THE UNIVERSITY OF BRITISH COLUMBIA

Physics 122 Assignment # 5: POTENTIAL & CAPACITANCE

Fri. 1 Feb. 2002 — finish by Fri. 8 Feb.

1. **CLASSICAL RADIUS OF THE ELECTRON:** You are probably familiar with Einstein's famous equation $E = mc^2$. If m is the mass of an electron and E is the electrostatic potential energy required to "assemble" the electron from bits of charge infinitely distant from each other into a uniform spherical shell of radius r_0 and net charge e, find the numerical value of r_0 in meters.[1]

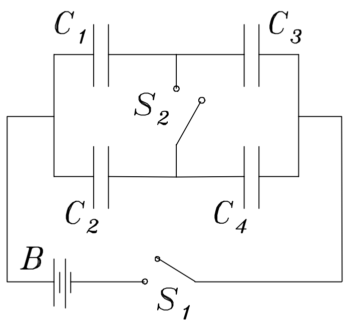
2. **CAPACITOR WITH INSERT:** Suppose we have a capacitor made of two large flat parallel plates of the same area A (and the same shape), separated by an air gap of width d. Its capacitance is C. Now we slip another planar conductor of width $d/2$ (and the same area and shape) between the plates so that it is centred halfway in between. What is the capacitance C' of the new system of three conductors, in terms of the capacitance C of the original pair and the other parameters given? (Neglect "edge effects" and any dielectric effect of air.)

3. **CUBIC CAPACITOR** Suppose we take a roll of very thin (50 μm) copper sheet and a roll of 150 μm thick strontium titanate dielectric (see Table 29-2 on p. 671 of the textbook) and form a capacitor as follows: cut the sheets into strips 5 cm wide and sandwich the dielectric sheet between two sheets of copper. Then fold the sandwich back and forth to fill a cube 5 cm on each side. Assuming that we can press the layers together so that there are no empty spaces, find:

   (*a*) the capacitance of the resulting cube-shaped capacitor;

   (*b*) the maximum charge it will hold without breaking down;

   (*c*) the total energy we can store in this small cube.



4. **ARRAY of CAPACITORS:** The battery B supplies 6 V. The capacitances are $C_1 = 2.0\ \mu$F, $C_2 = 1.0\ \mu$F, $C_3 = 4.0\ \mu$F and $C_4 = 3.0\ \mu$F. (*a*) Find the charge on each capacitor when switch S_1 is closed but switch S_2 is still open. (*b*) What is the charge on each capacitor if S_2 is also closed?

5. **THUNDERCLOUD CAPACITOR:** A large thundercloud hovers over the city of Vancouver at a height of 2.0 km. Between the cloud and the ground (both of which we may treat as parallel conducting plates, neglecting edge effects) the electric field is about 200 V/m. The cloud has a horizontal area of 200 km^2.

   (*a*) Estimate the number of Coulombs [C] of positive charge in the cloud, assuming that the ground has the same surface density of negative charge.

   (*b*) Estimate the number of joules [J] of energy contained in the air between the cloud and the ground.

[1]The value you calculate will not agree with the value you look up; this is because the r_0 listed in textbooks is actually the Compton radius of the electron and has a completely different meaning. Nevertheless, numerous texts glibly describe r_0 as defined in this problem. The amazing thing is that the two values are so close!