A radar transmits a power of 1W at 30MHz frequency towards the target, and the received power was measured to be 0.1425mW with antenna gain of 75. If the same antenna is used for both transmitting and receiving and the polarizations of both are matched and the distance between the antenna and target was 500m, then the cross section of the target is _____.

(A) 20m^2

(B) 41.31cm^2

(C) 1500m^2

(D) 31419m^2

Not Attempted -- Correct Answer : D

Solution :

$$\frac{P_r}{P_t} = \frac{G_T G_R \sigma}{4\pi}\left[\frac{\lambda}{4\pi R^2}\right]^2$$

$$\Rightarrow \sigma = \frac{P_r 4\pi}{P_t G_T G_R}\left[\frac{4\pi R^2}{\lambda}\right]^2 \left(\therefore \lambda = \frac{3\times10^8}{30\times10^6} = 10\text{m}\right)$$

$$= \frac{0.1425\times10^{-3}\times4\pi}{1\times75\times75}\times\left(\frac{4\pi\times(500)^2}{10}\right)^2 = 31419.69\text{m}^2$$

Question No: 14

Analysis

The maximum radiation intensity of a 90% efficiency antenna is 200mW/Sr. The directivity and power gain (in dB) respectively, when the radiated power is 125.66mW are ______.

(A) 13.45 and 13

(B)10.55 and 12

(C) 13 and 12.55

(D) 10.45 and 11

Not Attempted -- Correct Answer : C

Solution :

Given: $U_{max} = 200$ mW/Sr

$\eta = 0.9$

$P_{rad} = 125.66$mW

Directivity of antenna is given by

$$D = 4\pi \frac{U_{max}}{P_{rad}}$$

$$= 4\pi \times \frac{200 \times 10^{-3}}{125.66 \times 10^{-3}}$$

$= 20$

$D_{(in\ dB)} = 10\log 20$

$= 13.01$

Power gain of antenna is given by

$G_P = \eta D$

$= (0.9)(20)$

$= 18$

$G_{P(in\ dB)} = 10\log 18$

$= 12.55$

Question No: 15

Analysis

A linearly polarized uniform plane wave traveling in the positive z-direction with a power density of 10mW per square meter, is incident upon a left circularly polarized antenna whose gain is 10dB at 10GHz. The power that will be delivered to a load attached directly to the terminals of the antenna is ___ .

(A) 3.58μW

(B) 7.16μW

(C) 10μW

(D) 3.5mW

Not Attempted -- Correct Answer : A

Solution :

Poynting vector of incident wave, $P = 10mW/m^2$

Directive gain, $10\log D = 10$

$D = 10$

Frequency $f = 10GHz$

$$\lambda = \frac{3\times10^8}{10^{10}} = 3\times10^{-2}\,m$$

Maximum aperture area of antenna is given by

$$A_{e\,(max)} = \left(\frac{\lambda^2}{4\pi}\right) D\times e_p$$

$$= \left[\frac{\left(3\times10^{-2}\right)^2}{4\pi}\right]\times10\times\frac{1}{2} \quad \text{(polarization efficiency } e_p=\frac{1}{2}\text{)}$$

$=3.58\times10^{-4}$

$$A_{e(max)} = \frac{P_{received}}{P}$$

$P_{received} = (10\times10^{-3})\times3.58\times10^{-4} = 3.58\times10^{-6}W$

Question No: 16

Analysis

Two elements of an array have amplitudes 1A nd 0.5A with the spacing between them is half wavelength. The directions of maximum (in radians) and minimum (in radians) field respectively, when the array is excited with phase difference of zero radians, are ______.

