**Prob A:** A slab of dielectric material with dielectric constant $\varepsilon$ is placed between two square planar electrodes of side $L$ separated by a distance $d$. In the dielectric is a spherical void of radius $a \ll d \ll L$. A voltage $V_0$ is applied to one electrode while the other is grounded.

A) First, ignoring the effect of the void what are: (20 pts)
- the electric field in the dielectric
- the free surface charge densities on each conductor
- the induced surface charge densities on the dielectric
- the energy stored in the configuration

B) Now consider the effect of the void. What are: (20 pts)
- the electric field inside the void
- the induced surface charge densities on the dielectric adjacent to the void

C) Will the presence of the void increase or decrease the capacitance of the configuration? Explain. Estimate the change. (10pts)
**Prob B:** A charge $q_0$ is brought from infinity to a distance $z_0$ from the center of a conducting sphere of radius $a$. Calculate the amount of work that must be done to do this if A) the sphere is grounded, B) the sphere is held at a potential $V$, and C) the sphere has a fixed charge $Q$ on it. (20 pts)

Hint, this problem is best tackled using the method of images. Even then it is not as straightforward as you might think it is.

**Prob C:** A ring of radius $a$ carries a uniform charge $Q_2$ and lies a distance $d_2$ above a grounded conducting plane. Two point charges of magnitude $Q_1$ and $Q_3$ also lie a distance of $d_1$ and $d_3$ respectively above the conducting plane. (30 pts)

a.) Find an expression for the potential $\Phi(z)$ along the axis of symmetry.
b.) Find expressions for the net forces on the point charges $Q_1$ and $Q_3$.
c.) Find an expression for the leading order multipole moment of the charge distribution.