請考生將答案寫在答案卷上,並依題號順序作答。

Problem 1 (20%)

A volume charge distribution is given in spherical coordinates by $\rho = \rho_0 (r/a)^2$ for $r < a$ (inside) and $\rho = 0$ for $r > a$ (outside).

(a) Find the total charge.

(b) Find the energy stored in the electric field.

(c) Find the work required to re-arrange the charge distribution with uniform density in the region of $r < a$

(d) Find the work required to re-arrange the charge distribution on the surface of the sphere $r = a$

Problem 2 (30%)

Given two infinite plane current sheets in free space, where $\bar{J}_{s1} = \hat{x} 0.2 \cos 6\pi \times 10^8 t$ (A/m) in the y=0 plane, and $\bar{J}_{s2} = \hat{z} 0.2 \cos 6\pi \times 10^8 t$ (A/m) in the y=0.25m plane, the plane waves are generated and propagate in the outgoing directions along the positive and negative y-axis.

(a) Using B.C. at y=0 and y=0.25m, find the **H** fields of the waves in the region of y<0 and y>0.25m.

(b) Considering TEM plane wave propagation, find the **E** fields and polarization in both regions.

(c) Find the time-averaged power density (W/m^2) of the radiated waves in both regions.

(d) Find the input power per unit area (W/m^2) to sustain this system. Check if the Poynting Theorem (power conservation law) holds in this case? (yes/no, and explain)

(e) Now, the second current sheet is re-designed as $\bar{J}_{s2} = \hat{x} 0.2 \cos(\alpha + 6\pi \times 10^8 t)$. (Note the polarization and phase are changed, but location is the same.) Determine the value of phase α such that a minimum power flow is obtained in the region of y<0.

<Note: Assume these two current sheets are independent and the mutual coupling is neglected.>

Problem 3 (18%)

In the system shown below, all the transmission lines are lossless

(a) Find the input impedances Z_{in1} and Z_{in2}. (4%)

(b) Find the reflection coefficient Γ_{in} and the voltage standing-wave ratio VSWR$_{in}$. (4%)

(c) Find the time-average powers delivered to the resistors R_2 and R_3, respectively. (10%)

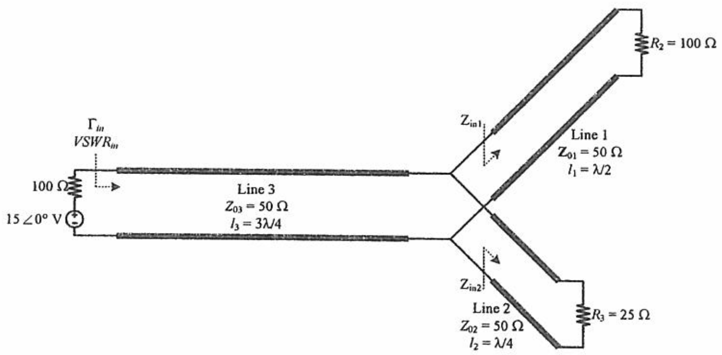

Figure of Problem 3

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Problem 4 (12%)

Draw your results with Smith Chart, as a simplified example shown below, in your answer sheet

(a) Specify the locations for the reflection coefficient of $\Gamma = 1\angle 90°$ and the impedance of $Z = 0\ \Omega$. (4%)

(b) For system impedance (Z_0) of 100 Ω, specify the location for the load impedance of $Z_l = 300 + j100$. (2%)

(c) Use ideal transmission lines with 100-Ω characteristic impedance to design a matching circuit from the load impedance Z_l to the system impedance Z_0. Draw your matching circuit and use the Smith chart to explain the impedance trace movement of your matching circuit from Z_l to Z_0. (6%)

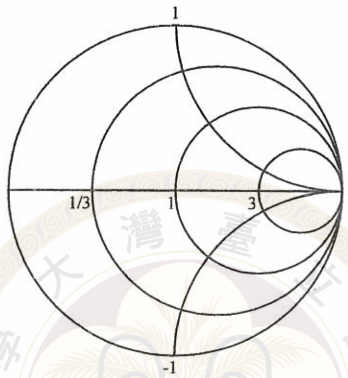

Figure of Problem 4

Problem 5 (20%)

For an air-filled rectangular waveguide of dimensions $a = 3.75$ mm and $b = 1.875$ mm.

(a) Define the cut-off frequency and describe the dominant mode of a rectangular waveguide. (10%)

(b) Find the frequency range which only allows the propagation of the dominant mode in this waveguide. (10%)