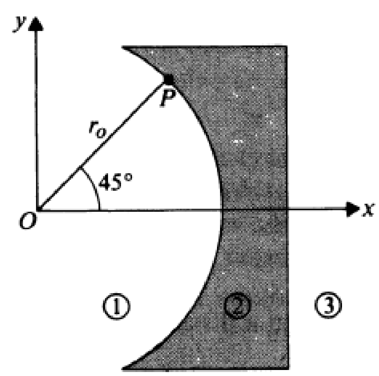
1. The polarization in a dielectric cube of side L centered at the origin is given by $\mathbf{P} = P_0(\mathbf{a_x}x + \mathbf{a_y}y + \mathbf{a_z}z)$.
   a) Determine the surface and volume bound-charge densities.
   b) Show that the total bound charge is zero.
2. Determine the electric field intensity at the center of a small spherical cavity cut out of a large block of dielectric in which a polarization $\mathbf{P}$ exists.
3. Assume that the $z = 0$ plane separates two lossless dielectric regions with $\epsilon_{r1} = 2$ and $\epsilon_{r2} = 3$. If we know that $\mathbf{E_1}$ in region 1 is $\mathbf{a_x}2y - \mathbf{a_y}3x + \mathbf{a_z}(5 + z)$, what do we also know about $\mathbf{E_2}$ and $\mathbf{D_2}$ in region 2? Can we determine $\mathbf{E_2}$ and $\mathbf{D_2}$ at any point in region 2? Explain.
4. Dielectric lenses can be used to collimate electromagnetic fields. As shown in the figure below, the left surface of the lens is that of a circular cylinder, and the right surface is a plane. If $\mathbf{E_1}$ at point $P(r_0, 45°, z)$ in region 1 is $\mathbf{a_r}5 - \mathbf{a}_\phi 3$, what must be the dielectric constant of the lens in order that $\mathbf{E_3}$ in region 3 is parallel to the x-axis?



5. The radius of the core and the inner radius of the outer conductor of a very long coaxial transmission line are r_i and r_o, respectively. The space between the conductors is filled with two coaxial layers of dielectrics. The dielectric constants of the dielectrics are ϵ_{r1} for $r_i < r < b$ and ϵ_{r2} for $b < r < r_o$. Determine its capacitance per unit length.
6. Prove that equations

$$W_e = \frac{1}{2}CV^2$$

$$W_e = \frac{1}{2}QV$$

$$W_e = \frac{Q^2}{2C}$$

for stored electrostatic energy hold true for any two-conductor capacitor.