國立台灣科技大學九十九學年度碩士班招生試題

系所組別： 電機工程系碩士班己二組

科　　目： 電磁學

（總分為100分）

Problem 1 (total 25 points)

An infinite plane sheet in the $z = -\frac{\lambda}{4}$ plane carries a surface current of density

$$\mathbf{J}_s = +\sin \omega t \ \mathbf{a}_x \ \text{A/m}$$

As shown in Fig. 1, region 1 ($z < 0$) is free space, whereas region 2 ($z > 0$) is a perfect dielectric of $\varepsilon = 4\varepsilon_0, \mu = \mu_0$. Answer the following questions:

a) Find the instantaneous expressions of the incident electric and magnetic fields generated by the plane sheet onto the interface $z = 0$. (10%)
b) Obtain the phasor expressions of the reflected and transmitted electric and magnetic fields in both regions. (10%)
c) Determine the reflection coefficient and transmission coefficient at the interface $z = 0$. (5%)

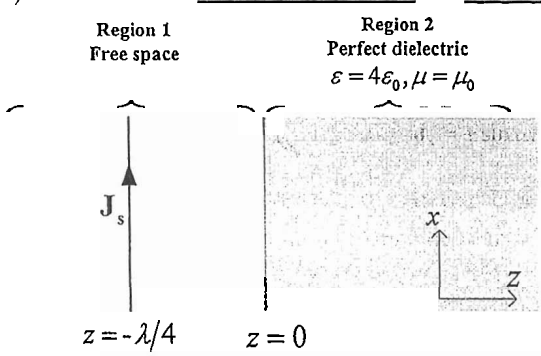

Fig. 1

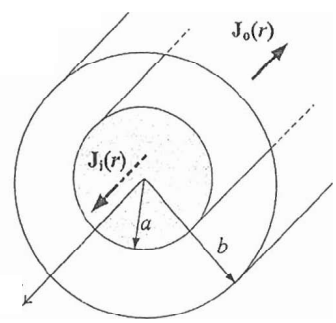

Fig. 2

Problem 2 (total 10 points)

Consider a pair of infinitely long co-centered cylindrical conductor in Fig. 2. Inside the cylindrical conductor ($r < a$) and on the conducting shell ($r = b$), there are, respectively, uniform volume current with density $\mathbf{J}_i(r) = J_o \mathbf{a}_z$ (A/m^2) and uniform surface current with density $\mathbf{J}_o(r) = -J_o / 4 \ \mathbf{a}_z$ (A/m). Find the condition such that the magnetic field outside the conducting shell ($r > b$) is zero. (10%)

Problem 3 (total 15 points)

The electric field of a uniform plane wave is given by

$$\mathbf{E} = -10e^{-0.1z}\cos\left(\pi \times 10^{10} t - 50\pi z\right)\mathbf{a}_x + 10e^{-0.1z}\sin\left(\pi \times 10^{10} t - 50\pi z\right)\mathbf{a}_y \quad \text{V/m}$$

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a) Find the following parameters associated with the wave: (a) linear frequency, (b) phase constant, (c) wavelength, (d) relative dielectric constant, and (e) attenuation constant. (10%)

b) Determine the polarization sense of this wave. (5%)

Problem 4 (total 16 points)

For a parallel-plate waveguide discontinuity shown in Fig. 3, if $TE_{1,0}$ and $TM_{1,0}$ waves at 4 GHz are incident on the junction from the dielectric-loaded side, find the followings:

Hint: $[\eta_g]_{TM} = \eta\sqrt{1-(f_c/f)^2}$ $\quad [\eta_g]_{TE} = \eta/\sqrt{1-(f_c/f)^2}$

(a) the wavelengths on the dielectric side λ_1 and free space side λ_2. (4%)

(b) the characteristic impedances η_{g1} and η_{g2} for $TE_{1,0}$ mode. (4%)

(c) the characteristic impedances η_{g1} and η_{g2} for $TM_{1,0}$ mode. (4%)

(d) the reflection coefficients Γ for $TE_{1,0}$ and $TM_{1,0}$ waves. (4%)

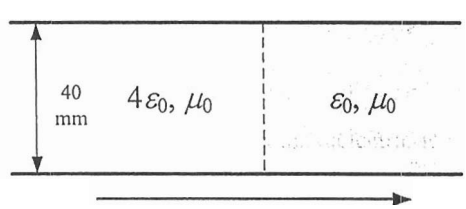

Fig. 3

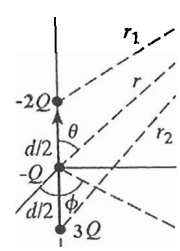

Fig. 4

Problem 5 (total 14 points)

For following charges and displacements: $-2Q$ at (0, 0, $d/2$), $-Q$ at (0, 0 ,0), and $3Q$ at (0, 0, $-d/2$), as shown in Fig. 4

