國立清華大學命題紙

九十七學年度第二學期 光電工程研究所 博士班研究生資格考試

科目 電磁理論 科號____ 共 4 頁第___頁 ＊請在試卷(答案卷)內作答

1. (Total 25%) Consider two large parallel plates of area S (m^2), separated by a distance d (m), and deposited with charges $\pm Q$ (C), respectively (Fig. 1).

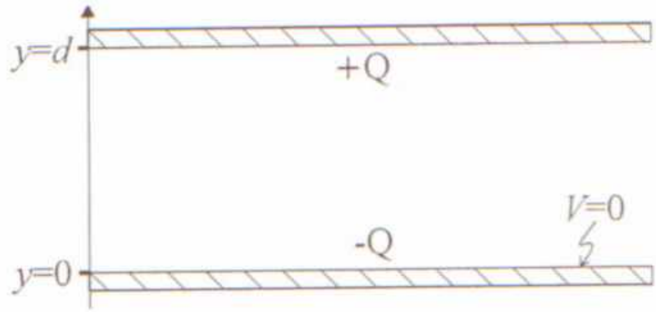

Fig. 1

1a. (6%) If $\{0 < y < d\}$ is filled with air, derive the distributions of electric field intensity $\bar{E}(y)$ (V/m), electric flux density $\bar{D}(y)$ (C/m^2), and electric potential $V(y)$ (Volt) for the air region (neglecting the fringing effect). Justify your answers.

1b. (6%) If $\{0 < y < d\}$ is filled with a dielectric of permittivity $\varepsilon = 2\varepsilon_0$, compare the resulting $\bar{E}$, $\bar{D}$, V distributions with their counterparts in problem 1a. Justify your answers.

1c. (4%) What is the physical meaning that permittivity ε stands for?

1d. (4%) Let $\left\{0 < y < \frac{d}{2}\right\}$ and $\left\{\frac{d}{2} < y < d\right\}$ are filled with dielectrics of permittivities $\varepsilon_1 = 4\varepsilon_0$ and $\varepsilon_2 = 2\varepsilon_0$, respectively (Fig. 2). Derive the distributions of electric field intensity $\bar{E}(y)$ (V/m), electric flux density $\bar{D}(y)$ (C/m^2), and electric potential $V(y)$ (Volt) for $\{0 < y < d\}$.

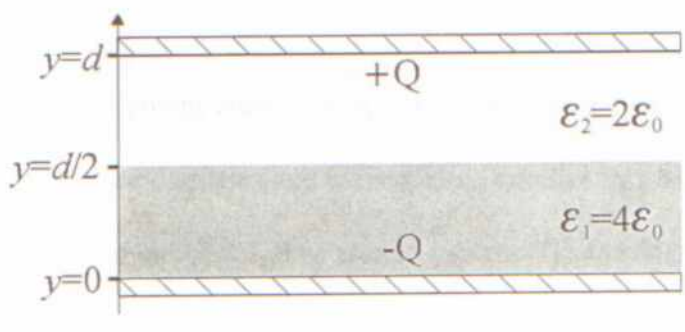

Fig. 2

4. (Total 15%) Consider oblique incidence of a TM (parallel polarization) plane-wave from medium 1 of (ε_1, μ_0) into medium 2 of (ε_2, μ_0) with incident angle θ_i. Show all of your works.

4a. (3%) Derive the reflection coefficient $r = E_r / E_i$.

4b. (5%) Write out a simple expression relating the incident, reflected and transmitted power.

4c. (7%) Derive the value of the incident angle so that there is no reflected wave.

5. (8%) The following figure shows the equivalent circuit of an infinitesimal section of two-conductor transmission line of length *z*, where *R*, *L*, *G*, *C* represent resistance, inductance, conductance, and capacitance per unit length.

Justify why *L* is connected in series, and why *C* is connected in parallel.

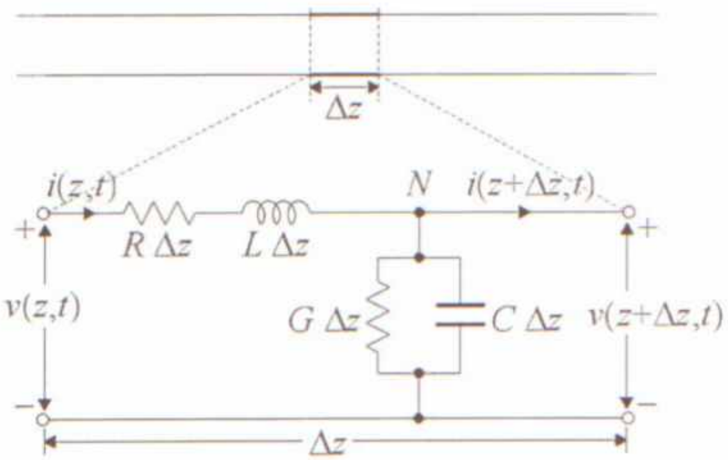

Fig. 4.

