Problem set 4

1. Jackson 4.1.

2. Show that a charged particle in a good quantum state of angular momentum l, m has no permanent electric dipole moment.

3. An infinitely long copper cylinder of radius a is surrounded by a cylindrical shell of inner radius a, outer radius b. The dielectric has a dielectric constant ϵ. The combined cylinder is now placed in a uniform static electric field E_o perpendicular to the axis of the cylinder.

- (a). Before solving this problem, find all the z-independent solutions of Laplace's equation in cylindrical coordinates.
- (b). State the boundary conditions at $r = a$, $r = b$ and as $r \to \infty$
- (c). Using the solutions of Laplace's equation found in part (a), find the electrostatic potential in the three regions $r < a$, $a < r < b$ and $r > b$
- (d). Find the charge per unit area on the surface of the metal cylinder as a function of θ.

4. Jackson problem 4.5 (part a only).

5. Jackson 4.10.

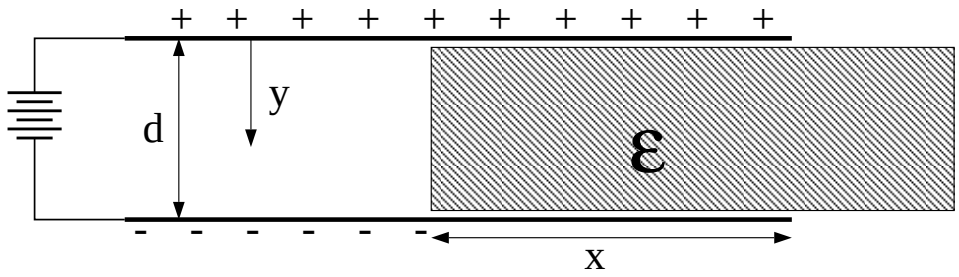
6. A spherical capacitor in a zero-gravity environment has electrodes of radii a and d, $a < d$. It is partially filled by a solid piece of dielectric material with dielectric constant ϵ in the form of a spherical shell of inner radius b, and outer radius c, $a < b < c < d$.

- Given charges $\pm Q$ on the electrodes, what is the energy stored in the capacitor?
- There will be stresses within the dielectric due to the electric forces. If the dielectric is suddenly melted into a fluid, how will it be redistributed within the capacitor?

7. Part a. A parallel plate capacitor consists of two square plates of edge length a a distance of d apart. It is connected to a battery of voltage V_o. A linear homogeneous isotropic dielectric slab (of dielectric constant ϵ) having the same dimensions is inserted a distance x ($0 < x < a$) between the plates. Find the following (neglecting edge effects):

- The electric field everywhere between the plates.
- The total charge on each plate.
- The energy stored in the capacitor.
- The force on the dielectric material.

- The polarization of the dielectric.



Part b. The battery is disconnected from the capacitor *before* the dielectric is inserted, leaving the capacitor charged. Then the dielectric is inserted. Now what are the answers to five questions above?