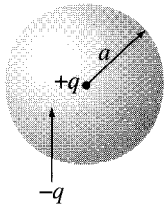
PHYS 507
HANDOUT 7 - *Questions on Dielectrics*

7.1 A primitive model for an atom consists of a point nucleus (+*q*) surrounded by a uniformly charged spherical cloud (-*q*) of radius *a.* Calculate the atomic polarizability of such an atom.



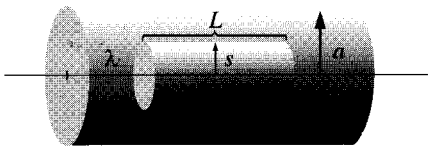
7.2 Prove that a dipole in an electric field experiences a torque given by $\mathbf{N} = \mathbf{p} \times \mathbf{E}$.

7.3 Prove that a dipole in an electric field, which is not uniform experiences a net force equal to $\mathbf{F} = (\mathbf{p} \cdot \nabla)\mathbf{E}$.

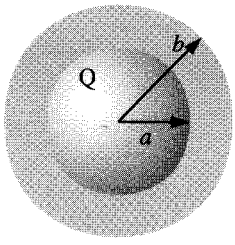
7.4 Prove that the field created by a polarized object is made up by the field of a volume charge density and a field of a surface charge density.

7.5 Find the electric field produced by a uniformly polarized sphere of radius *R.*

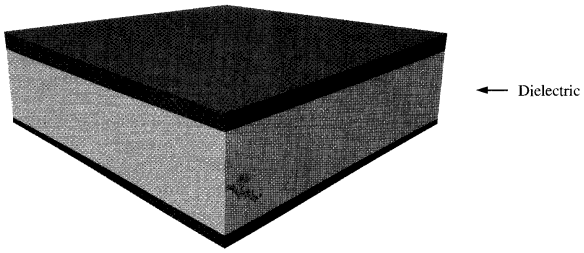
7.6 A long straight wire, carrying uniform line charge λ, is surrounded by rubber insulation out to a radius *a.* Find the electric displacement.



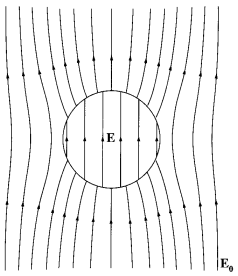
7.7 A metal sphere of radius *a* carries a charge *Q.* It is surrounded, out to a radius *b*, by linear dielectric material of permittivity ε. A) Find the potential at the center (relative to infinity). B) Find the polarization of the dielectric. C) Find the surface bound charge density.



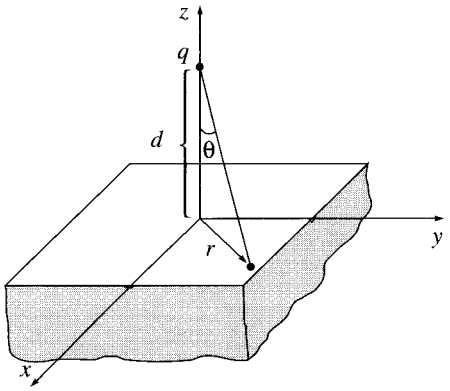
7.8 A parallel plate capacitor is filled with insulating material of dielectric constant ε_r. What effect does this have on its capacitance?



7.9 A sphere of homogeneous linear dielectric material is placed in an otherwise uniform electric field $\mathbf{E}_0$. Find the electric field inside the sphere.

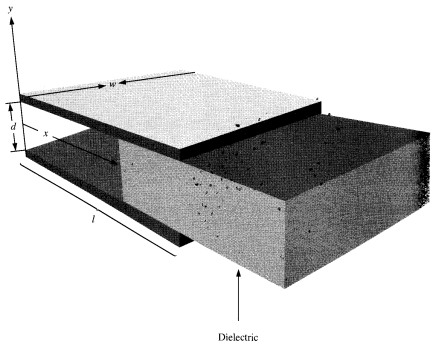


7.10 Suppose the entire region below $z = 0$ in figure is filled with uniform linear dielectric material of susceptibility χ_e. Calculate the force on a point charge q situated a distance d above the origin.



