

國立交通大學 97 學年度碩士班考試入學試題

科目：電磁學(8012)

考試日期：97 年 3 月 8 日 第 3 節

系所班別：電機學院碩士在職專班

組別：電子與光電組甲類

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*作答前請先核對試題、答案卷(試卷)與准考證之所組別與考科是否相符!!

1. A positive point charge Q is at the center of a spherical dielectric shell of an inner radius R_i and an outer radius R_o . The dielectric constant of the shell is ϵ_r . Find $\vec{E}$, V , and $\vec{D}$ as functions of radial distance R . (15%)

2. An air coaxial transmission line has a solid inner conductor of radius a and an outer conductor of inner radius b and outer radius c . (15%)

(a) Find $\vec{B}$ as a functions of radial distance r .

(b) Determine the inductance per unit length of the line.

3. The $\vec{H}$ field in air just above a perfect conductor is given by

$$\vec{H} = 3 \hat{z} + 4 \hat{y} \quad \text{Amp/m}$$

Find the surface current $\vec{J}_s$ on the surface of the perfect conductor. The conductor occupies the space $x < 0$. (10%)

4. Study the following $\vec{H}$ field in a source-free region:

$$\vec{H} = \hat{z} H_0 e^{jkx} + j\hat{y} H_0 e^{jkx}.$$

Does it satisfy Maxwell's equations? If so, find the polarization (linear or LHP or RHP) and the corresponding $\vec{E}$ field. If not, explain why not. (10%)

5. For a wave traveling inside a uniform waveguide along z -axis with arbitrary cross section on the x - y plane, the electrical and magnetic fields can be expressed as

$$\vec{E}(x, y, z, t) = \text{Re}[\vec{E}^0(x, y) e^{j(\omega t - k_z z)}], \quad \vec{H}(x, y, z, t) = \text{Re}[\vec{H}^0(x, y) e^{j(\omega t - k_z z)}].$$

And of course

$$\nabla \times (\vec{E}^0(x, y) e^{-jk_z z}) = -j\omega \mu (\vec{H}^0(x, y) e^{-jk_z z}), \quad \nabla \times (\vec{H}^0(x, y) e^{-jk_z z}) = j\omega \epsilon (\vec{E}^0(x, y) e^{-jk_z z})$$

where $\vec{E}^0(x, y)$ and $\vec{H}^0(x, y)$, or $\vec{E}^0$ and $\vec{H}^0$ as a simplification, can be further de-composed into

$$\vec{E}^0 = \hat{x} E_x^0 + \hat{y} E_y^0 + \hat{z} E_z^0, \quad \vec{H}^0 = \hat{x} H_x^0 + \hat{y} H_y^0 + \hat{z} H_z^0.$$

Using the curl equations, please derive step-by-step the four expressions of E_x^0 , E_y^0 , H_x^0 , H_y^0 in terms of E_z^0 , H_z^0 like (10%)

$$H_x^0 = -\frac{1}{\omega^2 \mu \epsilon - k_z^2} \left(\dots \frac{\partial H_z^0}{\partial x} - \dots \frac{\partial E_z^0}{\partial y} \right).$$

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6. The standard Ka-band waveguide has the following dimension: $a = 0.28$ inch, and $b = 0.14$ inch (1 inch = 2.54 cm). The medium inside the waveguide is air. Please find the cutoff frequencies for the first five modes. (10%)
7. (10%)
 - (a) Please write down the wave number while the wave propagates in a highly conducting media, and briefly describe the behavior of the wave.
 - (b) Now if we wrap a food using the aluminum foil and put it into a microwave oven, can we still heat up this food? If yes, please write down the heating mechanism. Here we assume the microwave oven is very robust, and the electrical conductivity of the aluminum foil is 3.54×10^7 S/m.
8. The resonant frequency of a cubic cavity resonator is 60 GHz when it is excited in the TE_{110} mode. Please calculate the dimensions of the resonator. (10%)
9. For an short-circuited 75Ω transmission line of length l , the input impedance at the other end is $33j$. Find the length l in terms of λ . (10%)