APPC, E & M: Unit A HW 4

Name: _____
Hr: ____ Due at beg of hr on: _____

UA, HW4, P1
Reference Video: "Gauss's Law Basics"
YouTube, lasseviren1, GAUSS'S LAW playlist

A. Write the equation for Gauss's law. Be sure to include the symbol in the equation that indicates that the integral must be taken over a closed surface.

Your goal now is to find an expression for the electric field E at a distance R away (in any direction) from a point charge q, in the following way…

B. In the space at right, draw a (–) point charge. Label it q.

C. Draw correct electric field lines, with arrows, in the vicinity of the charge.

D. In reality, what shape of Gaussian surface should be (mentally) constructed around this charge, in order to achieve your goal here?

E. In your drawing, represent the Gaussian surface you mentioned in Part D.

F. Now, achieve the goal stated prior to Part B. Begin by writing again the equation from Part A, then show your work and, finally, represent your answer in two different forms, one that has the symbols π and ε_0, and the other that has the symbol k.

G. Can you find the mistake that the narrator makes in this video? State here what he says and then state what he should have said.

UA, HW4, P2
Reference Video: "Gauss's Law (Part II)"
YouTube, lasseviren1, GAUSS'S LAW playlist

A. The figure shows a very long line of (+) charge. What is the name of the variable λ ?

B. What are the units on the variable λ ?

C. Here, we want an expression for the electric field *E* at a radial distance *R* outward from the centerline of the line of charge. What shape of Gaussian surface do we need?

D. In the figure, draw in the Gaussian surface you mentioned in Part C; make it have a height *h*, and label what *R* is.

E. Through which part(s) of the Gaussian surface is/are there…

i…zero flux Φ_E? ii…nonzero flux Φ_E?

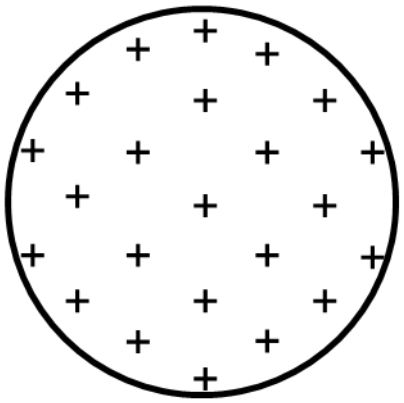
F. Now, use Gauss's law to solve the problem. Start by rewriting the equation from Part A of Problem 1 of this HW set, and then show your work.

G. To the right, make a graph of the electric field *E* vs. the radial distance *r* away from the centerline of charge. Above-and-to-the-right of the curve, indicate how the *E* field relates to *r*, i.e., you need to write $E \propto ?$. Hint: The only variable in the ? is some variation of *r*, such as…r, r^2, $\frac{1}{r}$, $\frac{1}{r^2}$, etc.

UA, HW4, P3

Reference Video: "Using Gauss's Law to Find the Electric Field for a Nonconducting Sphere" YouTube, lasseviren1, GAUSS'S LAW playlist

A. The figure shows an insulating sphere of radius R with (+) charge embedded evenly throughout. What is the name of the variable ρ?



B. What are the units on the variable ρ?

C. In this problem, we want an expression for the electric field E at a radial distance $^2/_3\ R$ from the center of the sphere. What shape of Gaussian surface do we need?

D. In the figure, as best you can, draw in the Gaussian surface you mentioned in Part C; make it have a radius of $^2/_3\ R$.

E. Use Gauss's law to find the magnitude of the E field at a distance of of $^2/_3\ R$ from the sphere's center. Start by writing the closed-integral form of the Gauss's law equation, then show your work.

F. With reference to the video, make a graph of E vs. r for the case of the sphere with a uniform charge distribution. On the x-axis, specify the location where $r = R$. Also, above the two distinct portions of the curve (one for $r < R$ and one for $r > R$), indicate how the electric field E varies with r. (If you are confused about this, see the explanation in Part G of Problem 2 of this HW set.)