(A) $\frac{\pi}{2}, \frac{3\pi}{2}$ and $0,\pi$

(B) $0,\pi$ and $\frac{3\pi}{2}, \frac{\pi}{2}$

(C) $\frac{\pi}{3}, \frac{2\pi}{3}$ and $\frac{\pi}{2}, \frac{3\pi}{2}$

(D) $0, \frac{\pi}{2}$ and $\pi, \frac{3\pi}{2}$

Not Attempted -- **Correct Answer : A**

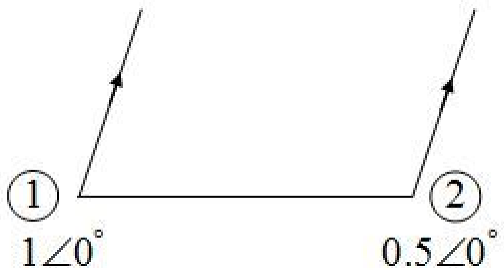
Solution :

Given spacing $d = \frac{\lambda}{2}$

$\alpha = 0^{\circ}$

Total field intensity

at the far-field zone is given by



$E_T = E_0\, e^{j0} + 0.5E_0\, e^{j\psi}$

$= E_0\, [1+0.5e^{j\psi}]$

Where $\psi = \beta d\cos\theta + \alpha$

$$= \frac{2\pi}{\lambda} \times \frac{\lambda}{2} \cos\theta + 0$$

$\psi = \pi\cos\theta$

$E_T = E_0\, [1+0.5e^{j\pi\cos\theta}]$

To get direction of maximum radiation

$\pi\cos\theta_{max} = \pm 2n\pi$; n =0,1,2, -----

n = 0

$\cos\theta_{max} = 0$

$\therefore\ \theta_{max} = 90^0, 270^0$ (or) $\frac{\pi}{2}^c, \frac{3\pi}{2}^c$

To get direction of minimum radiation

$\pi\cos\theta_{max} = \pm 2n\pi$; n =0,1,2, -----

n = 0

$\cos\theta_{max} = 0$

$\therefore\ \theta_{max} = 90^0, 270^0$ (or) $\frac{\pi}{2}^c, \frac{3\pi}{2}^c$

To get direction of minimum radiation

$\pi\cos\theta_{min} = \pm(2n+1)\pi$;   n =0,1,-----

n=0

$\cos\theta_{min} = \pm 1$

$\theta_{min} = 0^0, 180^0$ (or) $0^c, \pi^c$

Therefore the directions of maximum and minimum are occurring at $\frac{\pi}{2}^c, \frac{3\pi}{2}^c$ and 0^c, π^c respectively

Question No: 17

Analysis

Two infinitely large conducting plates are located at x=1m and x=4m. The region between them is free space with non-uniform charge distribution $\frac{x}{6\pi}$ nC/m^3.If V(1) = –50V and V(4) = 50V, then the potential at x=2m is ______.

(A) – 2.35V

(B) 3.55V

(C)–2.66V

(D) +5.23V

Not Attempted -- **Correct Answer : C**

Solution :

From Poisson's equation

$$\nabla^2 V = \frac{-\rho_v}{\varepsilon_0} (\because \text{free space})$$

$$\Rightarrow \frac{\partial^2 V}{\partial x^2} = \frac{-\frac{x}{6\pi}\times 10^{-9}}{\frac{10^{-9}}{36\pi}}$$

$$\Rightarrow \frac{\partial^2 V}{\partial x^2} = -6x$$

$$\Rightarrow \frac{\partial V}{\partial x} = -3x^2 + A$$

$$\Rightarrow V(x) = -x^3 + Ax + B$$

Given: V(1) = –50V

V(4) = 50V

$-50 = -1 + A + B$ and

$50 = -64 + 4A + B$

$A + B = -49$

$4A + B = 114$

$A = 54.33$

$B = -103.33$

$V(x) = -x^3 + 54.33x - 103.33;\ 1<x<4$

The potential at x=2m is given by

$V(2) = -2^3 + 54.33\times 2 - 103.33$

$\therefore V(2) = -2.66V$

Question No: 18

Analysis

An uniform plane electromagnetic wave with electric field $E = 100e^{-\alpha z}\cos(\omega t - \beta z)\hat{a}_x$ V/m is traveling in pure ice (ε_r =3.45 ,loss tangent $\tan\theta = 0.035$) at a frequency 100MHz. The time average power (in mW) crossing an area of 1 cm^2 at z=0 plane is _____.

