1. Match the following descriptions with the figures shown in Fig. 1. Fields are near the interface but on the opposite sides of the boundary. **(12%)**

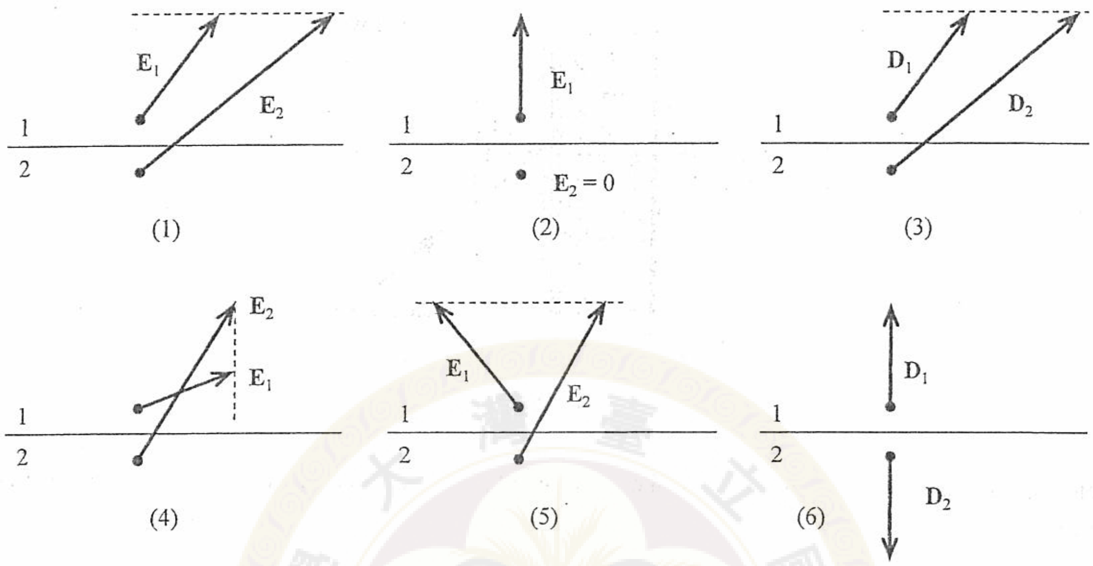

Fig. 1

(a) medium 1 and medium 2 are dielectrics with $\varepsilon_1 > \varepsilon_2$

(b) medium 1 and medium 2 are dielectrics with $\varepsilon_1 < \varepsilon_2$

(c) impossible

(d) there is a positive surface charge on the boundary between two dielectrics

(e) medium 2 is a perfect conductor

2. Find the static potential distribution ϕ between two infinite parallel plates. One plate is located at $x = 0$ with $\phi = 0$ V, and the other is located at $x = 1$ with $\phi = 1$ V. The space between the plates is filled with a medium having a constant permittivity ε F/m and a varying electric charge density $\rho(x) = -\varepsilon(x+1)$ C/m^3. **(8%)**

3. Skin depth δ has been defined as $k_{c,im}\delta = -1$ for highly conducting media, where $k_{c,im}$ represents the imaginary part of the complex wavenumber in the medium. Following the same definition, please determine at 1 GHz the **skin depth** of (a) a perfect conductor, (b) a lossless medium, and (c) a slightly conducting medium with $\sigma = 10^{-6}$ mho/m and $\varepsilon \approx 3.2\varepsilon_0$. [$\varepsilon_0 = 8.85\times10^{-12}$ F/m] **(8%)**

4. A uniform plane wave is incident upon a homogeneous dielectric slab backed by a perfect electric conducting plane. The dielectric slab has thickness $L = \lambda$ (free-space wavelength), relative permittivity $\varepsilon_r = 8$, and relative permeability $\mu_r = 2$. The surrounding medium is free space having $\varepsilon_r = \mu_r = 1$. The electric field intensity of the incident wave can be represented by $\vec{E}_{inc}(x, y, t) = \hat{z}E_0 e^{jk_0(x-L)\cos\theta - jk_0 y\sin\theta} e^{j\omega t}$, where E_0 is a complex constant of the incident field, k_0 is the free-space wavenumber, and θ is the angle of incidence defined in Fig. 2. Please find the reflection coefficient Γ at the air-dielectric interface ($x = L$) as a function of θ. **(10%)**
[*Hint: write down the total electric and magnetic fields within the $0 < x < L$ and $x > L$ regions, respectively, and then apply boundary conditions at $x = L$.*]

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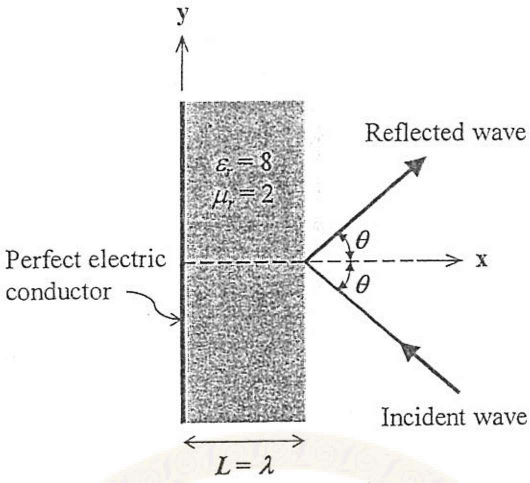

