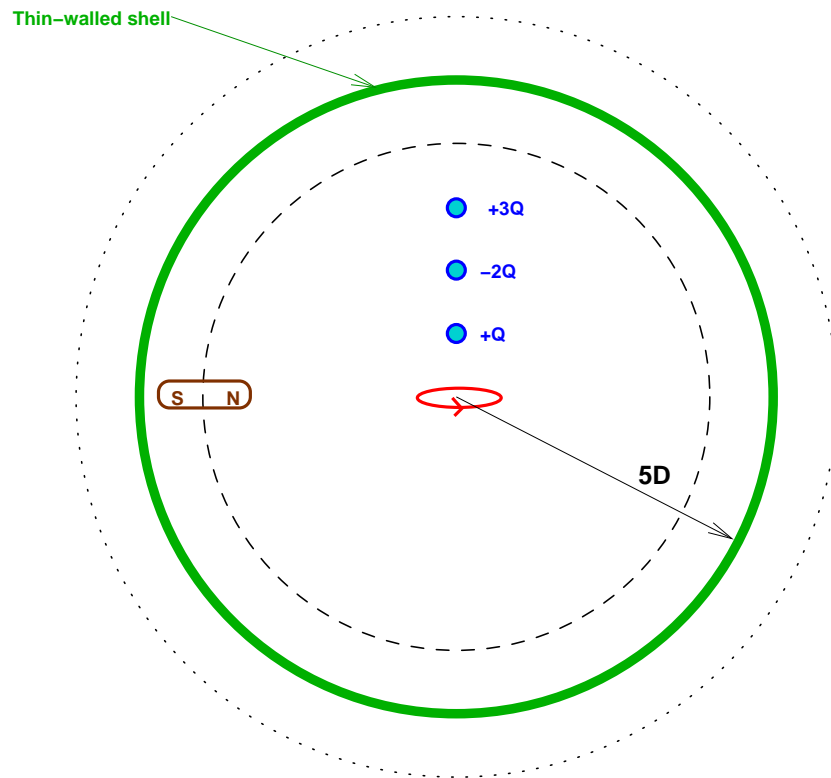


PHYS 122: – April 25, 2009

More Practice Problems:

These are mostly from last year's final exam. I'll post these now, solutions posted Sunday....

Problem PF1: Flux concept

A thin-walled electrically neutral conducting shell with given radius $R_{shell} = 5D$ encloses three point charges, one non-conducting permanent bar magnet, and one small current loop as shown above. The shell itself is *perfectly conducting*. The magnetic dipole moment associated with the current loop is given as μ_0 which is also precisely ten times greater than the dipole moment associated with the bar magnet. Assume that the above figure is drawn to scale so that the given point charges $+Q$, $-2Q$, and $+3Q$ are positioned at a given distances of D , $2D$, and $3D$ from the center of the sphere as shown. Assume that the current loop corresponds to a counter-clockwise rotation as seen from the above the sphere.