Not Attempted -- Correct Answer : 2.46 & Valid Answer Range :2.3,2.6

Solution :

$\varepsilon_r = 3.45$

$\tan\theta = 0.035$

$f = 100\text{MHz}$

$E_0 = 100\text{V/m}$

$\text{Area} = 1\text{cm}^2 = 10^{-4}\text{m}^2$

$$\tan\theta = \tan 2\theta_\eta = \frac{\sigma}{\omega\varepsilon} = 0.035$$

$\theta_\eta = 1.002$

$\cos\theta_\eta = 0.99984$

$$|\eta| = \frac{\sqrt{\frac{\mu}{\varepsilon}}}{\left[\sqrt{1+\frac{\sigma^2}{(\omega\varepsilon)^2}}\right]^{1/2}} = \frac{120\pi\sqrt{\frac{1}{3.45}}}{\left[\sqrt{1+(0.035)^2}\right]^{1/2}}$$

$|\eta| = 202.90\Omega$

$$p_{avg}(z) = \frac{E_0^2}{2|\eta|}e^{-2\alpha z}\cos\theta_n\hat{a}_z$$

So, the average power crossing an area of 1cm^2 is given by

$$P_{avg}\Big|_{at\ z=0} = \left(\frac{E_0^2}{2|\eta|}\cos\theta_n\right)\times\text{Area} = \frac{10^4}{2\times 202.90}\times 0.99984\times 10^{-4}$$

$\therefore P_{avg} = 2.46\text{mW}$

Question No: 19

Analysis

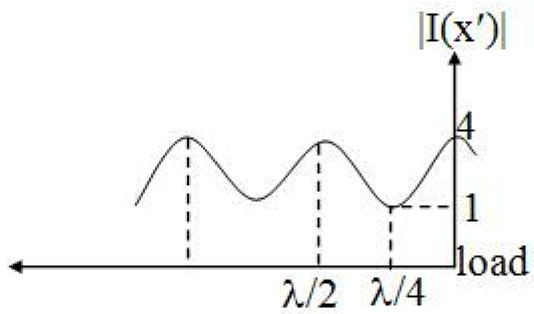
The current standing wave pattern on a lossless line with characteristic impedance 48Ω and a resistive load is shown in figure. Then the reflection coefficient at load is

(A) $\frac{3}{5}\angle 180^0$

(B) $\frac{3}{5}\angle 0^0$

(C) $\frac{3}{5}\angle 45^0$

(D) $\frac{3}{5}\angle 90^0$



Not Attempted -- Correct Answer : A

Solution :

As I_{max} is found at the load

Hence, $Z_{L\,(min)} = \frac{Z_0}{S}$

From the figure, $S = \frac{I_{max}}{I_{min}} = \frac{4}{1} = 4$

$Z_{L(min)} = \frac{48}{4} = 12\Omega$

Reflection coefficient

$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$

$= \frac{12-48}{12+48} = \frac{-3}{5}$ (or) $\frac{3}{5}\angle 180^0$

Question No: 20

Analysis

For the dominant mode propagating in a rectangular waveguide with breadth 10cm, the guide wavelength for a signal of frequency 2.5GHz will be equal to

(A) 0.12cm (B) 20cm

(C) 0.15m (D) 30cm

Not Attempted -- Correct Answer : C

Solution :

given dominant mode (TE_{10})

f= 2.5GHz

a = 10cm

$\lambda_c(TE_{10}) = 2a = 20cm$

$$\lambda = \frac{c}{f} = \frac{3\times10^{10}}{2.5\times10^{9}} = 12cm$$

$$\frac{1}{\lambda_g^2} = \frac{1}{\lambda^2} - \frac{1}{\lambda_c^2}$$

$$= \frac{1}{(12)^2} - \frac{1}{(20)^2}$$

$\therefore \lambda_g = 15cm$ (or) 0.15m

Question No: 21

Analysis

In a nonmagnetic medium the electric field is given by

E= 10 cos (10^8t–3y) $\hat{a}_x$ V / m . What type of medium it is ?