Fig. 2

5. The electric and magnetic field intensities radiated by an antenna located at the origin are given in spherical coordinates by

$$\vec{E} = E_0 e^{j\omega[t-(r/c)]}\left[\hat{r}\cos\theta\left(\frac{2c}{j\omega r^2} - \frac{2c^2}{\omega^2 r^3}\right) + \hat{\theta}\sin\theta\left(\frac{1}{r} + \frac{c}{j\omega r^2} - \frac{c^2}{\omega^2 r^3}\right)\right] \text{ (V/m)}$$

$$\vec{H} = E_0 c\varepsilon_0 e^{j\omega[t-(r/c)]}\hat{\phi}\sin\theta\left(\frac{1}{r} + \frac{c}{j\omega r^2}\right) \text{ (A/m)}$$

where $c = 1/\sqrt{\varepsilon_0\mu_0}$

Find in the **far zone**: (a) the polarization of the wave radiated by the antenna, (b) the time-average Poynting vector, and (c) the time-average power radiated by the antenna by evaluating the surface integral of the instantaneous Poynting vector over a spherical surface of radius r centered at the antenna and enclosing the antenna. **(12%)**

6. A 100-Ω lossless transmission line is terminated with a load impedance $Z_L = R_L + jX_L$.
   (a) If the standing-wave ratio is 2 and $R_L = 200$ Ω, Find X_L. **(5%)**
   (b) Where do the voltage maximum and voltage minimum which are the nearest to the load occur on the line for part (a)? (in terms of wavelength, λ) **(10%)**

7. Fig. 3(a) shows a FET amplifier with input and output matching networks. In order to achieve the maximum gain, the reflection coefficients of the input and output matching networks should be Γ_{ms} and Γ_{ml}, respectively. Design the input and output matching network to achieve maximum gain of the FET amplifier.
   (a) If reflection coefficient $\Gamma_{ms} = 0.4 + j0.2$, calculate the corresponding normalized impedance z_{ms} (express in the format of $r_{ms} + jx_{ms}$) and use the Smith chart shown in Fig. 3(b) to explain the impedance trace movement of the transmission line matching circuit shown in Fig. 3(c) for input matching network. **(10%)**
   (b) If reflection coefficient $\Gamma_{ml} = 0.5\angle 90^\circ$, calculate the corresponding normalized impedance z_{ml} (express in the format of $r_{ml} + jx_{ml}$) and use the Smith chart shown in Fig. 3(b) to explain the impedance trace movement of the transmission line matching circuit shown in Fig. 3(d) for input matching network. **(10%)**

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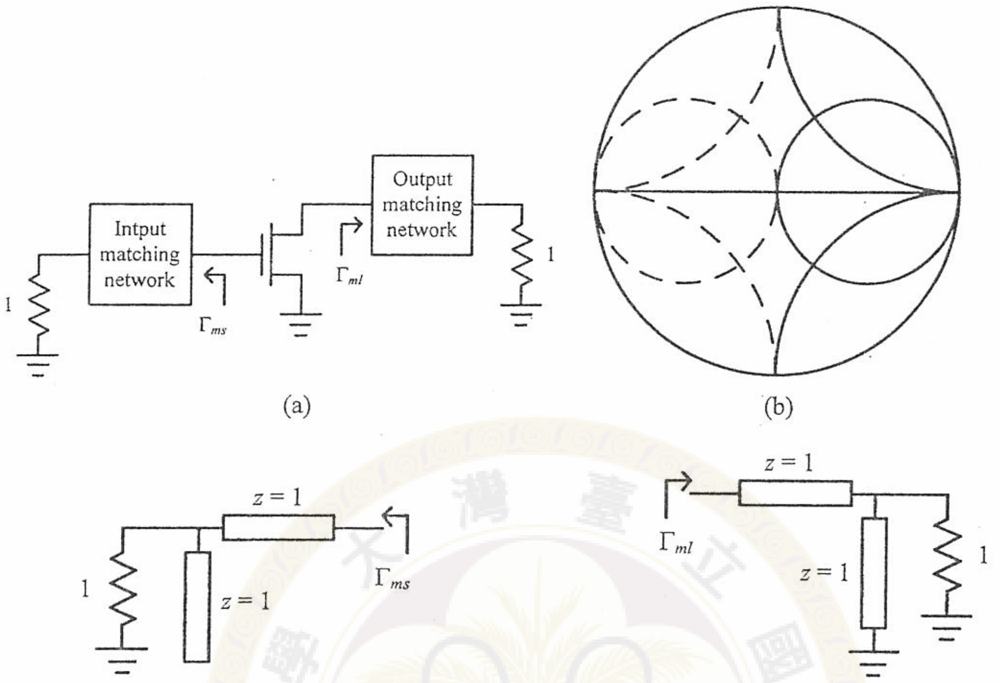

(a)　(b)　(c)　(d)

Fig. 3

8. A dielectric slab of thickness 2 cm and permittivity $4\varepsilon_0$ exists in an air-dielectric electric rectangular waveguide of dimensions a = 6 cm and b = 3 cm, as shown in Fig. 4. Find the lowest frequency for which the dielectric slab allows complete transmission for $TE_{1,0}$ mode propagation in the waveguide. **(15%)**

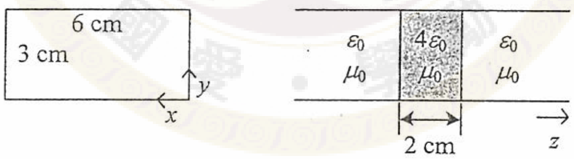

Fig. 4

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