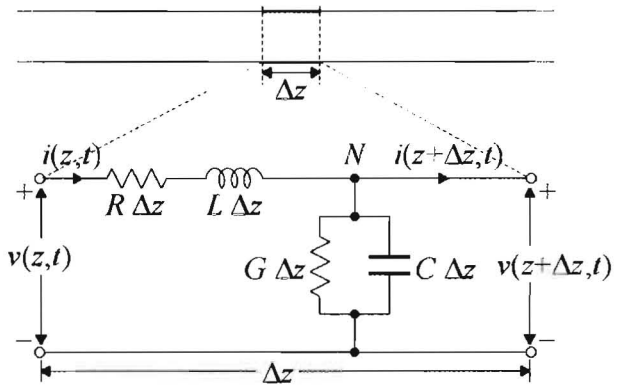
國 立 清 華 大 學 命 題 紙

一百零四學年度第一學期 光電工程研究所 博士班研究生資格考試

科目 電磁理論 共 頁第 頁 ＊請在試卷(答案卷)內作答

1. (10%) If you were a lecturer of freshman year " General Physics " class, please write a half page description and explanation of the phenomenon of "magnetic hysteresis" such that your students can understand the basic physics and grasp the physical insight of the phenomenon.

2. (10%) 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.



3. (a) (5%) Explain the relationship between the cut-off wavelength and the spacing between the plates of a parallel-plate waveguide based on the phenomenon at cut-off.

   (b) (5%) Explain why single-conductor hollow or dielectric-filled waveguides can not support TEM waves.

4. (15 %) When there is a relative motion between a time-harmonic source and a receiver, the frequency of the wave detected by the receiver tends to be different from that emitted by the source. This phenomenon is known as the Doppler effect. Let us assume that a light

transmitter of a time-harmonic wave of a frequency f moves with a velocity u (assume u << c) at an angle θ relative to the direct line to a stationary receiver.

(a) (5%) Please derive and show that the frequency of the received wave is

$$f' = \frac{f}{1 - \frac{u}{c}\cos\theta}.$$

(b) (5%) If the transmitted signal has a spectral linewidth of $\Delta\upsilon$, what would be the linewidth of the received signal after the Doppler effect?

(c) (5%) If the receiver (target) has a rough surface comparable to the wavelength of the light, how would the spectral linewidth of the received signal change? Why?

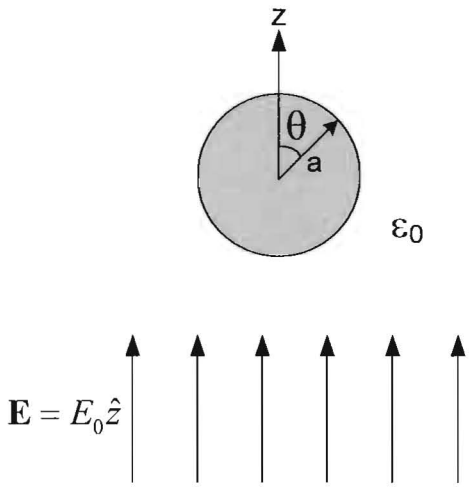
5. (15 %) Two orthogonal linearly polarized waves are combined. State the conditions under which the resultant will be

(a) (5%) another linearly polarized wave

(b) (5%) a circularly polarized wave

(c) (5%) an elliptically polarized wave

6. (15%) An ideal metallic sphere of radius a is positioned in free-space with an uniform applied electric field intensity of $\mathbf{E} = E_0\hat{z}$. Discuss and provide a detailed sketch showing the electric field lines of the sphere and its vicinity. Also show the distribution of the surface charges.



7. (10%) A symmetric slab waveguide is found to support exactly 5 TE and 5 TM modes at the optical wavelength 500nm. Assume that material dispersion from the waveguide is negligible.

(a) (5%) How many TE and TM modes does it support at the wavelength 1um?

(b) (5%) Among those mode in (a), which has the largest propagation constant?

8. (3%) $\vec{H}(\vec{r},t) = \hat{x}\,0.01 \cdot \cos(900t + \beta z)\ \ A/m$ in vacuum with no current source. What is $f, \lambda, \vec{E}$?

Maxwell's Equations

$$\nabla \cdot \vec{E} = \frac{\rho_t}{\varepsilon_o}$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\nabla \cdot \vec{B} = 0$$

$$\nabla \times \vec{B} = \mu_o\left(\vec{J}_t + \varepsilon_o \frac{\partial \vec{E}}{\partial t}\right)$$

9. (12%) An infinite current sheer J=$\hat{x}$ 5 A/m coinciding with xy-plane separates air (region 1, z>0) from the medium with $\mu_{r2} = 2$ (region 2, z<0). Given that $\vec{H}_1 = 30\hat{x} + 40\hat{y} + 20\,\hat{z}\ A/m$, find

(a) (3%) $\vec{H}_2$,
(b) (3%) $\vec{B}_2$,
(c) (3%) angle α_1 that $\vec{B}_1$ makes with the z-axis, and
(d) (3%) angle α_2 that $\vec{B}_2$ makes with the z-axis.

Boundary Conditions

$$\hat{n} \times (E_1 - E_2) = 0$$
$$\hat{n} \cdot (D_1 - D_2) = \rho_s$$
$$\hat{n} \times (H_1 - H_2) = J_s$$
$$\hat{n} \cdot (B_1 - B_2) = 0$$