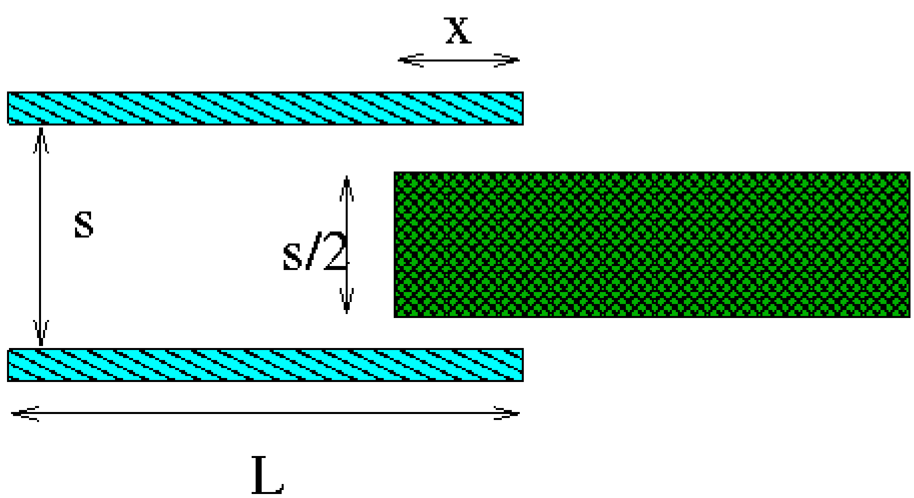
Massachusetts Institute of Technology
Department of Physics
Physics 8.022 - Fall 2002

Assignment #4
Conductors, Capacitance
Current, Resistance, Ohm's Law

Reading *Purcell* Chapter 3 and 4.

Problem Set #4
Work on **all** problems. Not all problems receive equal points. Total points for this set is 100.

- **(20 points) [1]** Energy of a conductor in a capacitor.



Two flat square metal plates with sides of length L are arranged parallel to each other with a separation of S where $S \ll L$. This assumption allows you to neglect the fringing effects due to the finite size of the plates. A charge +Q is moved from the top plate to the bottom. A third, uncharged, conducting plate of the same size with thickness $\frac{S}{2}$ is slid between the other two to a depth of x, maintaining the same spacing of $\frac{S}{4}$ between its surface and that of the other two.

  - What are the surface charge densities σ_W and σ_N on the lower plate adjacent to the wide and narrow gaps?
  - What is the electric field in the wide and narrow gaps?
  - What is the capacitance of the system?

- How much energy is stored in the electric field?
- What force must be exerted on the middle plate to keep it from moving?

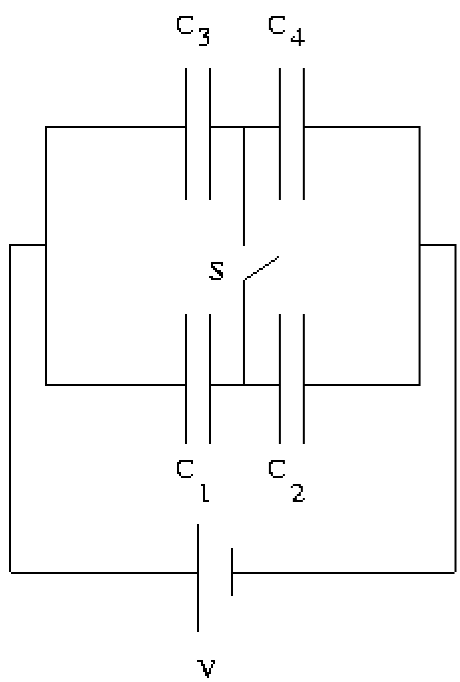
- **(15 points) [2]** *Purcell* Problem 3.6 (p.114): Line charge near a conducting plane.

- **(15 points) [3]** *Purcell* Problem 3.9 (p.115): Point charges and conducting plane.

- **(20 points) [4]** Image on a sphere.
  Find the image (location and magnitude) of a point charge of strength $+Q$ located at distance l from the center outside of a grounded conducting sphere. Assume the radius of the sphere is a (clearly, $a<l$). Prove that the potential on the sphere due to the charge $+Q$ and its image is indeed zero.

- **(15 points) [5]** *Purcell* Problem 3.23 (p.117): Cylindrical capacitor.

- **(15 points) [6]** Capacitors in Series and in Parallel.



- Derive an expression for the *equivalent* capacitance of two capacitorsC_1 and C_2 connected in series and in parallel (express in terms of C_1 and C_2).
- Assume capacitors C_1, C_2, C_3 and C_4 are connected as shown in the figure. What is their equivalent capacitance when the switch S is open (as shown)? Find the charge on each of the capacitor plates when the switch is open and when it is closed. Express all your answers in terms of C_1, C_2, C_3, C_4 and V

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