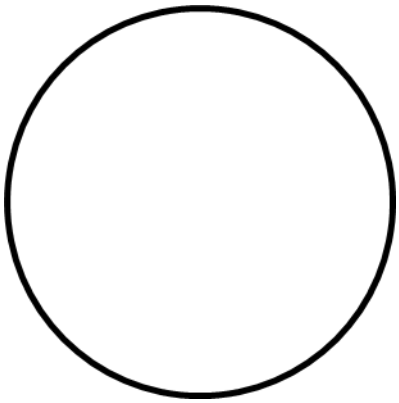
UA, HW4, P4
Reference Video: "Conductors in Electrostatic Equilibrium"
YouTube, lasseviren1, GAUSS'S LAW playlist

A. In conductors, what particles are free to roam throughout the material? Be specific.

B. In terms of what electric charges are doing, "electrostatic equilibrium" means what?

C. Electrostatic equilibrium means that the object has zero net charge. TRUE FALSE

D. Within the volume of any conductor in electrostatic equilibrium, what is the magnitude of the electric field?



We will now prove to you that your answer to Part D is necessarily and inextricably related to the fact that any excess charge resides on the outermost surface of a conductor in electrostatic equilibrium.

E. The sphere in the figure is positively charged.
Draw several (+) signs at the sphere's surface.

F. As close to the surface as you can, use a dashed line to draw a Gaussian sphere, just below the surface of the sphere shown. Label your Gaussian sphere as having a radius of "$< R$", which means that your Gaussian sphere has a radius that is just barely, BARELY less than R.

Now, Gauss's law… $\frac{q_{enc}}{\varepsilon_o} = \oint \vec{E} \cdot \overrightarrow{dA}$ …becomes… $\frac{q_{enc}}{\varepsilon_o} = E\, A_{\substack{Gaussian \\ surface}}$ …or, here… $\frac{q_{enc}}{\varepsilon_o} = E\, 4\pi(< R)^2$.

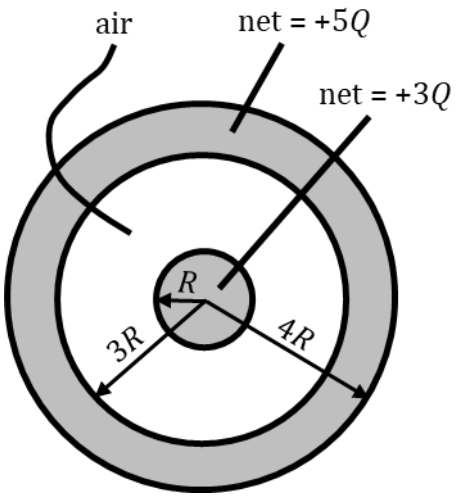
G. For our case – if, indeed, all excess charge resides on the outer surface – then q_{enc} is _____, which means that the left side of Gauss's law is _____.

H. What, then, do your answers to Part G tell you HAS TO BE TRUE about the right side of Gauss's law? Again, be specific.

I. Let's wrap this up by summarizing…Thus, we see that, for any conductor in electrostatic equilibrium, it must be true that, within the conductor, the E field is _____ and that any excess charge must reside…where?

UA, HW4, P5
Reference Video: "Gauss's Law and Concentric Spherical Shells (Part I)"
YouTube, lasseviren1, GAUSS'S LAW playlist

A solid metal sphere of radius R is separated by an air space from a solid metal shell of inner radius $3R$ and outer radius $4R$. There is a total net charge of $+3Q$ on the innermost sphere and a total net charge of $+5Q$ on the outer shell. See the figure at right.



A. How is the $+3Q$ of charge distributed on the inner sphere? Be specific.

B. Easy question: What is the E field for distances $r < R$?

C. Use Gauss's law to determine an expression for the E field for $R < r < 3R$.

D. Another easy one: What is the E field for distances $3R < r < 4R$?

E. Hopefully, you were able to answer Part D without using Gauss's law, but go ahead now and sketch into the above figure a Gaussian surface somewhere between $3R$ and $4R$.

F. Now, based on your answer to Part D, what must the q_{enc} be, for the Gaussian surface you drew in Part E?

G. Based on your answer to Part F, as well as the known net charge on the innermost sphere, you should now be able to figure out the net charge (both magnitude and sign) that must reside on the inner surface of the metal shell. Write that amount of charge here.

H. Finally, taking into account your answer to Part G, as well as the known net charge on the outer metal shell, you should now be able to figure out the net charge (both magnitude and sign) that must reside on the outer surface of the metal shell. Write that amount of charge here.