Some data for your reference: $\varepsilon_0 = 10^{-9}/36\pi$ Farads/m , $\mu_0 = 4\pi \times 10^{-7}$ Henrys/m

Problem 1: (10 Points)   Medium 1, consisting of the region $r < a$ in spherical coordinates, is a perfect dielectric of permittivity ε_1, whereas medium 2, consisting of the region $r > a$ in spherical coordinates, is free space. The electric field intensities in the media are given by

$$\mathbf{E}_1 = E_{01}\left(\cos\theta\mathbf{a}_r - \sin\theta\mathbf{a}_\theta\right)$$

$$\mathbf{E}_2 = E_{02}\left[\left(1+\frac{a^3}{2r^3}\right)\cos\theta\mathbf{a}_r - \left(1-\frac{a^3}{4r^3}\right)\sin\theta\mathbf{a}_\theta\right]$$

respectively. Find ε_1.

Problem 2: (25 Points)   A space-charge density distribution is given by

$$\rho = \begin{cases} -\rho_0\left(1+\dfrac{x}{d}\right) & \text{for } -d < x < 0 \\[2mm] \rho_0\left(1-\dfrac{x}{d}\right) & \text{for } 0 < x < d \\[2mm] 0 & \text{otherwise} \end{cases}$$

where ρ_0 is a constant. Obtain the solution for the potential V versus x for all x. Assume $V = 0$ for $x = 0$.

Problem 3: (25 Points)   Find the value(s) of k such that the expression $\mathbf{E} = E_0 e^{-kx} \cos\left(2\times10^8 t - y\right)\mathbf{a}_z$ can really represent an electric field in free space.

Problem 4: (10 Points)   The central conductor of a coaxial cable is shifted away from its axis due to the inaccuracy of manufacture. Are the values of these parameters of the transmission line increased or decreased: (a) the capacitance per unit length, (b) the inductance per unit length, (c) the characteristic impedance, and (d) the phase velocity. Show why.

Problem 5: (15 Points)   Find the cutoff frequency of the dominant mode and the maximum frequency that can be used to the exclusion of all other modes for a 0.4- by

（背面仍有題目，請繼續作答）

0.9-in waveguide.

Problem 6: (15 Points)　A 50-Ω transmission line is connected to a load impedance $Z_L = 100-j100$. Find the position and length of the short-circuited stub required to match the line. (Note: you may use the Smith chart below, temporarily. But don't forget to write down important procedures and results on your answer sheet. Otherwise it will not be graded.)