國立中山大學104學年度碩士暨碩士專班招生考試試題

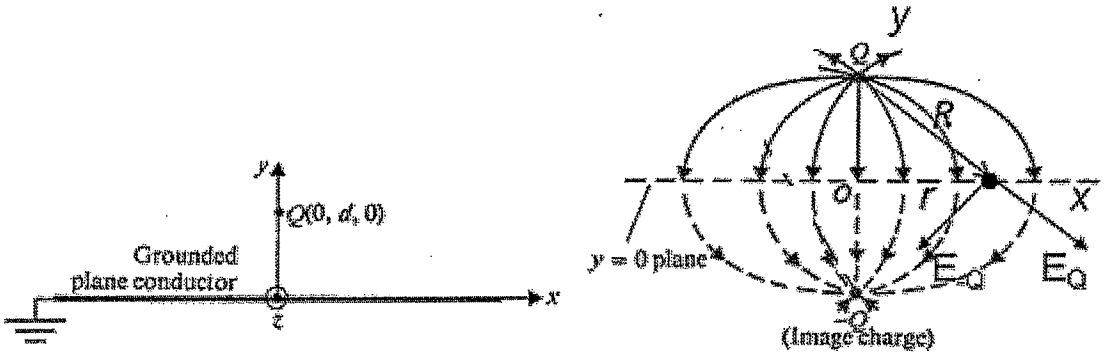
科目名稱：電磁學【電機系碩士班戊組、電波領域聯合】　　題號：431004

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　共2頁第1頁

Problem 1

a. (5%) A point charge Q exists at (0, *d*, 0) in space, as shown in Figure (a). Using Theory of image, a point charge of –Q exists at (0, -*d*, 0) symmetrically, as indicated in Figure (b). The dielectric constant of the space is ε_0. Write the electric intensities ($Ex|_{y=0}$, $Ey|_{y=0}$, and $Ez|_{y=0}$) for a point on the *ZX*-plane in terms of (*d* and *R*), or (*d* and *r*), as indicated in Figure (b).

b. (5%) What is the surface charge distribution on the *ZX*-plane? Sketch the distribution.



Figures (a) and (b) a single charge *Q* above a ground plane

Problem 2

A air-filled coaxial with dimensions as shown in the following figure,

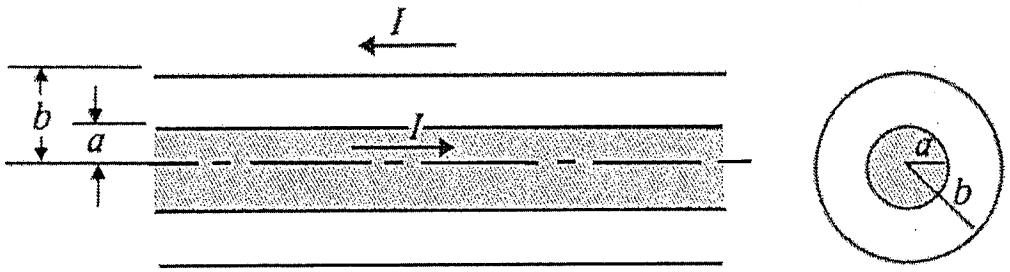


Figure (c) a coaxial transmission line with signal carrying conductor of radius *a* inside the surrounding ground of radius *b*.

The inductance per unit length is $L' = \frac{\Lambda'}{I} = \frac{\mu_0}{8\pi} + \frac{\mu_0}{2\pi}\ln\frac{b}{a}\left(\mathrm{H/m}\right)$. Here we have assumed that the current inside the signal-carrying conductor is uniformly distributed. And, the capacitance per unit length is $C' = \frac{2\pi\varepsilon_0}{\ln\left(\frac{b}{a}\right)}$ (F/m).

a. (5%) For the inductance, which term drops off at high frequencies? Why?

b. (5%) The characteristic impedance is defined as $Z_c = \sqrt{\frac{L'}{C'}}$, find out the characteristics impedance at high frequencies, and please indicate the unit for it.

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Problem 3

a. (5%) The dielectric constant for Teflon is 2; it is a low one for a dielectric material. What is the dielectric constant for air?

b. (5%) What is the dielectric constant for a metal, for example, Copper?

c. (5%) The relative permeability for Steel is 100, and is frequency dependent. What is the relative permeability for Copper?

Problem 4

a. (5%) Why Curl of Gradient of a potential field is zero, that is, $\nabla \times (\nabla V) \equiv 0$?

b. (5%) Why Divergence of Curl of a vector field is zero, that is, $\nabla \cdot (\nabla \times \mathbf{A}) \equiv 0$?

c. (5%) Refer to the following figure and prove the law of Cosines, $C = \sqrt{A^2 + B^2 - 2AB\cos\alpha}$.

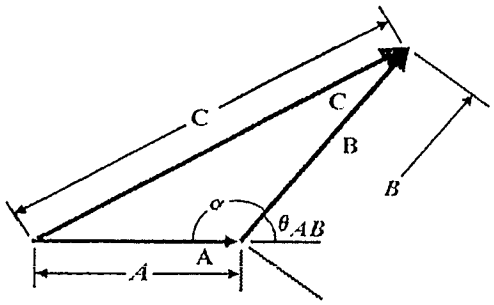

Figure (d) Illustrating example for Problem 4

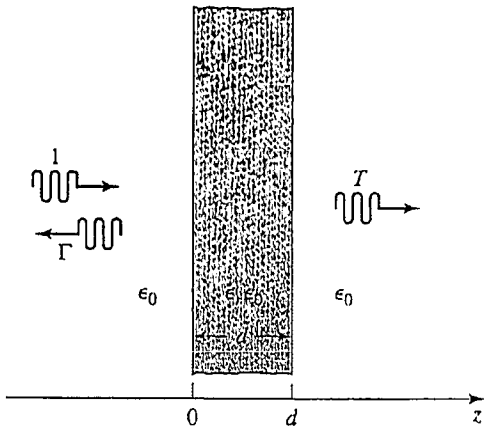

Figure (e) Illustrating example for Problem 5

Problem 5

(20%) A plane wave is normally incident on a dielectric slab of relative permittivity ε_r and thickness d, where $d = \lambda_0 / (4\sqrt{\varepsilon_r})$, and λ_0 is the free-space wavelength of the incident wave, as shown in Figure (e). If free-space exists on both sides of the slab, find the reflection coefficient of the wave reflected from the front of the slab.

Problem 6

(10%) A lossless transmission line is terminated with a 100 Ω load. If the standing wave ratio (SWR) on the line is 1.5, find the two possible values for the characteristic impedance of the line.

Problem 7

(20%) An average power of 1 (kW) at 10 (GHz) is to be delivered to an antenna at the TE_{10} mode by an air-filled metallic rectangular waveguide 1 (m) long and having sides a = 2.25 (cm) and b = 1 (cm). Assume that all the conductors are perfect electric conductors. Find the maximum values of the electric and magnetic field intensities within the waveguide.