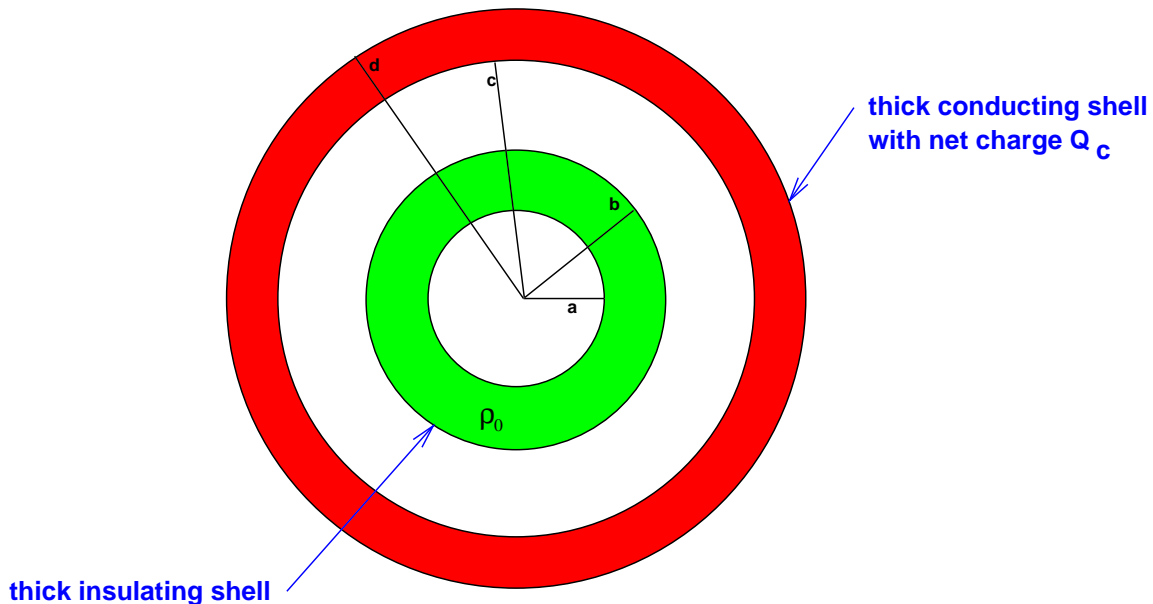
Part a) In terms of the parameters given, calculate the *total electric flux* through a concentric spherical surface that has a radius $\mathcal{R} = 4D$ (dashed circle). Explain your answer.

Part b) In terms of the parameters given, calculate the *total electric flux* through a concentric spherical surface that has a radius $\mathcal{R} = 6D$ (dotted circle). Explain your answer.

Part c) On the figure above, draw some *electric field lines* to indicate conceptually what the field in the region *outside* the conducting shell looks like. Is the field in this region spherically symmetric? Explain your work.

Part d) In terms of the parameters given, calculate the *total magnetic flux* through a concentric spherical surface that has a radius $\mathcal{R} = 4D$. Explain your answer.

Part e) Suppose we change the problem so that the perfectly conducting sphere shell is now replaced with a thin *perfectly insulating* spherical shell of the same size. How will this change your answers to parts (a), (b), and (c) above? Be specific. Explain your work.

Problem PF2: Spherical Shells

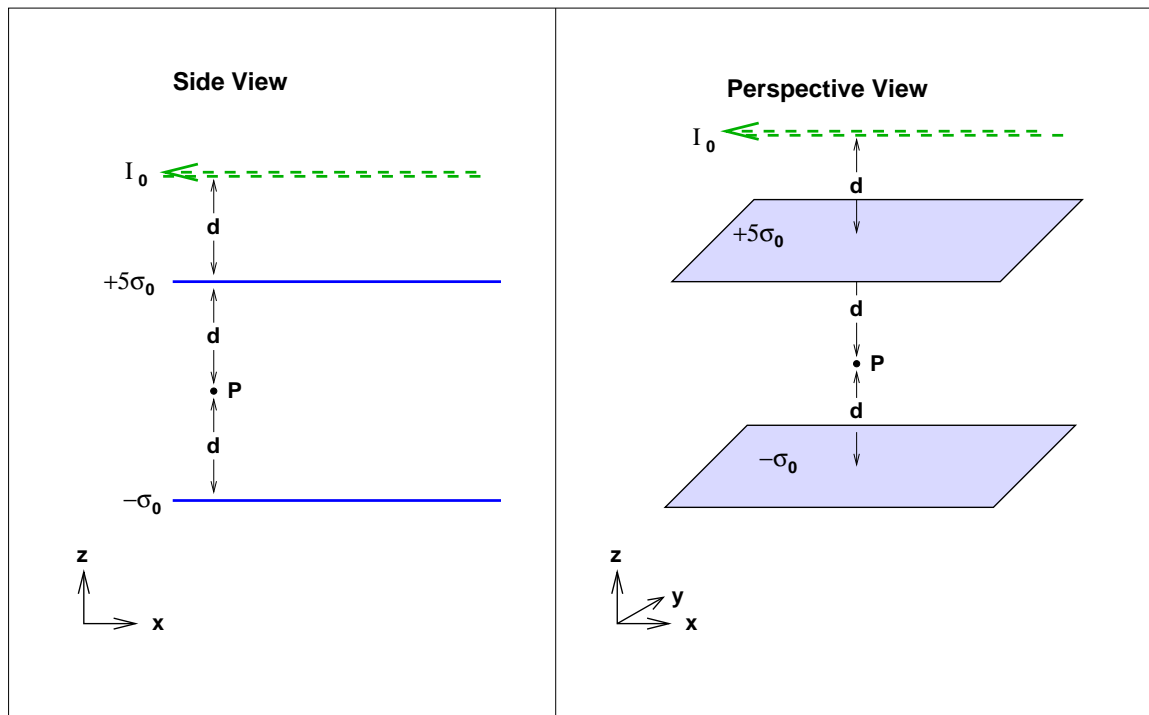
Two thick concentric spherical shells are placed as shown above. The inner shell is made of *perfectly insulating material*. The outer shell is made of *perfectly conducting material*. The inner radius of the insulating shell is a , the outer radius of the insulating shell is b , the inner radius of the conducting shell is c , the outer radius of the conducting shell is d .

