

科目：電磁學 A(5007)

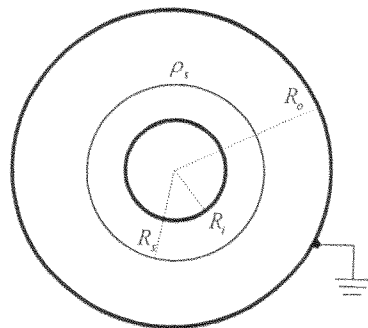
校系所組：中大電機工程學系(固態組)

交大電子研究所(甲組、乙組)、電信工程研究所(乙組)

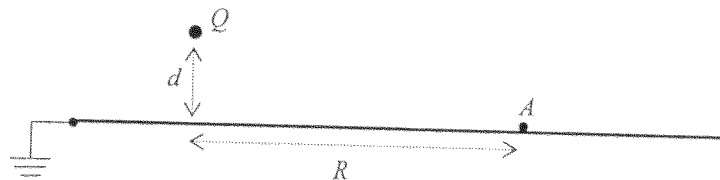
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1. (10%) A group of charges distribute uniformly as a thin spherical shell of radius  $R_s$ . The surface charge density is denoted as  $\rho_s$ . These charges are inside the region bounded by two conducting spherical shells, as shown in the figure. All the shells share the same center. The outer conducting shell of radius  $R_o$  is grounded. Determine the electric field intensity and electric potential at  $R_1$ ,  $R_2$ ,  $R_3$ , and  $R_4$ , where  $R_1 > R_o > R_2 > R_s > R_3 > R_4 = R_s$ .



2. (10%) A positive point charge  $Q$  is located at a distance  $d$  above a very large grounded conducting plane, as shown in the figure. Assuming that the conducting plane is on the x-y plane in Cartesian coordinates. Find the electric field intensity at the point  $A$  on the plane, where  $R \gg d$ .



注意：背面有試題

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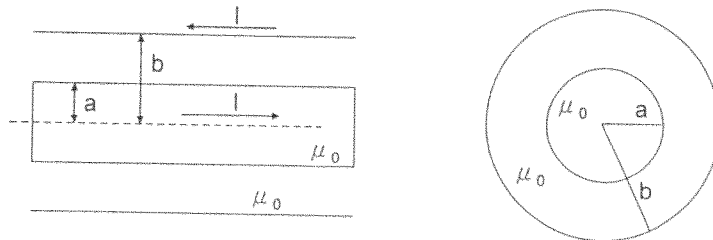
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3. (15%) An air coaxial transmission line has a solid inner conductor of radius  $a$  with uniform current  $I$  and a very thin outer conductor of inner radius  $b$ , as shown in following figure.
- (a) Determine the magnetic flux density  $\mathbf{B}$  in  $r < a$ , and  $a < r < b$ , respectively.
- (b) Determine the stored magnetic energy  $W_m$  per unit length in  $r < a$ , and  $a < r < b$ , respectively.
- (c) Use (a) & (b) results, determine the inductance  $L$  per unit length.



4. Consider two fields whose electrical field and magnetic flux density are  $(\mathbf{E}_a, \mathbf{B}_a)$  and  $(\mathbf{E}_b, \mathbf{B}_b)$ , respectively in a linear and isotropic medium.
- (a) (10%) Please prove that

$$[\nabla \cdot (\mathbf{E}_a \times \mathbf{B}_b - \mathbf{E}_b \times \mathbf{B}_a)]_P = 0$$

while the medium is a nonmagnetic material and  $P$  is not a source point.

- (b) (5%) If the medium is a magnetic material, please prove that

$$[\nabla \cdot (\mathbf{E}_a \times \mathbf{H}_b - \mathbf{E}_b \times \mathbf{H}_a)]_P = 0$$

5. The electrical field intensity in a source free dielectric medium is given as the following:

$$\mathbf{E} = e^{j(\omega t - \alpha x - kz)} \hat{y} \quad \text{V/m}$$

- (a) (6%) Find the corresponding  $\mathbf{H}$  field.
- (b) (3%) What is the necessary condition for these fields to exist?
- (c) (6%) Calculate the time-average electrical energy density, magnetic energy density, and the Poynting vector.
6. (a) (5%) Prove that a maximum power is transferred from a voltage source with an internal impedance  $Z_g$  to a load impedance  $Z_L$  over a lossless transmission line when  $Z_L = Z_g^*$ , where  $Z_L$  is the impedance looking into the loaded line.
- (b) (5%) What is the maximum power transfer efficiency?

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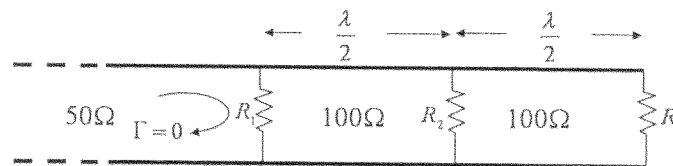
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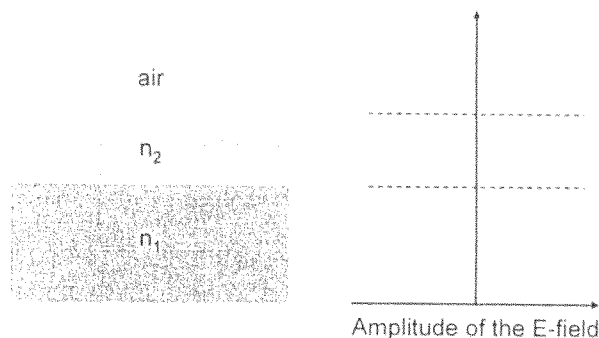
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7. (15%) A signal generator is to feed power through a lossless transmission line with a characteristic impedance  $50 \Omega$  to the circuit shown below. The circuit is composed of three resistors ( $R_1, R_2, R_1$ ) connected by two half-wavelength lossless transmission lines with a characteristic impedance  $100 \Omega$ . If the input reflection coefficient  $\Gamma = 0$ , and the ratio of power consumed in the three resistors is  $1 : 2 : 1$  ( $= P_{R1} : P_{R2} : P_{R1}$ ), find  $R_1$  and  $R_2$ .



8. (a) (5%) Sketch the field distributions for the  $TE_2$  guided mode for the following asymmetric planar dielectric waveguide, where the refractive index  $n_1 = 3.5$  and  $n_2 = 3.6$ . Make sure the evanescent field in different regions is plotted explicitly.



- (b) (5%) Plot the dispersion relation  $\alpha(\beta)$  of this waveguide for the different  $TE_m$  modes with  $m = 0, 1$ , and  $2$ .