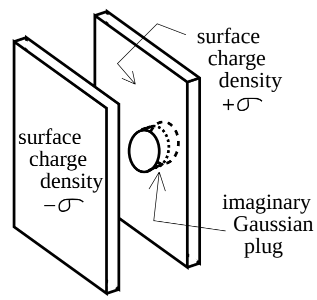
Gauss's Law -- Conceptual Questions

1.) A electric charge exists outside a balloon. The net electric flux through the balloon is zero. Why?

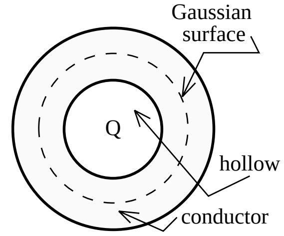
2.) A point charge Q is placed off-center inside a sphere. What is the electric flux passing through the sphere?

3.) If you use Gauss's Law to determine the electric field between two parallel, infinitely large (well, big anyway), oppositely charged plates, the electric field function you will derive is σ/ε_o, where σ is the area charge density on the inside surface of the plate (i.e., in the region where the Gaussian plug intersects the plate face). That is, the electric field is a constant--it doesn't change as you travel from one plate to the other. What is unsettling about all this is that the derivation seems to completely ignore the plate that *isn't* involved with the Gaussian surface. After all, says Gauss, the only charge that matters is the charge *inside* the Gaussian surface. In fact, I claim the charge on the second plate *does* have something to do with the problem. Your thrill is to justify my assertion.



4.) In static electric situations, why must the electric field inside a conductor always equal zero?

5.) Consider a hollow, electrically neutral, thick skinned, conducting sphere of inside radius a and outside radius b. At the center of the hollow exists a charge -Q. If you construct an imaginary Gaussian sphere whose radius falls somewhere between a and b, the apparent presence of a net charge inside the Gaussian surface suggests that there must be an electric field on the Gaussian surface inside the conductor. The problem is that in static electric situations, a conductor is supposed to have *no electric field* inside it. How can you reconcile these two seemingly disparate observations?



6.) Assume you have a spherically symmetric charge configuration that produces an electric field at some point in the vicinity of the configuration. You draw a Gaussian surface that includes the point. You find that at every point on the Gaussian surface, the magnitude of the electric field is the same.

a.) What do you know about the surface?

b.) Let's assume that you aren't sure whether the electric field passing through your Gaussian surface is oriented inward or outward. How do you deal with Gauss's Law in this situation? That is:

i.) How do you deal with the *dot product* found on the left side of the Gauss's Law relationship?

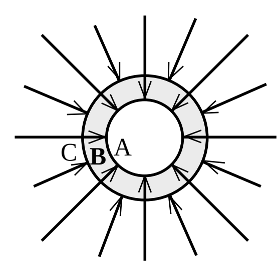
ii.) How do you deal with the *charge enclosed* term found on the right side of Gauss's Law?

7.) Assume you have a cylindrically symmetric charge configuration that produces an electric field at some point in the vicinity of the configuration. You draw an appropriate Gaussian surface. From what you know about Gauss's Law:

a.) What shape must that surface take?

b.) Is there a place on the Gaussian surface where the electric field is zero? If not, is there a place where the dot product between E and dS is zero? Explain.

8.) To the right is a cut-away cross-section of a thick-skinned sphere. The lines shown are electric field lines.

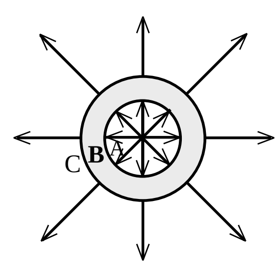


a.) Using what you know about Gauss's Law, what can you tell me about *area A*.

b.) Using what you know about Gauss's Law, what can you tell me about *area B*.

c.) Using what you know about Gauss's Law, what can you tell me about *area C*.

9.) To the right is a cut-away cross-section of a hollow pipe. The lines shown are electric field lines.



a.) Using what you know about Gauss's Law, what can you tell me about *area A*.

b.) Using what you know about Gauss's Law, what can you tell me about *area B*.

c.) Using what you know about Gauss's Law, what can you tell me about *area C*.

10.) A hollow, thick skinned, spherical shell has an inside radius of a and outside radius of b. Inside the shell exists a volume charge density $-kr$, where $k = 1$ with the appropriate units. On the shell's surface exists a surface charge density that is positive. The total free charge inside the sphere is *less than* the total free charge on the surface.