Suppose we embed charge on the inner shell with a given uniform charge density ρ_0 . Suppose also that we place a given net charge of Q_c on the conducting shell.

Part a) In terms of ρ_0 , a , and b , what is the total net charge Q_i of the insulating shell? Explain your work.

Part b) Use Gauss' Law to determine the electric field *everywhere*. Note that the four radii divide all space into five regions. Clearly indicate the value of the electric field for each of the five regions. Explain your work.

Part c) What is the *surface charge density* on the both the inner and outer surfaces of the conducting sphere? Explain your work. Hint: to earn full credit here, you should invoke Gauss' Law and your answer should completely avoid these three words: "attract", "force", and "induced".

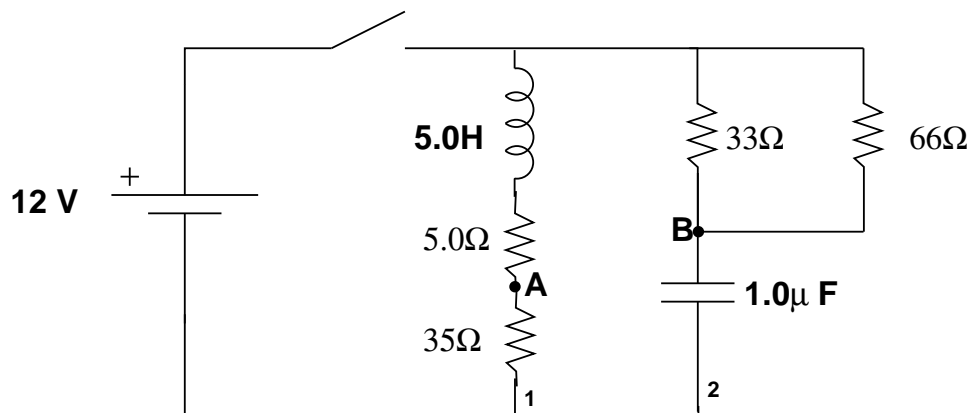
Problem PF3: Plates and Currents

The above plot shows an arrangement of two infinite charged plates. The upper plate has a given positive surface charge density $+5\sigma_0$ and the lower plate has a given negative surface charge density $-\sigma_0$. The separation between the plates is given as $2d$. Also, at a distance d above the upper plate is an infinite wire carrying a given current I_0 in the negative x -direction as shown.

Part a) Consider the point P which is located half-way between the plates. In terms of the given parameters, what is the *electric field* at point P ? Write down your answer as a *vector* using the coordinate system shown: x points right, y points back (into page) and z points up. Explain your work.

Part b) What is the *magnetic field* at point P ? Write down your answer as a *vector* using the coordinate system shown. Explain your work.

Part c) Now suppose a particle with a given mass m and a given negative charge $q = -q_0$ is placed at point P and is given an initial velocity $\vec{v} = v_0\hat{z}$. Is it possible to assign a positive value of the velocity v_0 that will allow the particle to move in a straight line without being deflected in any direction? *Here do not ignore gravity: Assume gravity results in a force on the particle downward, that is, in the $-\hat{k}$ direction.* If your answer is yes, then what is this value of v_0 in terms of the parameters given? If your answer is no, explain why not? Explain your work.

