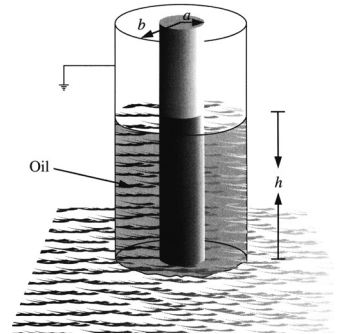


◇ Answer the questions as complete as possible.

1. (20%) Two long coaxial cylindrical metal tubes (inner radius a , outer radius b) stand vertically in a tank of dielectric oil (susceptibility χ_e , mass density ρ). The inner one is maintained at potential V , and the outer one is grounded (See the figure).

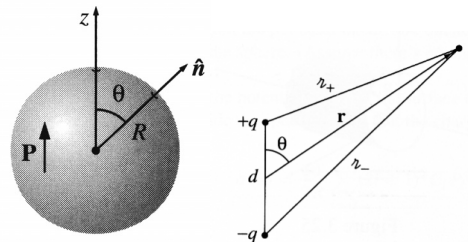
- (a) Find the electric field $\mathbf{E}$ in the air part and the oil part? (8%)
 (b) Find the capacitance? (6%)
 (c) Find the height (h) that the oil rises in the space between the tubes? (6%)



2. (20%) Consider a uniformly polarized dielectric sphere of radius R . $\mathbf{P} = P_0 \hat{\mathbf{z}}$

- (a) Find the surface bound charge density σ_b and the volume bound charge density ρ_b . (10%)
 (b) Find the potential V of the dipole sphere for $r \geq R$. (10%)

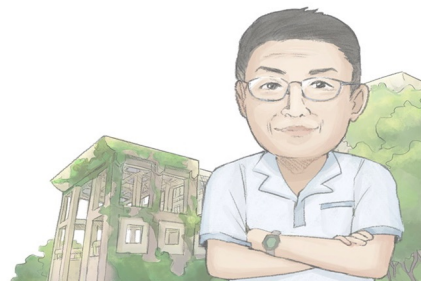
[Hint: Use the dipole approximation, or $V = \frac{1}{4\pi\epsilon_0} \oint_S \frac{\sigma_b}{r} da' + \frac{1}{4\pi\epsilon_0} \int_V \frac{\rho_b}{r} d\tau'$].



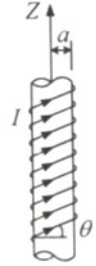
3. (20%) Boundary conditions and applications.

- (a) $\nabla \cdot \mathbf{D} = \rho_f$. Find the boundary condition for the normal component of $\mathbf{D}$, $D^\perp$. (6%)
 (b) $\nabla \times \mathbf{H} = \mathbf{J}_f$. Find the boundary condition for the tangential component of $\mathbf{H}$, $\mathbf{H}^\parallel$. (6%)
 (c) Consider the interface between two dielectric materials with ϵ_1 and ϵ_2 as shown in the figure. Find the relations between the normal and the tangential components of the electric fields. Assume that there is no surface charge, i.e., $\sigma_f = 0$. (8%)

$$\frac{\epsilon_1, E_1^\perp, E_1^\parallel}{\epsilon_2, E_2^\perp, E_2^\parallel}$$



4. (20%) An infinitely long solenoid with air core having a radius a and n closely wound turns per unit length, as shown in the figure. The windings are slanted (傾斜) at an angle θ and carry a current I .
- (a) Find the z -component of the magnetic flux density (B_z) both inside and outside the solenoid. (10%) [Hint: Use Ampere's law.]
- (b) Find the ϕ -component of the magnetic flux density (B_ϕ) both inside and outside the solenoid. (10%) [Hint: Use cylindrical coordinates, r, ϕ, z .]



5. (20%) A long cylinder of radius R carries a magnetization $\mathbf{M} = M_0 \hat{\mathbf{z}}$, where M_0 is a constant.
- (a) Find $\mathbf{J}_b$ within the material and $\mathbf{K}_b$ on the surface of the material. (10%)
- (b) Find the magnetic field $\mathbf{B}$ due to $\mathbf{M}$ for points inside ($r \leq R$) and outside the cylinder ($r \geq R$). (10%)

