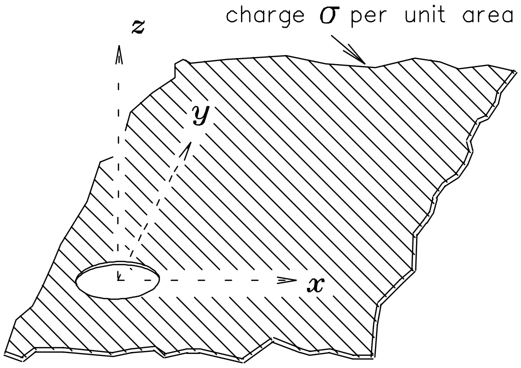
The University of British Columbia

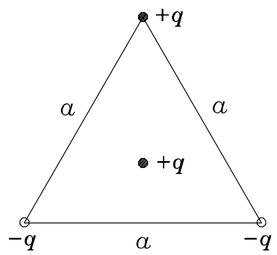
Science 1 Physics Assignment # 14:
POTENTIAL & CAPACITANCE

Thu. 01 Feb. 2001 — finish by Wed. 07 Feb.

1. Hole in a Plane of Charge: A large flat non-conducting surface (treat it as an infinite sheet) carries a uniform charge density $\sigma = 4.0 \times 10^{-9}\ C/m^2$. A small circular hole has been cut out of the middle of this sheet of charge, as shown on the diagram. Calculate the electric field at point P a distance $z = 1.0\ m$ up from the centre of the hole along its axis. The radius of the hole is $R = 0.4\ m$.



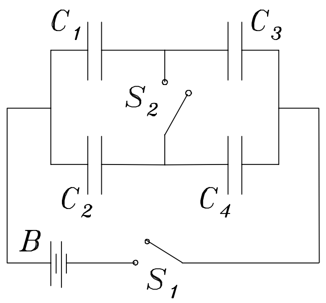
2. Triangle of Charges: Derive an expression for the **work** required to bring four charges together into an equilateral triangle of side a (as shown) with one charge at the centre of the triangle. (Initially the charges are all infinitely far apart.)



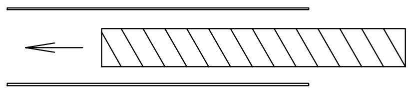
3. ARRAY of CAPACITORS: The battery B supplies 6 V. The capacitances are $C_1 = 2.0\ \mu F$, $C_2 = 1.0\ \mu F$, $C_3 = 4.0\ \mu F$ and $C_4 = 3.0\ \mu F$.

(*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?



4. 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.)



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Ch. **24**: problems **19**, **49**, **65** and **97**

Ch. **25**: problems **33**, **54**, **57**, **67**, **101** and **109**

Challenge Problems:

1. 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.

2. CUBIC CAPACITOR: Suppose we take a roll of very thin (50 μm) copper sheet and a roll of 150 μm thick strontium titanate dielectric (dielectric constant 310) 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 firmly so that there are no empty spaces, find:

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

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