Department of Physics, IIT Kanpur

Tutorial Problem Set-6

PHY103 HCV/SMT **1st Sept 2015**

1. A long cylindrical dielectric with radius R and axis along the z-axis has uniform polarization $P_0\hat{i}$ in it. Using cylindrical coordinates, find

(a) The bound charge density

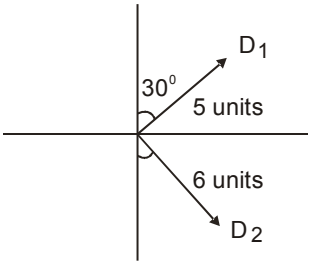
(b) The electric field due to this dielectric at a point inside the dielectric $(s < R)$.

(c) The electric field due to this dielectric at a point outside the dielectric $(s > R)$.

2. A point charge q is embedded at the center of a sphere of radius R, made from a linear dielectric material of electric susceptibility χ_e. Find (a) the displacement vector, (b) electric field, (c) polarization vector and (d) bound charge density everywhere.

3. A dielectric sphere of susceptibility χ is placed in an otherwise uniform electric field $\mathbf{E}_0$. Assuming that the polarization produced in the sphere is uniform, find the electric field inside the sphere.

4. The displacement vector $\mathbf{D}_1$, at a point close to a surface on one side of it, has a magnitude of 5 units and $\mathbf{D}_2$, close to the surface on the other side, has a magnitude of 6 units as shown in the figure. If the angle made by $\mathbf{D}_1$ with the upward normal to the surface is 30^0, what will be the angle made by $\mathbf{D}_2$ with this normal. The surface has only bound charges.



More Problems

1. A point charge q is placed at a distance d from a large, plane, linear, dielectric slab of dielectric constant K. Calculate the induced surface charge density, close to the foot of perpendicular from q.

[Ans. $\dfrac{2(K-1)q}{(K+1)4\pi d^2}$]

2. The polarization in a material varies in x- direction and is given as $\mathbf{P} = P_0 e^{-x^2/a^2}\hat{z}$. What charge density appears in the material? [Ans. $\dfrac{2xP_0e^{-x^2/a^2}}{a^2}$]

3. A dielectric cube is placed with its center at the origin and edges parallel to the coordinate axes. It contains a polarization $\mathbf{P} = k\,\mathbf{r}$ where k is a constant. Find all the bound charge densities. What is the total bound charge? [Ans. $\rho_b = -3k$, $|\sigma_b| = \dfrac{ka}{2}$ on each face]

4. A small spherical cavity is carved out from a large block of a dielectric material. A uniform polarization $\mathbf{P}$ exists in the material. Find the electric field inside the cavity.

5. A long, thin cylindrical cavity is carved out in a big dielectric material having a uniform polarization $\mathbf{P}$ parallel to the length of the cavity. The radius of the cavity is r and the length is L. Find the electric field at the center of the cavity. [Ans. $\dfrac{\mathrm{P}r^2}{\varepsilon_0 L^2}$]