Practice Problem Set 6

1. A parallel-plate capacitor has square plates 7.5 cm on a side, separated by 0.29 mm. The capacitor is charged to 12 V, then disconnected from the charging power supply.

   (a) Calculate the capacitance of this capacitor.

   (b) What is the total charge on each plate? What is the charge density on the plates?

   (c) What is the electric field between the plates?

   (d) A *dielectric* is an insulating material that modifies the external electric field in which it is placed. Suppose a sheet of glass is placed between the parallel-plate capacitor. Calculate the capacitance and total charge on each plate as you did above, this time including the glass sheet. Do the values increase or decrease? Now repeat these calculations for polyethylene and quartz. Which dielectric gives the greatest capacitance? Why might using a dielectric in a capacitor be useful in practice? (Hint: See Table 23.1)

2. A spherical conductor of radius R carries a total charge Q.

   (a) Determine the energy density, u_E, at each point over all space as a function of the distance r from the sphere's centre. Plot u_E as a function of r.

   (b) Use this energy density to compute the system's total energy, U, by integrating over all space.

3. Consider a parallel-plate capacitor where the separation between the plates can be varied. The maximum capacitance it can withstand is 120 pF. You charge the capacitor to a potential difference of 50 mV at maximum capacitance and then isolate it. With the capacitor still isolated, what plate separation is required so that it now has a potential difference of 30 V? The plate area is $3.1\,\text{cm}^2$.