1. Show that the electric field and the electric potential of a dipole located at $\vec{r}'$, are calculated as followed:

$$
\phi(\vec{r}) = \frac{1}{4\pi\epsilon_0} \frac{\vec{p} \cdot (\vec{r} - \vec{r}')}{|\vec{r} - \vec{r}'|^3}
$$

$$
\vec{E}(\vec{r}) = \frac{1}{4\pi\epsilon_0} \left[ \frac{3\vec{p} \cdot (\vec{r} - \vec{r}') (\vec{r} - \vec{r}')}{|\vec{r} - \vec{r}'|^5} - \frac{\vec{p}}{|\vec{r} - \vec{r}'|^3} \right]
$$

2. A sphere of radius $R$ carries a polarization $\vec{P} = k\vec{r}$, where $\vec{r}$ is the vector from the origin,

i) Find the bounded charge densities, $\sigma_p$ and $\rho_p$.

ii) Find the electric field inside and outside of the sphere.

3. Consider a sphere with radius $a$ and electric potential $\phi_0$, we put this sphere in a new dielectric media with constant $\varepsilon_r = 1 + \frac{a}{r}$. Find the electric potential of the sphere in the later condition.

4. In this problem assume that the dielectric is linear but not necessarily homogeneous, try to find the bounded densities, $\sigma_p$ and $\rho_p$, in order of $\varepsilon$ and $\vec{E}$. (Note that in the nonhomogeneous dielectrics $\varepsilon$ is a function of the space coordinates)

5. A cylinder of radius $a$ and length $l$ along the $z$ axis, carries the polarization $\vec{P} = k \cos \varphi \hat{z}$. Find the electric field on the $z$ axis.

6. Two long, coaxial, cylindrical conducting surfaces of radii $a$ and $b$, are lowered vertically into a liquid dielectric. A potential difference $V$ is established between them, Find the surface charge on the cylinder faces.(In the next series of homeworks we calculate the susceptibility of the liquid when it rises an average height $h$ between the electrodes)