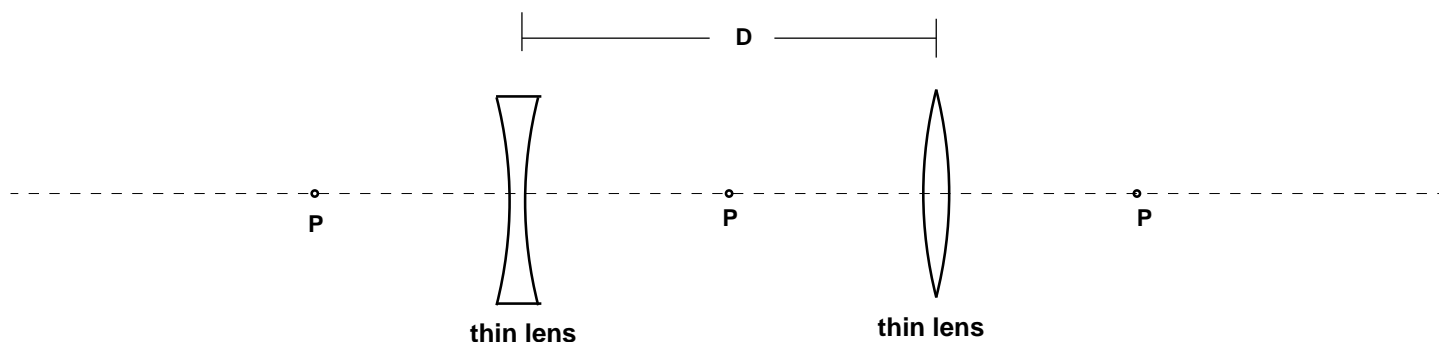
Problem PF4:

A circuit is assembled as shown above. The inductor has a value $L = 5.0$ henrys. The capacitor has a value of 1.0 micro-farads. The values of five resistors are shown above. The circuit is attached to a sturdy 12 volt battery as shown and then the switch is closed.

Part a) What is the current through the inductor *immediately* after the switch is closed? Explain how you know this.

Part b) What is the approximate voltage measured at point B relative to point A at a time 10 seconds after the switch is closed? Give your answer in volts. Explain.

Part c) What is the approximate current through the voltage source when measured at a time 0.10 seconds after the switch is closed? Give your answer in amps. Explain.

Problem PF5: Optics

Two thin lenses are positioned as shown above. The distance between the two lenses is given as D . The left lens is *concave* and the right lens is *convex*. Each lens has the same given focal length f . You also know that D is precisely twice the focal length f . Primary and secondary focal points are drawn to scale above.

In this problem the *left* lens creates an image of the *right* lens, and the *right* lens creates an image of the *left* lens.

Part (a) – Determine the position of each of the two images using the lens equation.

Part (b) – Verify your result to part (a) by using ray tracing for at least two principle rays for each image.

Part (c) – Also calculate the magnification for each image, and for each of the two images, determine if the image is *real* or *virtual* and whether or not the image is *inverted*. Explain your work here.

Problem PF6: Maxwell's Revenge

Suppose an electric potential function is defined within some arbitrary region as a position of both time and space in accordance with the following parametrization:

$$V(x, y, z, t) = Axyz^2e^{-\left(\frac{t}{\tau}\right)} + Bzt^{-\alpha} + C \cos(\omega t)$$

Here, A , B , C , α , τ and ω are given positive constants with the appropriate units.

Part (a) Determine the Electric Field as a function of position and time. Explain how you got your answer. Hint: Don't forget, the electric field is a *vector*.

Part (b) Suppose we define a *loop* which is a flat square that bounds a unit area on the x-y plane. The four corners of the square in Cartesian coordinates (x, y, z) are therefore $(0, 0, 0)$, $(1, 0, 0)$, $(1, 1, 0)$, and $(0, 1, 0)$. In terms of the given parameters, what is the *path integral* of the magnetic field integrated around this loop? Explain your answer.