

Name: _____ Student ID: _____ Session: T ____

PHYS 3033 - Electricity and Magnetism I

Quiz 7: 27 Oct 2015

Time allowed: 20 minutes

A (free) point charge q is embedded at the center of a linear dielectric sphere with radius R and permittivity ϵ .

- (a) Obtain, in terms of ϵ and q , the amount of bound charge which sticks on q . Is it of the same or opposite sign of q when $\epsilon > \epsilon_0$?
- (b) What is the volume bound charge density inside the sphere (but not at the position of q)?
- (c) What is the total amount of surface bound charge on the surface of the sphere?
- (d) What is the surface bound charge density?
- (e) If q is moved away from the center to another point inside the sphere, the answer in which part(s) from (a) to (d) will be different?

Solutions:

- (a) The total charge is reduced by a factor of ϵ_0/ϵ . Let the bound charge be q_b . Then

$$q + q_b = q \frac{\epsilon_0}{\epsilon} \Rightarrow q_b = q \left(\frac{\epsilon_0}{\epsilon} - 1 \right).$$

It is of opposite sign of q when $\epsilon > \epsilon_0$.

- (b) 0.

- (c) Total bound charge = 0 implies the amount of surface bound charge is

$$-q_b = q \left(1 - \frac{\epsilon_0}{\epsilon} \right).$$

- (d) Due to symmetry, the surface bound charge should be uniformly distributed.

Hence

$$\sigma_b = \frac{q}{4\pi R^2} \left(1 - \frac{\epsilon_0}{\epsilon} \right).$$

- (e) Only (d) will be different. The surface bound charges are no longer uniformly distributed.