1. Write down Maxwell's equations in differential form and integral form and explain the physical meaning (10%). Derive the wave equation in a linear, isotropic, nondispersive, lossy, and homogeneous medium (5%). Find a time-varying solution to the wave equation with loss (5%). Derive the Poynting's theorem in the same medium and explain the physical meaning of each term (10%).

2. Consider a plane wave propagating in a homogeneous, lossless, and nonmagnetic medium. If the electric field is given by the expression

$$\overline{E} = 3\sin\left(2\pi\times10^8 t - \frac{4\pi}{3}y\right)\hat{z}\ \text{(V/m)}$$

(a) Write down the phasors of $\overline{E}$ and $\overline{H}$. (5%)
(b) Determine the time-averaged Poynting vector. (5%)

3. Given a uniform plane wave normally incident upon a plane air-to-dielectric interface, show that the standing-wave ratio is equal to the index of refraction of the dielectric. (10%)

4. Two plates of perfect electric conductor are placed at $x = 0$ and $x = a$, respectively, in free space with permittivity ϵ_0 and permeability μ_0. A TM wave is guided between these two plates, in the z direction, with magnetic field given by $\vec{H} = \hat{y}H_0\cos\left(\frac{n\pi}{a}x\right)e^{-jk_z z}$.
   (a) Derive the electric field (5%) and Poynting vector (5%).
   (b) Given angular frequency ω, derive the dispersion relation between k_z and ω (5%) and the cutoff frequency (5%).

5. Consider an empty rectilinear box made of perfect electric conductor. Its dimensions in x, y and z directions are a, b and d, respectively. The free space has permittivity of ϵ_0 and permeability of μ_0.
   (a) Derive the resonant frequency of $TM_{nm\ell}$ mode and possible indices of (n, m, ℓ) (5%).
   (b) Derive the resonant frequency of $TE_{nm\ell}$ mode and possible indices of (n, m, ℓ) (5%).
   (c) If the empty box is filled with material of permittivity $2\epsilon_0$ and permeability $3\mu_0$, how is the resonant frequency affected? (5%)

6. The far fields of a Hertzian dipole $\hat{z}I\ell$ placed at the origin are given by $\vec{E} = \hat{\theta}\eta\frac{jkI\ell}{4\pi r}e^{-jkr}\sin\theta$, $\vec{H} = \hat{\phi}\frac{jkI\ell}{4\pi r}e^{-jkr}\sin\theta$, where $\eta = 120\pi$.
   (a) Derive the Poynting vector (5%).
   (b) Derive the total time-average power radiated by the Hertzian dipole (5%).
   (c) Derive the input resistance of the Hertzian dipole (5%).

試題隨卷繳回