Conductors and Insulators, Conductors as Shields
Challenge Problems

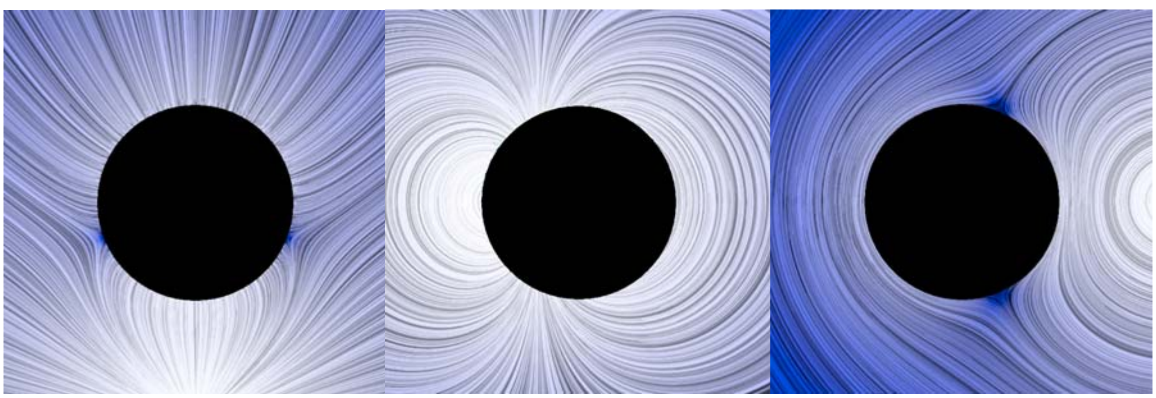
Problem 1:

Part of the lab this week involves shielding. We have a visualization to help you better understand this. Open it up:

http://web.mit.edu/viz/EM/visualizations/electrostatics/ChargingByInduction/shielding/shielding.htm

and play with it for a while. You can move the charge around the outside of the shield (or even inside) using the parameters “radius pc” and “angle pc.” You can change which field you are looking at – the total field, just the field of the external charge (“Free charge”) or just the field of the induced charge (on the shield). You can visualize it with grass seeds or display equipotential streaks by clicking “Electric Potential.”

Below are three captured images. I’ve blanked out the center so that you can’t see what is going on inside the conductor. For each describe where the charge is (ROUGH angle and distance), tell whether I am looking at field lines (grass seeds) or equipotential streaks (“Electric Potential”) and indicate whether I am doing so for the total field, or just the external or induced field. Also briefly explain HOW you know this (not just “I looked around until I was able to repeat the pattern”).



(a) (b) (c)

Problem 2:

Consider two nested, spherical conducting shells. The first has inner radius *a* and outer radius *b*. The second has inner radius *c* and outer radius *d*.

In the following four situations, determine the total charge on each of the faces of the conducting spheres (inner and outer for each), as well as the electric field and potential everywhere in space (as a function of distance *r* from the center of the spherical shells). In all cases the shells begin uncharged, and a charge is then instantly introduced somewhere.

(a) Both shells are floating – that is, their net charge will remain fixed. A positive charge +Q is introduced into the center of the inner spherical shell. Take the zero of potential to be at infinity.

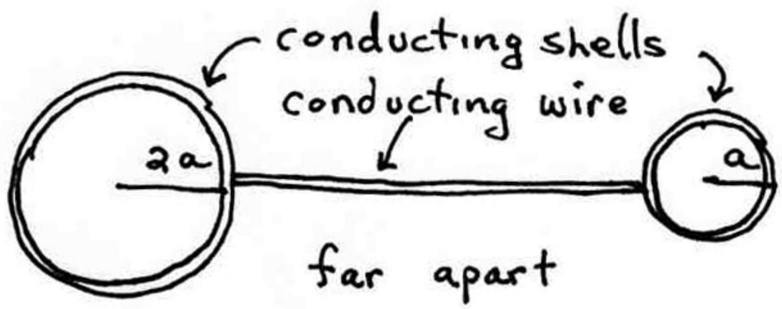
(b) The inner shell is floating but the outer shell is grounded – that is, it is fixed at V=0 and has whatever charge is necessary on it to maintain this potential. A negative charge –Q is introduced into the center of the inner spherical shell.

(c) The inner shell is grounded but the outer shell is floating. A positive charge +Q is introduced into the center of the inner spherical shell.

(d) Finally, the outer shell is grounded and the inner shell is floating. This time the positive charge +Q is introduced into the region in between the two shells. In this case the questions "What is **E**(r)/V(r)?" are not well defined in some regions of space. In the regions where these questions can be answered, answer them. In the regions where they can't be answered, explain why, and give as much information about the potential as possible (is it positive or negative, for example).

Problem 3:

A conducting wire is attached to an initially charged spherical conducting shell of radius $2a$. The other end of the wire is attached to the outer surface of a neutral conducting spherical shell of radius a that is located a very large distance away (at infinity). When electrostatic equilibrium is reached, the charge on the shell of radius $2a$ is equal to



a) one fourth the charge on the shell of radius a.
b) half the charge on the shell of radius a.
c) twice the charge on the shell of radius a.
d) four time the charge on the shell of radius a.
e) None of the above.

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