(a) Find the first significant term in the expression for the electric potential at distances far from the origin ($r >> d$) (9%) [Hint: use $r_1 \approx r - \frac{d}{2}\cos\theta$ $\quad r_2 \approx r + \frac{d}{2}\cos\theta$]

(b) Find the electric field intensity due to above charge distribution via the gradient of the electric potential. (5%)

$$\nabla\Phi = \frac{\partial\Phi}{\partial r}\mathbf{a}_r + \frac{1}{r}\frac{\partial\Phi}{\partial\theta}\mathbf{a}_\theta + \frac{1}{r\sin\theta}\frac{\partial\Phi}{\partial\phi}\mathbf{a}_\phi$$

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Problem 6 (total 20 points)

For points on Smith Chart shown below, assuming the characteristic impedance of the line is 50 Ω, find

(a) the impedance at Point A. (4%)

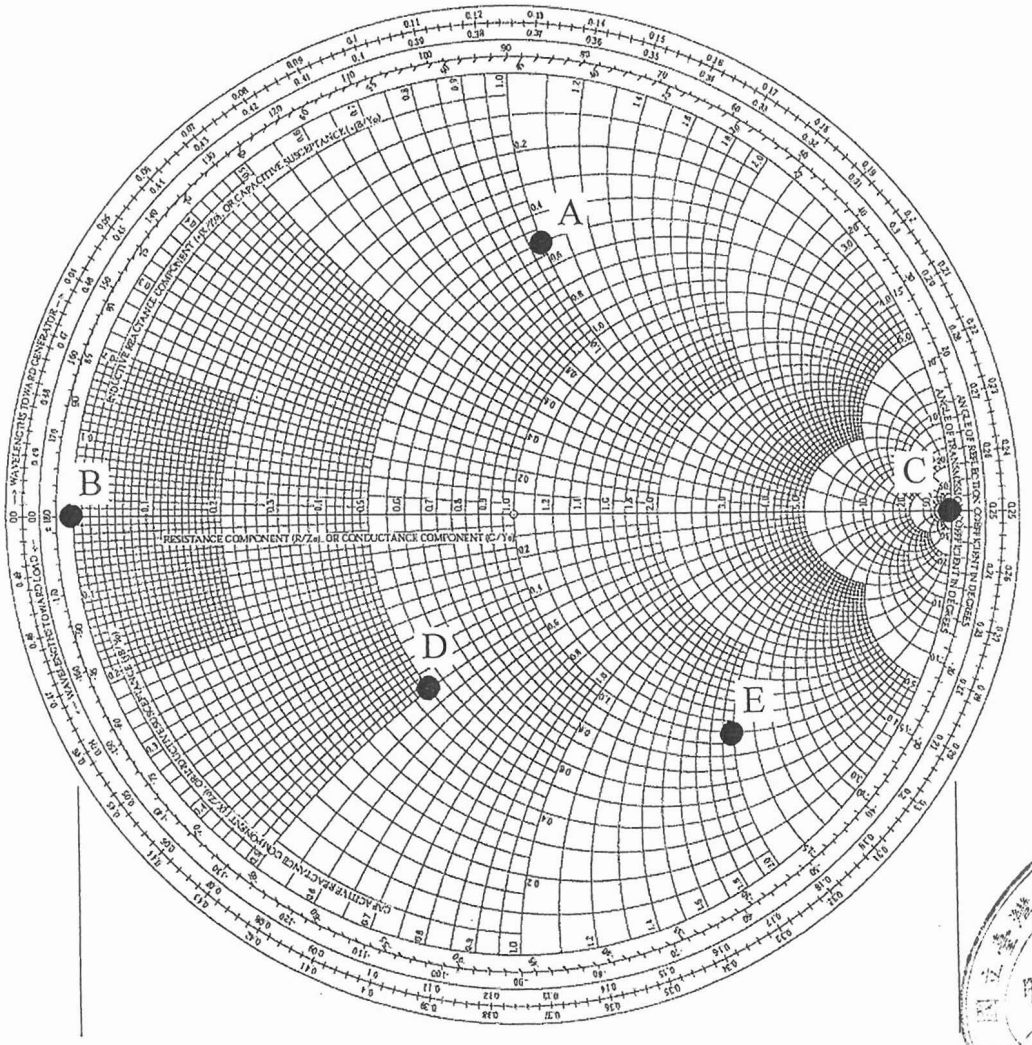
(b) the admittance at Point C. (2%)

(c) the reflection coefficient at Point D. (6%)

(d) the points with standing wave ratios lager than 10. (2%)

(e) the shunt reactance required to move point E to the matching point. (2%)

(f) if an open stub is shunted at Point E to provide matching, what is the stub length in terms of wavelength? (4%)



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