

Homework No. 05 (2018 Fall)

PHYS 320: Electricity and Magnetism I

Due date: Monday, 2018 Sep 24, 2:00 PM, in class

1. **(20 points.)** Using Gauss's law find the electric field inside and outside a solid sphere of radius R with total charge Q distributed inside the sphere with a charge density

$$\rho(\mathbf{r}) = br \theta(R - r), \quad (1)$$

where r is the distance from the center of sphere. Here $\theta(x) = 1$, if $x > 0$, and 0 otherwise.

2. **(20 points.)** Using Gauss's law find the electric field in a region, a distance R away from the origin, if the charge density in space is given

$$\rho(\mathbf{r}) = \frac{\sigma}{r}, \quad (2)$$

where r is the radial distance from origin and σ is a parameter with units of charge per unit area.

3. **(20 points.)** (Problem 2.15 Griffiths 4th/3rd edition.)
A thick spherical shell carries charge density

$$\rho(\mathbf{r}) = \frac{k}{r^2}, \quad a \leq r \leq b. \quad (3)$$

Find the electric field in the three regions: (i) $r < a$, (ii) $a < r < b$, (iii) $b < r$. Plot $|\mathbf{E}|$ as a function of r , for the case $b = 2a$.

4. **(40 points.)** Consider a uniformly charged solid sphere of radius R with total charge Q .

- (a) Using Gauss's law show that the electric field inside and outside the sphere is given by

$$\mathbf{E}(\mathbf{r}) = \begin{cases} \frac{Q}{4\pi\epsilon_0} \frac{1}{R^2} \frac{r}{R} \hat{\mathbf{r}}, & r < R, \\ \frac{Q}{4\pi\epsilon_0} \frac{1}{r^2} \hat{\mathbf{r}}, & r > R, \end{cases} \quad (4)$$

where $\mathbf{r}$ is the radial vector with respect to the center of sphere.

- (b) Plot the magnitude of the electric field as a function of r .
(c) Rewrite your results for the case when the solid sphere is a perfect conductor?
(d) Rewrite your results for the case of a uniformly charged hollow sphere of radius R with total charge Q .