Electricity and Magnetism - Test 2 - Spring 2014

Work four of the six problems. Place the problems in the order you wish them graded. The first two problems form the first half test; the second two problems form the second half test.

Problem 2.1 A grounded conducting sphere of radius $R = 12$cm is centered at $z = 50$cm along the z axis. A point charge with charge 1nC$=1 \times 10^{-9}$C is located at the origin. How much mass can the point charge have so that it floats in Earth's gravity? Gravity is directed in the $-z$ direction and for those who have forgotten all physics $g = 9.81 m/s^2$.

Problem 2.2 An infinitely long conducting cylinder of radius a is held at $V = 0$. The cylinder is surrounded by a cylindrical linear dielectric with inner radius a and outer radius b and dielectric constant κ. At the surface of the dielectric, the electric potential is $V = V_0 \sin(2\phi)$. Compute the electric potential in the dielectric. Since you are given the potential, you may find the solution does not contain the dielectric constant.

Problem 2.3 A spherical system of inner radius a and outer radius b contains a fixed polarization $\vec{P} = \gamma(r-a)\hat{r}$ where γ is a constant. Compute the potential difference between infinity and the origin. Compute any surface or volume bound charge densities.

Problem 2.4 A spherical surface of radius a has the potential $V(a, \theta) = V_0(3\cos(\theta)^2 - 1)$. Compute the potential everywhere and the surface charge density at the surface. Note, there are no conductors or dielectrics in this problem.

Problem 2.5 A point charge $+Q$ is fixed at the origin. The point charge is surrounded by a non-uniform, spherically symmetric volume charge density

$$\rho(r) = \frac{\gamma e^{-r/\tau}}{r^2}$$

where γ and τ are constants. This charge density extends to a radius of a and there is no charge density outside of a. The region $r < a$ is also filled with a linear dielectric with dielectric constant κ. Compute the electric field everywhere.

Problem 2.6 A sphere has radius R and uniform polarization $\vec{P} = P_0\hat{z}$. Compute the dipole moment of the sphere and the electric field along the z axis for distances $z \gg R$. Note, since the polarization depends on $\hat{z}$ the problem in not spherically symmetric.