6. (7%) Consider a plane wave with its electric field polarized parallel to the surface of an interface between two media (transverse electric, or TE, wave in the direction out of the paper ⊙). Show that under the total internal reflection condition, the characteristic impedance, $Z = -E_x/H_z$ of medium 2 (with index n_2) is now *imaginary*.

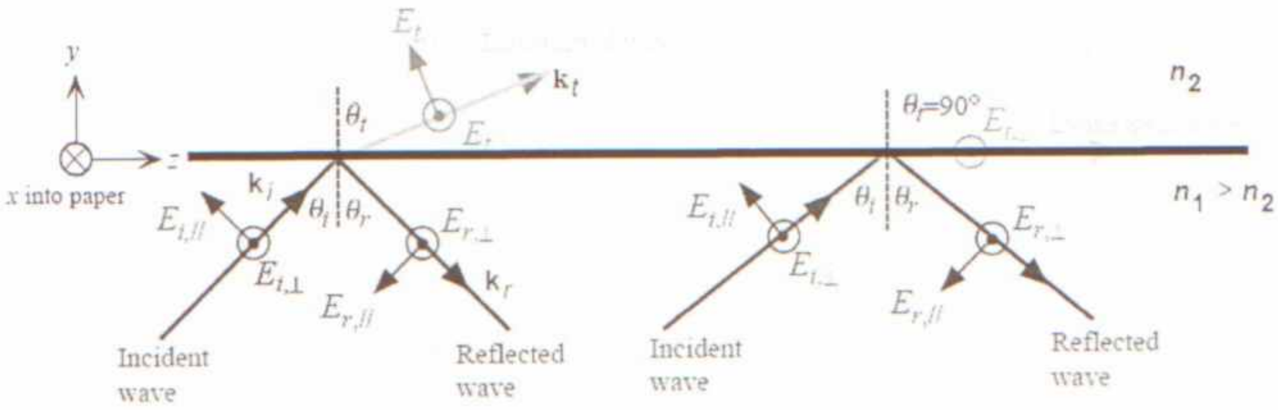

Fig. 5.

7. (Total 20%) Consider a metallic rectangular waveguide as shown in Fig. 6. The enclosed dielectric medium has the parameters ε and μ. For TM waves, $H_z = 0$, and we can write

$$E_z(x,y,z) = E_{z0}(x,y)\exp(-\gamma z),$$

where $E_{z0}(x,y)$ satisfies the wave equation:

$$\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + h^2\right)E_{z0}(x,y) = 0, \quad \text{with } h^2 = \gamma^2 + \omega^2\mu\varepsilon .$$

Put $E_{z0}(x,y) = X(x)\,Y(y)$ into the wave equation above, and then decouple X(x) and Y(y) in two equations.

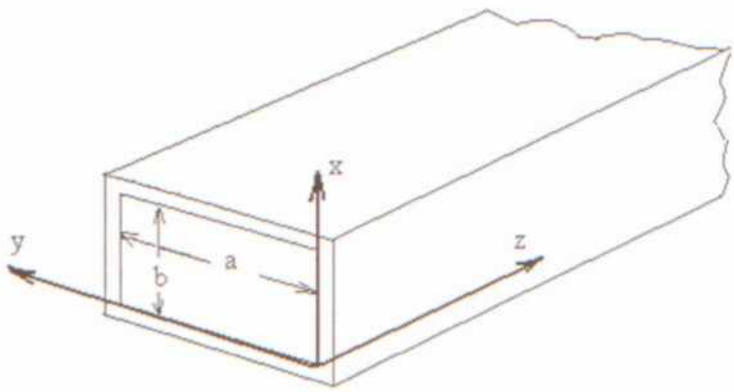

Fig. 6

7a. (12%) Find $E_{z0}(x,y)$ using proper boundary conditions.

7b. (8%) Find γ for TM_{mn} modes. (You have to find h^2 first.)