Workshop Module 3

1. A constant potential difference of 24 V is maintained between the terminals of a 0.25 m F parallel-plate air capacitor. A) A sheet of mylar is inserted between the plates of the capacitor, completely filling the space between the plates. When this is done, how much additional charge flows onto the positive plate of the capacitor? B) What is the total induced charge on either face of the mylar sheet? C) What effect does the mylar sheet have on the electric field between the plates? How does this jive with the increase in the charge on the plates which should serve to increase the field between the plates?

2. Sharks can detect electric fields as weak as 1 microvolt/meter, which is in the range of the elctric fields found along the skins of animals (in particular ... fish the shark wants to eat!). The organs that can detect such weak fields are called the ampullae of Lorenzini. These are jelly-filled tubes that are many centimeters long but only a millimeter or two in diameter. One end of the tube opens at the surface of the shark's head. The walls of the tubes have high resistivity, but the resistivity of the jelly is quite low. How do you suppose the ampullae of Lorenzini function?

3. You have a friend who recently bought an electrical space heater for his dorm room. The heater is rated at 1000 Watts and is designed to operate on a 240 volt circuit. Unfortunately for your friend, his dorm room is only equipped with 120 volt outlets. For this problem, assume these voltages are direct current (dc) rather than alternating current.

   (a) What is the resistance of the space heater?

   (b) If your friend goes ahead an plugs it into an outlet in his dorm room, what power output (dissipated as heat) will he get from his heater?

   (c) Your friend decides (against your safety-minded objections) to try and wire his two outlets together. What is likely to happen, and what wiring is most likely (assuming a lack of fire and death) to give the desired result of 240V?

4. Electric rays (genus Torpedo) can deliver electric shocks to stun their prey and to discourage predators. The voltage is produced by thin, wafer-like cells called electrocytes, each of which acts as a battery with an emf of about 10-4 V. Stacks of electrocytes are arranged syde-by-side on the underside of Torpedo. In such a stack, the positive face of each electrocyte touches the negative face of the next electrocyte. What is the advantage of stacking the electrocytes? Of having the stacks side by side?

5. When a capacitor, battery and resistor are connected in series, does the resistor affect the maximum charge stored on the capacitor? Why or why not? What purpose does the resistor serve?

6. Open the Magnetic Field and Charged Particle (`http://web.pas.rochester.edu/~manly/class/P142_2007/Lectures/MagneticFields/index.html`) link from the course webpage. Using 2 fields (red and green), adjust the settings to try and generate each of the following patterns (I find it handy to put the charge gun on repeated firing). If your workshop is too large to allow everyone a chance to try this, go ahead and skip this one until you get home as it requires a little more interaction to be worthwhile.

   (a) U-turn. Get the particles to return in exactly the opposite direction from which they left. What is their speed? Why?

   (b) Hit the gun. Get the charges to turn around and come back at the gun.

   (c) "Open figure 8". You could potentially achieve a closed figure 8 by changing the fields at the right time, but it appears that the area given is too small to make it work.

   (d) Sine wave. What field configurations and aiming will give you a sine wave shaped beam trajectory? Why does this work?

   (e) What do you need to do differently for each of these cases if you switch the sign of the charge?

   (f) Is it possible to get a charge to accelerate in a straight line in a magnetic field?