PHYS 122: Homework #04

February 8, 2009

Homework #04 is due in Box outside of Rock 207: 5:00 PM Sharp, Monday, February 16, 2009

Announcements:

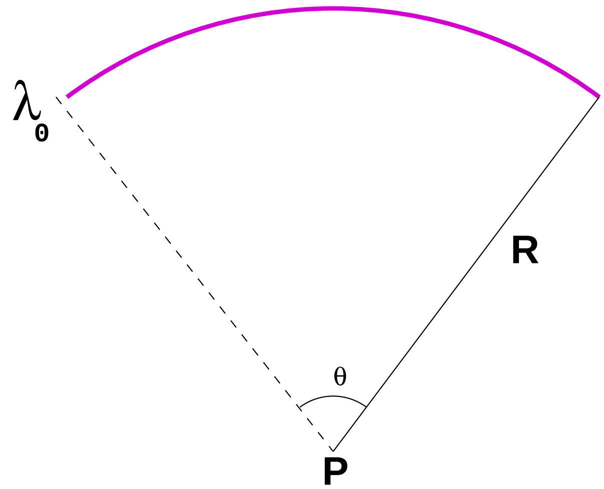
- Mr. Covault's Office Hours will generally be Mondays: 11 AM to noon and 1:30 PM to 4:00 PM, Thursdays: 1:15 PM to 2:30 PM and 3 PM to 4 PM, and Fridays: 10:45 AM to 12:15 PM.
- The Second Hour Exam (worth **10** percent of your grade) will be given Friday, March 6, **9:30 AM** in lecture. This is the last day of classes before spring break. Please plan your travel accordingly.
- The First Hour Exam is being graded and I expect it will be available to students by Friday. No promises, though.
- Don't forget: Odd labs this week.

Homework Assignment continues next page....

This homework due in Box outside of Rock 207:
5:00 PM Sharp, Monday, February 16, 2009

Problem 1.

A curved rod of linear charge density λ_0 has the shape of a circular arc of radius R. The rod subtends an angle θ as indicated below. Calculate the magnitude of the electric field at the position corresponding to point P at the center of the circular radius.



Note that the **only** way to work this problem is by direct integration of the Coulomb's Law in differential form. Note also that symmetry and some trigonometry are helpful in this calculation. This is an example of a problem that *cannot* be solved by Gauss' Law, where you *must* use the integration of Coulomb's Law to find the E-field.

Problem 2.

Consider four point charges as follows:

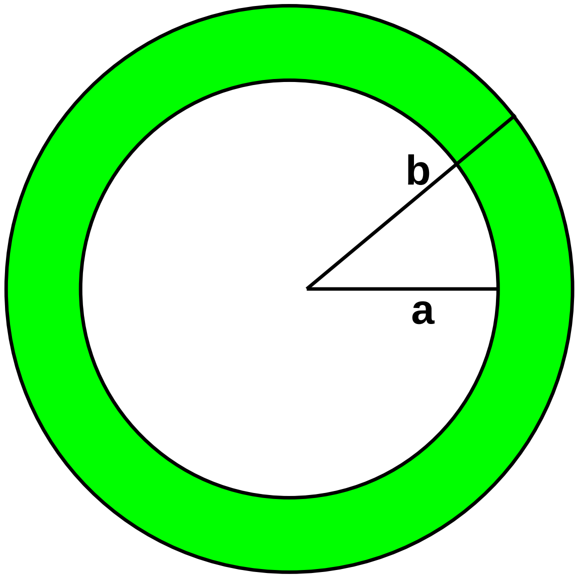
- a $+1.00\mu$C charge located 70 mm from point P.
- a -2.00μC charge located 120 mm from point P.
- a $+3.00\mu$C charge located 135 mm from point P.
- a -4.00μC charge located 215 mm from point P.

Draw a **sketch** to indicate some particular arrangement of charges that corresponds to this. The arrangement is entirely up to you. Now, consider a spherical surface of radius 210 mm centered on point P.

Part (a): Given your particular arrangement is it possible to use Gauss' Law calculate the the *total flux* of the electric field vector through the closed spherical surface? If so, calculate it. If not, explain why not.

Part (b): Given your particular arrangement is it possible to use Gauss' Law calculate the the *Electric Field* everywhere on the closed surface? If so, calculate it. If not, explain why not.

Problem 3:



A shell of insulating material with inner radius a and outer radius b as show above is embedded with a uniformly distributed positive charge. The total charge of the shell is $+Q_0$.

