Carleton University Physics Department
PHYS 3308 – Electromagnetism (Fall 2014)
Homework assignment #6

Handed out Thurs Oct 16; due Thurs Oct 23, 2014, at the start of class. H. Logan
(This will be the last assignment before the midterm exam.)
Problems are worth 5 points each unless noted otherwise.

1. Find the potential outside a *charged* metal sphere (with charge Q and radius R) placed in an otherwise uniform electric field $\vec{\mathbf{E}}_{\mathbf{0}}$. Explain clearly where you are setting the zero of potential. *(Note: you may use any of the results found in class or derived in the textbook.)*

2. Solve Laplace's equation by separation of variables in cylindrical coordinates, assuming there is no dependence on z (i.e., $V = V(s, \phi)$). Make sure you find *all* solutions to the radial equation; in particular, your result must accommodate the case of an infinite line charge, for which we already know the answer.

3. *(10 points)* A line charge with linear charge density λ is threaded down the centre of an infinitely long, uncharged metal pipe with inner radius a and outer radius b.
   (a) Find the electric field everywhere and the surface charge densities on the inner and outer surfaces of the pipe. *(Hint: there's nothing fancy about this part of the problem; you can use Gauss's Law if you want.)*
   (b) Describe in words how and whether each of your results in part (a) would change if the pipe-plus-line-charge were placed in an otherwise uniform external electric field pointing perpendicular to the pipe. Would there be a net force on the pipe?
   (c) Use the results of problem 2 to find the electric potential everywhere outside the pipe for the setup in part (b). Clearly specify how you define the zero of potential.

4. A solid dielectric sphere of radius R carries polarization $\vec{P}(\vec{r}) = k\vec{r}$, where k is a constant and $\vec{r}$ is the vector from the centre of the sphere.
   (a) Calculate the bound charges σ_b and ρ_b.
   (b) Find the electric field (due to the polarization) inside and outside the sphere. *Hint: use the bound charges.*