Physics 370 **Homework 5** **Due Monday February 26, 2018**

Reading: Griffiths pages 94-107 and 113-118.

Problem 1 At least one of these is an impossible electric field in electrostatics. Which one(s) and why? (Each of $\kappa_{1,2,3}$ is some constant with appropriately chosen units.)
(a) $\vec{\mathbf{E}} = \kappa_1 \left[2xy\,\widehat{x} + (x^2 + 2yz)\widehat{y} + y^2\,\widehat{z}\right]$ (rectangular coordinates)
(b) $\vec{\mathbf{E}} = \kappa_2 \left[\cos\phi\,\widehat{r} - \sin\theta\,\sin\phi\,\widehat{\phi}\right]$ (spherical coordinates)
(c) $\vec{\mathbf{E}} = \kappa_3 \left[z\cos\phi\,\widehat{r} + r\cos\phi\,\widehat{z} - z\sin\phi\,\widehat{\phi}\right]$ (cylindrical coordinates)

Problem 2 A solid sphere of radius R carries charge density $\rho(r) = \rho_0 r^2/R^2$, where r is the distance to the center and ρ_0 is a constant. Show that the energy stored in the configuration is

$$W = X\pi\rho_0^2 R^5/\epsilon_0$$

where X is a rational number that you will compute. [Hint: first find the electric field both inside and outside of the sphere, using Gauss' Law in integral form.]

Problem 3 A capacitor consists of two parallel square metal plates of side 1 cm. They are 0.2 mm apart.
(a) What is the capacitance, numerically, in pF? Remember that 1 pF $= 10^{-12}$F.
(b) If the two plates are connected to the terminals of a 9 volt battery, what is the magnitude of the charge on each plate, numerically, in Coulombs?
(c) How much energy, in Joules, is stored in the capacitor in part (b)?

Problem 4 Consider two long coaxial metal cylindrical tubes of length L, with radii a and b. [See Griffths Figure 2.53, p. 107 (4th edition) or p. 106 (3rd edition).]
(a) Compute the electric field and the potential everywhere for $a < r < b$, if the inner cylinder is given a charge $+Q$ and the outer cylinder a charge $-Q$, and assuming $L \gg a, b$.
(b) Show that the capacitance per unit length is $K\epsilon_0/\ln(b/a)$, where K is a certain number that you will compute. [Hint: The total capacitance will be proportional to L, but we are looking for the capacitance per unit length which does not depend on L.]
(c) For $a = 1$ mm and $b = 3$ mm, what is the result of part (b) numerically in pF/meter?