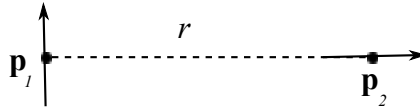
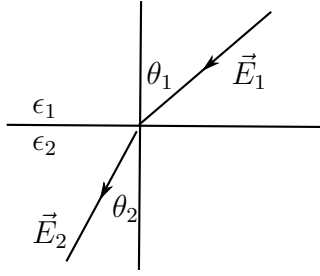


1. A dipole \vec{p} is at a distance r from a point charge q and oriented so that \vec{p} makes an angle θ with the vector \vec{r} from q to \vec{p} .
 - (a) What is the force on \vec{p} ?
 - (b) What is the force on q ?
2. \vec{p}_1 and \vec{p}_2 are perfect dipoles a distance r apart. \vec{p}_2 is along \vec{r} while \vec{p}_1 is orthogonal to \vec{r} . Calculate the torque on the dipoles. Are they equal and opposite?



3. A sphere of radius R carries a polarization $\vec{P}(\vec{r}) = k\vec{r}$
 - (a) Calculate the bound charges ρ_b and σ_b and the electric field caused due to them inside and outside the sphere.
 - (b) Find the electric field using the Gauss' law for the displacement vector \vec{D} given as $\oint_S \vec{D} \cdot \hat{n} da = Q_{f(enc)}$.
4. A point charge q is imbedded at the center of a sphere of linear dielectric material with susceptibility χ_e and radius R . Find the electric field, the polarization, and the bound charge densities, ρ_b and σ_b . What is the total bound charge on the surface? Where is the compensating negative bound charge located?
5. At the interface between one linear dielectric and another the electric field lines bend. Show that $\tan \theta_2 / \tan \theta_1 = \epsilon_2 / \epsilon_1$ assuming there is no free charge at the boundary. Refer to fig.1 below.



6. Suppose the field inside a large piece of dielectric is \vec{E}_0 , so that the electric displacement is $\vec{D}_0 = \epsilon_0 \vec{E}_0 + \vec{P}$.
- If we have a narrow cylindrical (needle-like) cavity inside the material running parallel to \vec{P} find the field near the center of the cavity in terms of \vec{E}_0 and \vec{P} . Also find the displacement at the center of the cavity in terms of \vec{D}_0 and \vec{P} .
 - Do the same for a thin wafer shaped cavity perpendicular to \vec{P} .
7. Suppose the entire region $z < 0$ is filled with uniform linear dielectric material of susceptibility χ_e . Calculate the force on a point charge q situated in air, at the point $(0, 0, d)$.