(A) Free space

(B) Lossy dielectric

(C) lossless dielectric

(D) perfect conductor

Not Attempted -- Correct Answer : C

Solution :

$\bar{E} = E_0 e^{-\gamma z} \cos(\omega t - \beta y)\hat{a}_x$

By comparing above equation with given $\bar{E}$

$\alpha=0$

But $\alpha = \omega\sqrt{\frac{\mu\varepsilon}{2}\left[\sqrt{1+\frac{\sigma^2}{\omega^2\varepsilon^2}}-1\right]}$

$\therefore \sigma=0$

And $\beta = \omega\sqrt{\frac{\mu\varepsilon}{2}\left[\sqrt{1+\frac{\sigma^2}{\omega^2\varepsilon^2}}+1\right]}$

$= \omega\sqrt{\frac{\mu\varepsilon}{2}\left[\sqrt{1+0}+1\right]}$

$\Rightarrow \beta = \omega\sqrt{\mu\varepsilon}$

$\Rightarrow \beta = \frac{\omega}{v}$

$\Rightarrow v = \frac{\omega}{\beta} = \frac{c}{\sqrt{\varepsilon_r \mu_r}}$

$\Rightarrow \frac{10^8}{3} = \frac{3\times 10^8}{\sqrt{\varepsilon_r}}$ ($\therefore \mu_r=1$ for non magnetic medium)

$\Rightarrow \varepsilon_r = 81$

$\sigma=0$, $\varepsilon=81\varepsilon_0$

$\therefore$ Medium is lossless dielectric

Question No: 22

Analysis

The amplitude of a wave traveling through a lossy non-magnetic medium reduces by 18% every meter. The wave operates at 10MHz and the electric field leads the magnetic field by 24°. The propagation constant is___ .

(A) 0.198+j0.448/m (B) 0.346+j 0.713/m

(C) 0.448+j0.198/m (D) 0.713+j0.346/m

Not Attempted -- Correct Answer : A

Solution :

$E=E_0e^{-\alpha z}$

At z= 1, magnitude of wave is 82% of that of at z=0

$\therefore\ 0.82\ E_0=E_0e^{-\alpha(1)}$

$\Rightarrow e^{-\alpha}=0.82$

$\Rightarrow \alpha=-\ln(0.82)=0.198\text{Np}/\text{m}$

$\phi=2\theta_\eta=2\times24°=48°$

$\tan\phi=\frac{\sigma}{\omega\varepsilon}\Rightarrow\frac{\sigma}{\omega\varepsilon}=\tan 48°$

$\Rightarrow\frac{\sigma}{\omega\varepsilon}=1.11$

$$\frac{\alpha}{\beta}=\frac{\omega\sqrt{\frac{\mu\varepsilon}{2}\left[\sqrt{1+\frac{\sigma^2}{\omega^2\varepsilon^2}}-1\right]}}{\omega\sqrt{\frac{\mu\varepsilon}{2}\left[\sqrt{1+\frac{\sigma^2}{\omega^2\varepsilon^2}}+1\right]}}=\sqrt{\frac{\sqrt{1+\frac{\sigma^2}{\omega^2\varepsilon^2}}-1}{\sqrt{1+\frac{\sigma^2}{\omega^2\varepsilon^2}}+1}}$$

$\Rightarrow\frac{0.198}{\beta}=\sqrt{\frac{1.49-1}{1.49+1}}=0.443$

$\Rightarrow\beta=0.446$ rad/m

$\therefore\ \gamma=\alpha+j\beta=0.198+j\ 0.446/\text{m}$

Question No: 23

Analysis

The expression for electric field of a uniform plane wave in a certain medium is $\overline{E}=\cos\left(\frac{10^7 t}{\pi}-2x-3y\right)(3\hat{a}_x-2\hat{a}_y)\text{V}/\text{m}$.