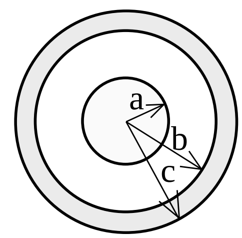
a.) What are k's units?

b.) Make a ten-second sketch of the general shape of $E(r)$ for this charge configuration. (Hint: Do this in sections--that is, think about what's going on for $r < a$, then for $a < r < b$, etc.)

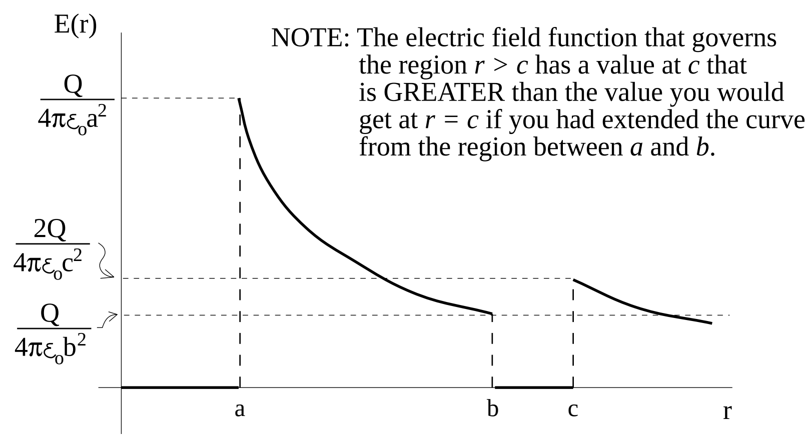
11.) A hollow pipe has an inside radius of a and an outside radius of b. Between a and b, the volume charge density is $-kr$, where $k = 1$ with the appropriate units.

a.) What are k's units?

b.) Make a ten-second sketch of the general shape of $E(r)$ for this charge configuration.

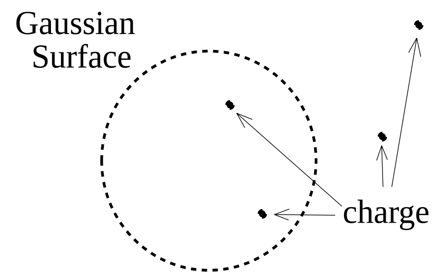


12.) An old AP test problem created the following scenario. *A charge Q is placed on a conducting sphere of radius a. Outside the sphere is a conducting shell of inside radius b and outside radius c (as shown) which also has a charge Q placed on it. Generate the graph of E(r).* The correct graph is shown. What is interesting is that AP graders took off points (or, more accurately, didn't give all the points possible) if the electric field evaluated at $r = c$ wasn't BIGGER than the value the field would have had if the electric field function for the $a < r < b$ region was extended out to $r > c$. My question to you is, *given the problem as stated, what were they thinking?* That is, what assumption would *you* have to



make *that wasn't stated in the problem* that would lead you to conclude that finding?

14.) Assume you have four charges scattered indiscriminately in space. You create an imaginary Gaussian surface so that two of the charges are inside the surface and the other two are outside the surface. According to Gauss's Law, the net electric flux through the surface is due solely to the charge enclosed inside the surface.



a.) Don't the charges outside the surface contribute to the electric field on the Gaussian surface?

b.) If the answer to *Part a* is *yes*, how can Gauss's Law ignore the charge outside the Gaussian surface?

15.) Assume you have a solid sphere of radius a in which charge is distributed uniformly throughout the volume. You create an imaginary Gaussian surface, symmetrically centered, such that its radius is $r < a$ (i.e., it's inside the sphere). According to Gauss's Law, the electric flux through the surface is due solely to the charge enclosed inside the Gaussian surface.

a.) Don't the charges outside the surface contribute to the electric field on the Gaussian surface? If so, how can Gauss ignore them?

b.) As far as Gauss's Law goes, how is this situation different from the four-charge situation alluded to at the beginning of *Problem 14*?

16.) A hollow ball has a charge filled, insulating material coating its outside surface (see sketch). A single point charge Q sits outside the complex somewhere along the *x axis*. Eva maintains that there is an electric field on the *x axis* INSIDE THE HOLLOW of the ball. Gunther say not. He puts a Gaussian sphere inside the hollow, observes that the charge enclosed is zero (this is true), observes that the electric flux through the surface is zero (this is also true), and deduces that the electric field on the surface must be zero. It turns out that this last deduction is wrong (i.e., Eva was right), but Gunther's argument still seem persuasive. What is he missing?