**Due: 11:59 pm on Oct 24, 2024**

Problem 1 (40 pts)

Two point charges $+q$ and $-q'$ $(0 < q' < q)$ are located at points A and B on the x-axis respectively. The distance between A and B is l. An electric field line emanating from $+q$ is at an angle α to the line AB.

1. Find the angle β between the final tangent line of this electric field line and the x-axis.

2. Find the position of the intersection point C of the final tangent line of this electric field line and the x-axis.

Problem 2 (30 pts)

A spherical capacitor with inner and outer radii R_1 and R_2 is filled with a dielectric whose permittivity varies with the angle $\varepsilon(\theta) = \varepsilon_0(1 + \varepsilon_r \sin\theta \cos^2\theta)$.

1. Find the capacitance of this capacitor.

2. When the inner and outer conductive spheres are charged with $+Q$ and $-Q$ respectively, find the electric field distribution inside the capacitor.
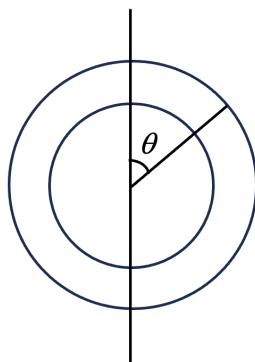
Problem 3 (30 pts)

A long coaxial cable consists of an inner cylinder with radius a and conductivity σ and an outer cylindrical shell with radius b. The conductivity of the outer cylindrical shell is infinite. The space between the inner cylinder and the outer cylindrical shell is empty. A uniform and steady current with the density $\vec{j} = j\hat{n}_z$ flows in the inner cylinder along the z-axis and returns uniformly from the outer cylindrical shell. The central section of the cable is the $z = 0$ plane. Find the surface charge density on the inner cylinder $\sigma_0(z)$.