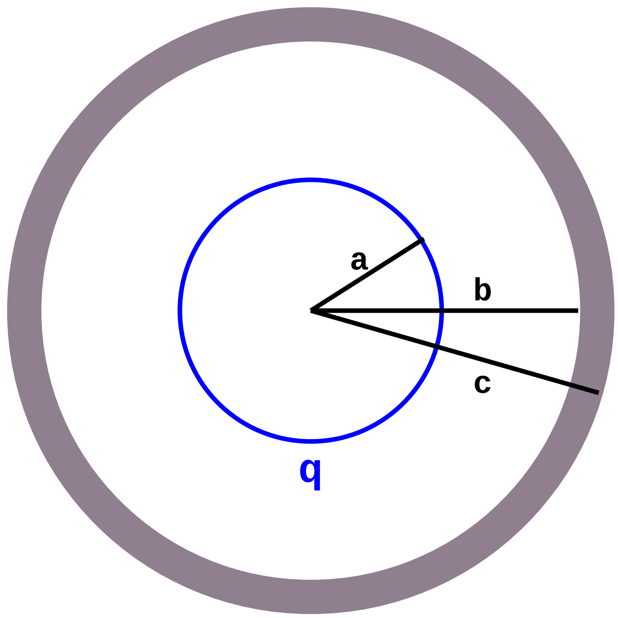
a) Using Gauss' Law, calculate the electric field everywhere.

c) Determine the electric potential (voltage) everywhere. Here, use the position at infinity as the zero-point reference.

Problem 4:

Consider the following spherically symmetric arrangement consisting of two concentric parts:

- A very thin-walled spherical shell of insulating material has a radius radius a, upon which is a given charge of $+q$ is evenly deposited.
- A neutral shell of conducting material has an inner radius of b and an outer radius of c.



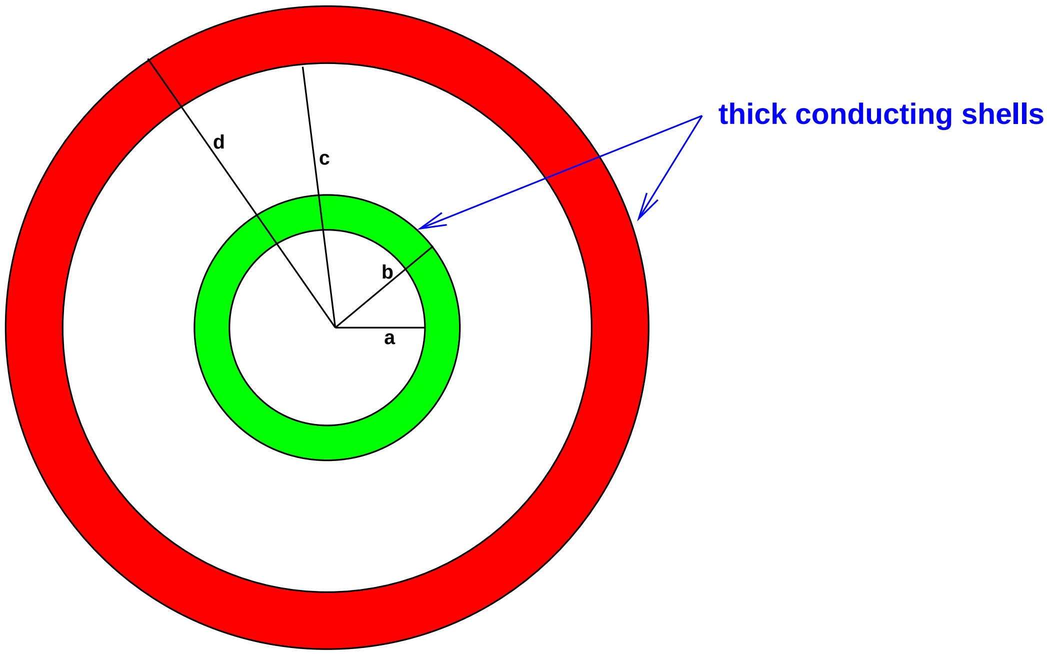
a) Using Gauss' Law, calculate the electric field everywhere.

b) What is the **surface charge density** on the inside and outside surface of the conducting shell?

c) Determine the electric potential (voltage) everywhere. Here, use the position at infinity as the zero-point reference.

(d) (e) and (f) What happens to your answers for parts (a) (b) and (c) if we change the problem so that the conducting shell in not neutral but instead is given a net charge of $-5q$?

Problem 5: This straight from an exam:



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

Suppose we place a net charge of $+Q_0$ on the inner conductor and a net charge of $-Q_0$ on the outer conductor.

a) What is the electric field *everywhere*. Note that the four radii divide all space into five regions. Clearly indicate the field for each of the five regions. Explain your work.

b) Define σ_a as the surface charge density on the inner surface of the inner conductor, σ_b the surface charge density on the outer surface of the inner conductor, etc. Determine the values of all four surface charge densities σ_a, σ_b, σ_c, and σ_d. Explain your work.

c) If we define the voltage "zero point reference" at the *inner radius of the inner conducting shell*, what is the value of the voltage (also called the electric potential) as a function of radius everywhere?

Problem 6. This one's a little harder: Suppose you are given the following specification for the electric potential as a function of radial position r within some volume out to a radius of R as

$$V(r) = \frac{V_0 r^4}{R^4}$$

a) What is the electric field that corresponds to this potential? Hint: Remember that to get voltage from the field you need to integrate. Now you want the field from the voltage.

b) Suppose $\rho(r)$ represents the charge density function (charge per unit volume). Determine $\rho(r)$ from your answer to part (a). Hint: you will want to apply Gauss' Law to do this problem.