科目：電磁學 A(5007)

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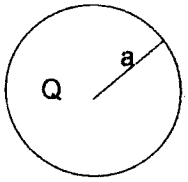
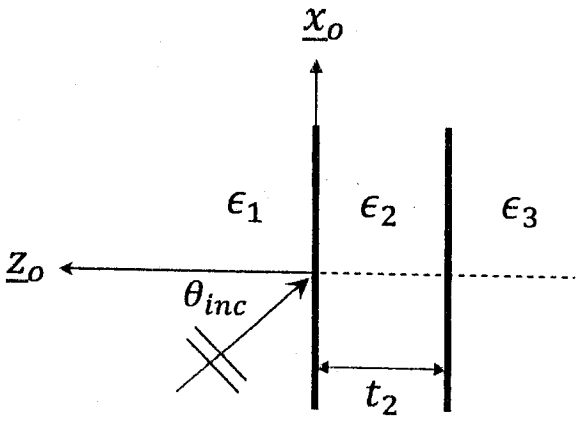
Problem 1. (15/100 points) 1.1(a):4points, 1.1(b):4points, 1.2:7points
Answer the following questions and justify your answers. (1) Suppose that in Coulomb's law the strength of the electrical field is inverse-r^3 law proportion to distance ($E \propto \frac{1}{r^3}$). (a) Is the field still conservative? (b) Is Gauss's law still valid? (2) Find the energy required to assemble a uniform sphere of total charge Q and radius a as shown in following figure.



Problem 2. (10/100 points)
What is the inductance of an inductor? Please define it. For a coaxial line designed with an inner radius of a and an outer radius of b respectively, please calculate its inductance per unit length.

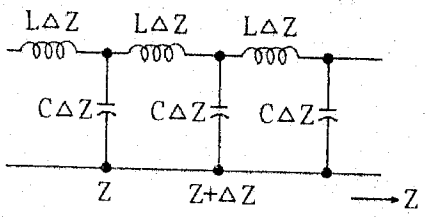
Problem 3. (10/100 points)
Derive the outward-traveling planes waves due to a current sheet $\underline{J} = \underline{x}_o J_o$ placed over the $z = 0$ plane.

Problem 4. (15/100 points) 4.1:4points, 4.2:4points, 4.3:7points
Consider a three-medium configuration shown in attached figure. The relative dielectric constants of the media are $\epsilon_1 = 11.8, \epsilon_1 = 1.0$, and $\epsilon_3 = 11.8$, respectively. The incident angle, which is counted from the z-axis with the coordinate system attached to the figure, of the plane wave is designated as θ_{inc}. The thickness of the medium #2 is denoted as t_2. Here, we assumed that there are no fields and structure variation along the y-axis. Answer the following questions. (1) Using the attached coordinate system to define TE (transverse electric to z) or perpendicularly polarized wave, TM (transverse magnetic to z) or parallel-polarized wave, and TEM wave, respectively. (2) Does the total transmission phenomenon occur for both TE- and TM- incident waves? Please also write down the equation for predicting the incident angle causing the occurrence of total transmission. (3) If the wave is incident at an incident angle greater than the critical angle from a denser medium to a less dense medium, can we receive the real power in medium #3? Please explain why or why not.



注意：背面有試題

Problem 5. (15/100 points)
By using the Maxwell's equation, please derive the equivalent circuit of transmission line, i.e., the existence of distributed inductance and capacitors of the equivalent circuit.



Problem 6. (5/100 points)
For high-speed applications, 50-Ω coaxial cables are usually used in connection. Please discuss whether such characteristic impedance of 50-Ω physically the same the impedance of an ohmic resistor. If NOT, please explain why we introduce such a term characteristic impedance of 50-Ω in our analysis.

Problem 7. (5/100 points)
In our system, two coaxial cables of the same size but different insulating dielectric materials between their inner and outer conductors are in series. The characteristic impedances of these two cables are different and thereby reflected signals are seen at the spatially perfectly matched junction of these two cables. From basic electromagnetism, please clearly explain the current in cable 1 "pushed backward" when it is moving across cable 2 though no extra electromagnetic force is applied along the direction of these cables.

Problem 8. (15/100 points) 8(a):7points, 8(b):8points
Answer the following questions. (a) Define and identify the dominant mode of propagation in a rectangular metallic waveguide whose width a along x exceeds its height b along y. (b) An empty (air-filled) rectangular waveguide of cross-sectional dimensions $a : b = 2 : 1$ operates in the dominant mode at a nominal frequency of 1.5 times the cutoff frequency. Determine the dimensions of the waveguide for operation at 7.5 GHz.

Problem 9. (10/100 points) 9(a):5points, 9(b):5points
A vehicular tunnel of width a = 12m and height b = 6m can be modeled as a perfectly conducting rectangular waveguide. The propagation constant in the waveguide is given by:

$$\gamma = \sqrt{(m\pi/a)^2 + (n\pi/b)^2 - \omega^2\mu\varepsilon}$$

where μ and ε are the free-space permeability and permittivity and ω is the angular frequency.
(a) An automobile equipped with an AM/FM radio receiver is traveling in the tunnel. Can it receive FM (100 MHz) broadcast? (b) Can it receive AM (1 MHz) broadcast? If not, what can be installed in the tunnel to enable AM broadcast to be received?