Physics 7311 Professor Scalise
Homework Assignment #4 Fall 2022

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8. Derive the electric field for a point charge at the origin $\left(\vec{E} = k\frac{q\vec{r}}{r^3}\right)$ from Gauss' law. Justify every step.

9. Solve Jackson Chapter 1 - Problem 1.1: Use Gauss' theorem (and $\oint \vec{E}\cdot d\vec{l} = 0$ if necessary) to prove the following:

   (a) Any excess charge placed on a conductor must lie entirely on its surface.

   (b) A closed, hollow conductor shields its interior from fields due to charges outside, but does not shield its exterior from fields due to charges placed inside it.

   (c) The electric field at the surface of a conductor is normal to the surface and has a magnitude σ/ϵ_0, where σ is the charge density per unit area on the surface.

10. Consider a spherically symmetric charge distribution, i.e. $\rho(\vec{r}) = f(r)$.

    (a) Use Gauss' law to obtain an expression for the electric field as an integral of $f(r)$.

    (b) Find the potential as a **double** radial integral with the requirement that $\Phi(r) \to 0$ as $r \to \infty$.

    (c) Find the electric field and potential for a charge density

    $$\rho(\vec{r}) = Q\delta^3(\vec{r}) - \frac{Q}{8\pi r_0^3}e^{-r/r_o} \quad .$$

    (d) What is the total charge of the system?

    (e) Is your answer for $\Phi(r)$ what you would expect from a multipole expansion? Comment.

Bonus: (5 points)

Two perfectly conducting infinite and grounded half-planes intersect at an angle $\pi/3$ radians. A charge q is located halfway between the planes at a distance d from the intersection. Find the potential $\Phi(x, y)$ for the region between the planes where the charge sits.