Set #6 - for Thursday, November 13

Read

HR&K, Vol. 2	Ch. 30
Purcell	Ch. 10
Feynman Vol. 2	Ch. 10, 11

Solve

From HR&K

Ch. 30 Problems 14, 19, 20, 24

From Purcell

Ch. 3 Problem 3.66

Ch. 10 Problem 10.30

Problem 1. (a) Determine the value of n_2 that satisfies expression $\nabla \frac{\vec{r}}{r^{n_2}} = A_2 \cdot \delta^2(\vec{r})$ with the nonzero value of A_2 in two dimensions. What is the value of A_2?

(b) Obtain similar expression in 1-d. Discuss the values of n_1 and A_1.

(c) Using these results discuss r-dependence of the "electric filed" of a point charge with density proportional to the delta function in 1 and 2 dimensional world if we assume that Gauss theorem works in these dimensions.

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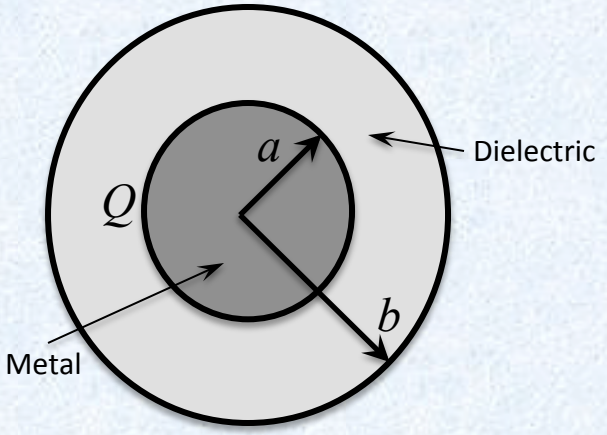
Problem 2. An isolated metal sphere of radius a has a free charge Q on its surface. The sphere is covered with a dielectric layer with inner radius a and outer radius b.

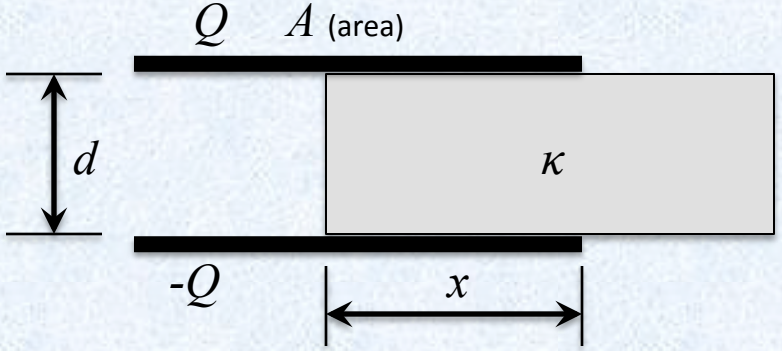
a) Calculate the polarization (bound) charge density on the inside and outside of the dielectric (linear dielectric).

b) What is the volume density of polarization charge inside the dielectric? Recall: $\sigma_{pol} = \vec{P} \cdot \hat{n}$ and $\rho_{pol} = -\vec{\nabla} \cdot \vec{P}$.



Problem 3. Show that when an electric field line cuts through a surface separating two dielectrics of dielectric constant κ_1 and κ_2, it makes angles θ_1 and θ_2 with the normal to the surface in the two media, given by the relation $\kappa_1 \cot\theta_1 = \kappa_2 \cot\theta_2$.

Problem 4. A dielectric of dielectric constant κ is inserted between the plates of a charged parallel plate capacitor. Find the magnitude and direction of the force that we need to apply to the slab so that it is inserted slowly and at constant velocity.



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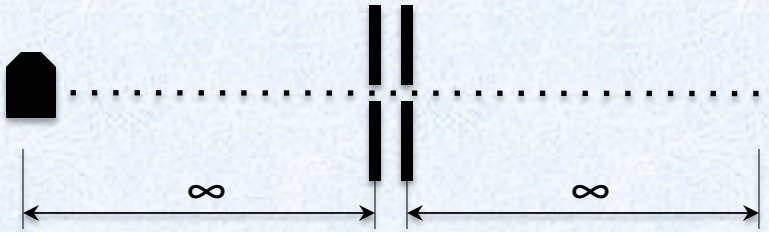
Problem 5. A dielectric sphere of uniform dielectric constant κ is given a free charge density ρ which is also uniform. Find the potential ϕ at the center of the sphere.

Problem 6. Consider electron cannon that shoots electrons towards a plane-parallel capacitor with a small hole in it. Cannon is targeting the hole. The capacitor is separated from the cannon at a distance that is much greater than dimensions of the capacitor. After passing capacitor electron gains energy $e \times V$ and moves far away. Does it violate the law of conservation of energy?



Problem 7 (extra credit). An infinite dielectric medium has uniform polarization $\vec{P}$. A spherical hollow of radius a is made in the dielectric. Find the electric field at the center of the hollow due to the polarization of the dielectric. Assume the hollow does not alter $\vec{P}$.

Hint: *First find how much surface charge density σ_p appears on the surface of the hollow. Next integrate to find the electric field.*

Good Luck, Dr. B