The expression for magnetic field is

(A) given wave is not valid

(B) $\frac{13}{4}\cos\left(\frac{10^7 t}{\pi}-2x-3y\right)\hat{a}_z\text{A}/\text{m}$

(C) $-\frac{13}{4}\cos\left(\frac{10^7 t}{\pi}-2x-3y\right)\hat{a}_z\text{A}/\text{m}$

(D) $-\frac{13}{4}\cos\left(\frac{10^7 t}{\pi}+2x+3y\right)\hat{a}_z\text{A}/\text{m}$

Not Attempted -- Correct Answer : C

Solution :

$\overline{K} = 2\hat{a}_x + 3\hat{a}_y$

$\overline{E} = \cos\left(\frac{10^7 t}{\pi} - 2x - 3y\right)(3\hat{a}_x - 2\hat{a}_y)$

$\overline{K}.\overline{E} = \cos\left(\frac{10^7 t}{\pi} - 2x - 3y\right)(6-6) = 0$

$\overline{K}\,\overline{E} = 0 \Rightarrow$ so given wave is valid

$\overline{K} \times \overline{E} = \omega\mu\ \overline{H}$

$\Rightarrow \overline{H} = \frac{1}{\omega\mu}(\overline{K} \times \overline{E})$

$= \frac{\pi}{4\pi}[2\hat{a}_x + 3\hat{a}_y] \times [(3\hat{a}_x - 2\hat{a}_y)\cos(\omega t - 2x - 3y)]$

$= \frac{1}{4}(-4\hat{a}_z - 9\hat{a}_z)\cos\left(\frac{10^7 t}{\pi} - 2x - 3y\right)$

$= -\frac{13}{4}\cos\left(\frac{10^7 t}{\pi} - 2x - 3y\right)\hat{a}_z$

Question No: 24

Analysis

A spherical capacitor, with outer radius of 4cm and inner radius of 1.5cm, has inhomogenous dielectric of $\varepsilon = \frac{10\varepsilon_0}{r}$. The capacitance of spherical capacitor is ______nF.

Not Attempted -- **Correct Answer : 1.13** **& Valid Answer Range :1.1,1.2**

Solution :

$$Q = \varepsilon \oint \bar{E}.d\bar{s} = \varepsilon E_r 4\pi r^2$$

$$\Rightarrow E_r = \frac{Q}{4\pi\varepsilon r^2}\hat{a}_r$$

$$V = -\int_b^a \bar{E}.d\bar{\ell} = -\int_b^a \frac{Q}{4\pi \times \frac{10\varepsilon_0}{r} r^2}\hat{a}_r.dr\,\hat{a}_r$$

$$= -\int_b^a \frac{Q}{40\pi\varepsilon_0}\frac{1}{r}dr$$

$$= \frac{-Q}{40\pi\varepsilon_0}\int_4^{1.5}\frac{1}{r}dr$$

$$= \frac{-Q}{40\pi \times \frac{10^{-9}}{36\pi}}[\ln r]_4^{1.5}$$

$$= \frac{36Q}{40\times 10^{-9}}\ln\left(\frac{4}{1.5}\right)$$

$$C = \frac{Q}{V} = \frac{40\times 10^{-9}}{36\times \ln\left(\frac{4}{1.5}\right)} = 1.13\text{nF}$$

Question No: 25

Analysis

For static fields, which of the following current densities are possible?

