國立台灣科技大學九十六學年度碩士班招生試題

系所組別： 光電工程研究所碩士班

科　　目： 電磁學

總分 100 分

1. Consider a spherical dielectric shell of inner radius a and outer radius b containing a positive point charge Q at its center. The dielectric constant of the shell is ε_r. Determine electric flux density $\vec{D}$, electric potential V, and polarization vector $\vec{P}$ in the regions

   (a) $R < a$, (b) $a < R < b$, and (c) $R > b$. (15%)

2. A parallel-plate capacitor consists of two parallel conducting plates of area S separated by a uniform distance d. The dielectric material between the plates has a relative permittivity $\varepsilon_r = \frac{5d^2}{z^2}$, where z is measured from the bottom plate. Compute the capacitance. (12%)

3. An interface between two magnetic media lies in the x-y plane at z = 0. Above the x-y plane (z > 0), there exists a magnetic material with $\mu_{r1} = 3.0$ and a field $\vec{H}_1 = 4.0\,\hat{a}_x + 5.0\,\hat{a}_z$ (A/m). Below the x-y plane (z < 0) is free space.

(a) Assuming the boundary is free of surface current, find $\vec{H}_2$ and the angle that $\vec{H}_2$ makes with a normal to the surface? (13%)

(b) Assuming the boundary has a surface current $\vec{J} = 6.0\,\hat{a}_x$ (A/m), Find $\vec{H}_2$. (10%)

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4. (a) Write down Maxwell's equations in the differential form (time-varying) and integral form, and also give the constitutive relations. (The symbols used in answers **SHOULD** be clearly specified.) (10%)

   (b) Derive the source-free wave equation governing the magnetic field in simple nonconducting medium. (hint: derive $\nabla^2 \bar{H}$) (5%)

5. A composite medium shown in Fig. 5 consists of four media. The intrinsic impedance η_i, wavelength λ_i, phase constant β_i and thickness of each medium are indicated in Fig. 5. As a plane wave is normally incident on this composite medium, answer the following questions.

   (a) Determine the wave impedance $Z(\ell_1)$. (5%)

   (b) Determine w and η_2 such that no reflection occurs when a uniform plane wave in medium 1 impinges normally on the interface with medium 2. (η_2 **SHOULD** be represented in terms of η_i, $i=1, 2, 3, 4$, and w **SHOULD** be represented by λ_i, $i=1, 2, 3, 4$.) (10%)

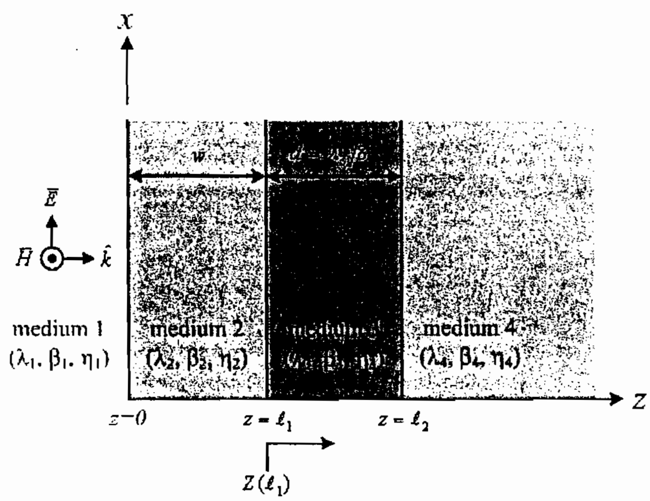

Figure 5

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6. A lossless 50Ω transmission line (TL) terminated by the short circuit and an unknown load, respectively. The other end of the TL is connected with RF source. For two termination situations, the voltage standing wave patterns of the TL are measured and plotted as shown in Fig. 6.
   (a) Calculate the wavelength (λ) of the electromagnetic wave propagating in this transmission line, and the voltage standing wave ratio (VSWR). (4%)
   (b) Determine the impedance of the unknown load. (6%)

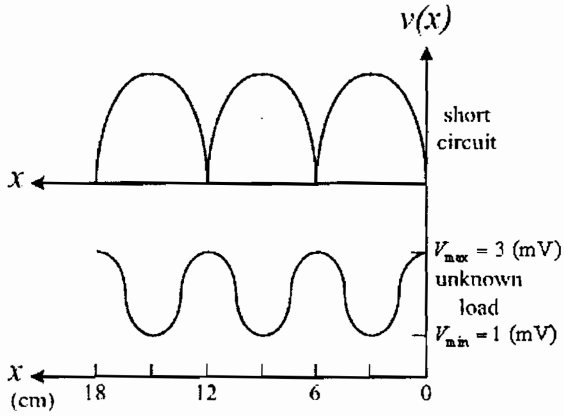

Figure 6

7. A metallic rectangular waveguide filled with the non-magnetic material having the relative permittivity $\varepsilon_r = 4$ is shown in Fig. 7 (a). The cross-section dimensions of the waveguide are a=7cm and b=3cm.
   (a) List the lowest 3 propagation modes and calculate the corresponding cutoff frequencies. (6%)
   (b) As someone has to cut a thin slot on the waveguide, and would **NOT** like to remarkably affect the TE_{10}-mode field distribution inside the waveguide, determine which slot shown in Fig. 7 (b) is the best choice and state the reasons. (4%)

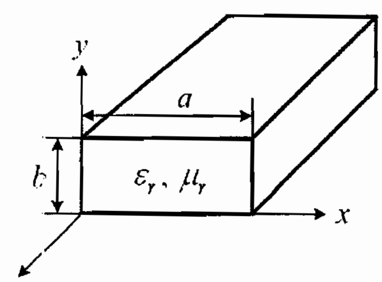

Figure 7 (a)

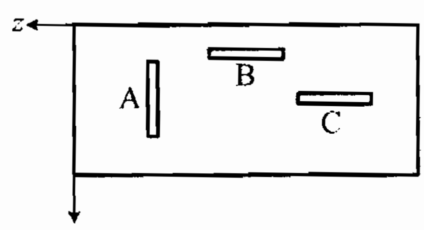

Figure 7 (b)