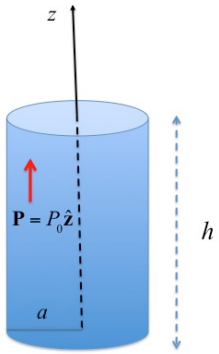
7.11 Prove that the energy of a capacitor filled in with a dielectric material is given by $W = \frac{1}{2}\int \mathbf{D}\cdot\mathbf{E}\,d\tau$.

7.12 Calculate the work needed to pull out a dielectric slab from the plates of a capacitor as shown in figure.



7.13 A slab of a dielectric material is infinite in the *x*-*y* plane and has a width *h* in the *z*-direction. The slab has a constant polarization $\mathbf{P} = P_0\hat{\mathbf{z}}$. What s the electric field in the whole space?

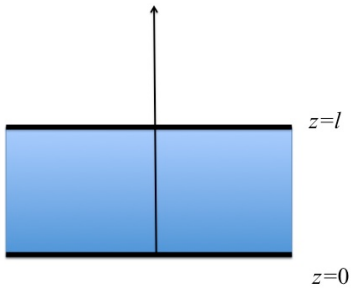
7.14 A cylinder of radius *a* and height *h*. The cylinder has a constant polarization $\mathbf{P} = P_0\hat{\mathbf{z}}$. What is the electric field on the axis of the cylinder?



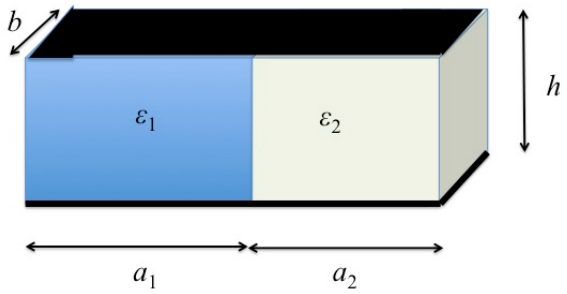
7.15 A cylinder of radius *a* and height *h*. The cylinder has a constant polarization $\mathbf{P} = P_0\hat{\mathbf{z}}$. What is the electric field on the axis of the cylinder?

7.16 A parallel plate capacitor has plates with area *A* and their mutual distance is *l*. The charge of the capacitor is *Q*. Calculate the force between the two plates using the formula for the energy of the capacitor.

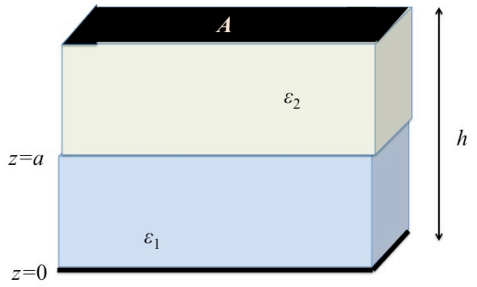
7.16 A parallel plate capacitor has plates with area *A* and their mutual distance is *l*. The capacitor contains a dielectric material whose permittivity is a linear function of the position between the plates. The permittivity has the values and $\varepsilon(0) = \varepsilon_1$ and $\varepsilon(l) = \varepsilon_2$. Find the capacity of the capacitor.



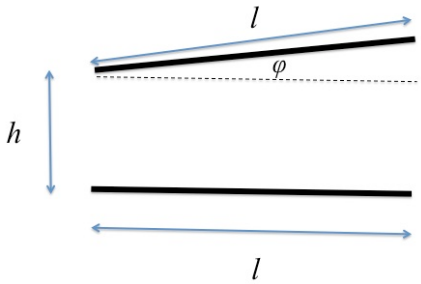
7.17 A parallel plate capacitor has plates at a distance h and dimensions as shown in the figure. It is filled with two dielectrics as shown. Find the capacity of the capacitor.



7.18 A parallel plate capacitor has plates at a distance h and area of plates A. It is filled with two dielectrics. Find the capacity of the capacitor.



7.19 A capacitor has square plates of side l. Due to an error in construction the plates are not parallel but have small slope with an angle φ. Show that the capacitance of the capacitor, to a good approximation, is given by: $C \approx \left(\varepsilon_0 l^2 / h\right)\left(1 - \frac{l\varphi}{2h}\right)$.



7.20 A spherical capacitor has radii a and b. Between the spherical plates there is a dielectric material with permittivity, which is given by $\varepsilon = \varepsilon_0 b / r$ (with r being the radial distance. Find the capacitance of the capacitor.