(A) $J = 2x^3 y\,\hat{a}_x + 4x^2 z^2 \hat{a}_y + 6x^2 yz\,\hat{a}_z$

(B) $J = xy\,\hat{a}_x + y(z+1)\hat{a}_y + 2y\,\hat{a}_z$

(C) $J = \frac{z^2}{\rho}\hat{a}_\rho + z\cos\phi\,\hat{a}_z$

(D) $J = \frac{\sin\theta}{r^2}\hat{a}_r$

Not Attempted -- **Correct Answer : D**

Solution :

(c) $\nabla.J = \frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho A_\rho) + \frac{1}{\rho}\frac{\partial A_\phi}{\partial\phi} + \frac{\partial Az}{\partial z}$

$$= \frac{1}{\partial}\frac{\partial}{\partial\rho}\left(\rho\frac{z^2}{\rho}\right) + \frac{\partial}{\partial z}(z\cos\phi)$$

$$= \cos\phi \neq 0$$

(d) $\nabla.\bar{J} = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 A_r) + \frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}(A_\theta \sin\theta) + \frac{1}{r\sin\theta}\frac{\partial A_\phi}{\partial\phi}$

$$= \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\sin\theta}{r^2}\right)$$

$$= 0$$

For static field $\nabla. J = 0$

Question No: 26

Analysis

Two plane parallel plates A and B are placed 8mm apart and plate B is 300V more positive than plate A. The electron travels from plate A to plate B with an initial velocity of 10^6 m/s. The velocity of electron after reaching the plate B is _____ $\times 10^6$ m/s

(Assume mass of electron= $m = 9.1 \times 10^{-31}$kg)

Not Attempted -- Correct Answer : 10.33 & Valid Answer Range :9.5,11

Solution :

$$\frac{1}{2}m(v_f^2 - v_i^2) = qV$$

$$\Rightarrow v_f^2 - v_i^2 = \frac{2qV}{m}$$

$$\Rightarrow v_f = \sqrt{v_i^2 + \frac{2qV}{m}}$$

$$\Rightarrow v_f = \sqrt{10^{12} + \frac{2\times1.6\times10^{-19}\times300}{9.1\times10^{-31}}}$$

$$= 10.33 \times 10^6 \text{ m/s}$$

Question No: 27

Analysis

A rectangular waveguide has a width to height ratio $\frac{a}{b} = 2$ and the ratio between operating frequency and the cutoff frequency is $\frac{f}{f_{c(10)}} = 2$ at f = 10GHz. Then the maximum time-averaged power (in Mega Watts) that can be transmitted in the waveguide in the TE_{10} mode without exceeding the breakdown electric field intensity of 30kV/cm in air is __.

Not Attempted -- Correct Answer : 2.3 & Valid Answer Range :2.1,2.5

Solution :

Given $\frac{a}{b} = 2$, $E_0 = 30kV/cm = 3 \times 10^6$ V/m

$$\frac{f}{f_{c(10)}} = 2$$

$f = 10GHz$

$$f_c = \frac{f}{2}$$

$$\frac{c}{2a} = 5GHz$$

$$\Rightarrow \frac{3\times 10^{10}}{2\times a} = 5\times 10^9$$

$\therefore a = 3cm$

$$\eta_{TE_{10}} = \frac{\eta_0}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$$

$$= \frac{120\pi}{\sqrt{1-\left(\frac{1}{2}\right)^2}} = \frac{240\pi}{\sqrt{3}} \qquad [\because \text{for air filled } \eta_0 = 120\pi\Omega]$$

$$P_{total} = \frac{E_0^2}{\eta(TE_{10})}\frac{ab}{4}$$

$$= \frac{9\times 10^{12}\times 9\times 10^{-4}}{\left(\frac{240\pi}{\sqrt{3}}\right)4\times 2}$$

$\therefore P_{total} = 2.325 \times 10^6$W (or) 2.32MW

Question No: 28

Analysis

A UHF lossless transmission line working at 1GHZ is connected to an unmatched line producing voltage reflection coefficient of $0.5\ \angle 30°$. The length and the position of the stub respectively to match the line will be approximately equal to,

(A) 6.25 cm and 3.4cm

(B) 3.4cm and 6.25 cm

(C) 3.125 cm and 6.82 cm

(D) 1.52cm and 3.41cm

Not Attempted -- Correct Answer : B

Solution :

length of the stub, $\ell_t = \frac{\lambda}{2\pi}\tan^{-1}\left(\frac{\sqrt{1-|K|^2}}{2|K|}\right)$

$$\lambda = \frac{\upsilon}{f} = \frac{3\times10^8}{10^9}$$

$$= 0.3\text{m}$$

$$|K| = 0.5$$

$$\ell_t = \frac{0.3}{2\pi}\tan^{-1}\left\{\frac{\sqrt{1-0.5^2}}{2(0.5)}\right\} = 3.4\text{cm}$$

The position of the stub from the load is given by $\ell_s = \frac{\phi+\pi-\cos^{-1}(|K|)}{2\beta}$

$$= \frac{\lambda}{4\pi}\left(\phi+\pi-\cos^{-1}(|K|)\right)$$

$$= \frac{0.3}{4\pi}\left[\frac{\pi}{6}+\pi-\cos^{-1}(0.5)\right]$$

$$\ell_s = 6.25\text{ cm}$$

Question No: 29

Analysis

A rectangular waveguide with internal dimensions 2.286 cm×1.016cm supporting TE_{10} mode at 5GHz is filled with a dielectric of relative permittivity '$\in_r$'. What are the limits of '$\in_r$' if only the dominant mode propagates?

(A) $1.72 < \in_r < 6.88$

(B) $2.95 < \in_r < 6.88$

(C) $6.88 < \in_r < 1.72$

(D) $2.95 < \in_r < 47.33$

Not Attempted -- Correct Answer : A

Solution :

When the waveguide is filled with dielectric $\lambda^1 = \frac{\lambda}{\sqrt{\epsilon_r}}$, and propagation can exist when $\lambda^1 < \lambda_c$ (or) $\frac{\lambda}{\sqrt{\epsilon_r}} < 2a = 4.572\text{cm}$.

$$\because \lambda = \frac{3\times10^{10}}{5\times10^{9}} = 6\text{cm}$$

To propagate only dominant mode

$$\lambda_C(TE_{20}) < \lambda^1 < \lambda_C(TE_{10})$$

$$a < \frac{\lambda}{\sqrt{\epsilon_r}} < 2a$$

$$\frac{\lambda}{2a} < \sqrt{\epsilon_r} < \frac{\lambda}{a}$$

$$\left(\frac{\lambda}{2a}\right)^2 < \epsilon_r < \left(\frac{\lambda}{a}\right)^2$$

$$\left(\frac{6}{2\times4.572}\right)^2 < \epsilon_r < \left(\frac{6}{4.572}\right)^2$$

$$\left(\frac{\lambda}{2a}\right)^2 < \epsilon_r < \left(\frac{6}{4.572}\right)^2$$

$$\therefore 1.72 < \epsilon_r < 6.88$$

Question No: 30

Analysis

A distortionless transmission line is operating at 120 MHz has $R = 20\Omega/m$, $L = 0.3\mu H/m$ and $C = 63$ pF/m. Then the distance travelled by voltage wave before its amplitude is reduced to 20% of its initial amplitude (in meters) is ________

Not Attempted -- **Correct Answer :** 5.55 **&** **Valid Answer Range :5.5,5.6**

Solution :

Given f = 120 MHz

$R = 20\ \Omega/m$, $L = 0.3\mu H/m$ and $C = 63$ pF/m

$$V_0 e^{-\alpha z} = 0.2\ V_0$$

$$e^{\alpha z} = 5$$

$$z = \frac{\ln(5)}{\alpha}$$

where $\alpha = \frac{R}{L}\sqrt{LC} = \frac{20}{0.3\times10^{-6}}\sqrt{0.3\times10^{-6}\times63\times10^{-12}} = 0.2898$ Np/m

$$\therefore \alpha = \frac{\ln(5)}{0.2898} = 5.55\text{ m}$$

Therefore the distance traveled by the voltage wave is 5.55 m