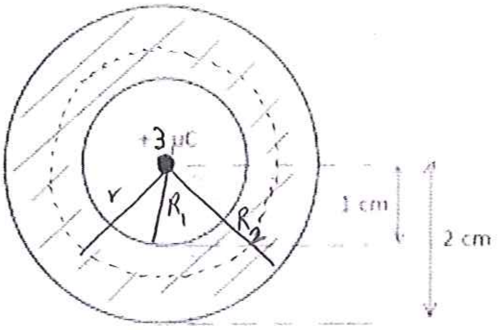
PHYS 102: General Physics - KOÇ UNIVERSITY
College of Sciences
Quiz 2 Oct 14, 2016

Closed book. No calculators are to be used for this quiz.
Quiz duration: 15 minutes
Name: Student ID: Signature:

$$k \simeq 9 \times 10^9 Nm^2/C^2$$
$$\epsilon_0 \simeq 9 \times 10^{-12} C^2/Nm^2$$
$$\pi \simeq 3$$

Q. A neutral hollow spherical conducting shell of inner radius 1.0 cm and outer radius 2.0 cm has a 3.0 μC point charge placed at its center. Find the surface charge density on the inner surface of the shell (show your work).

Hint: Use Gauss's Law with a Gauss surface *inside* the conducting shell.



Gauss's Law $\oint E.dA = \frac{q}{\varepsilon_0}$

$$E.4\pi r^2 = \frac{q}{\varepsilon_0} \Rightarrow \begin{cases} r < R_1 : & E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2} \\ R_1 < r < R_2 : & E = 0 \\ r > R_2 : & E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2} \end{cases}$$

at $r = R_1$, $-q$ charge distributed on the inner surface.

$$\text{Density } \sigma = \frac{Q}{A} = -\frac{q}{4\pi R_1^2} = -\frac{3\times10^{-6}}{4\times3\times(1\times10^{-2})^2} = -0.25\times10^{-2}\ \frac{C}{m^2}$$

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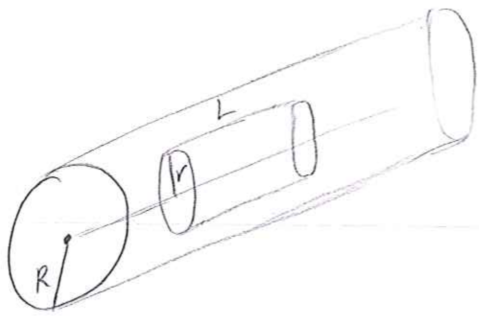
Q. An infinitely long nonconducting *cylinder* of radius R carries a uniform volume charge density ρ (units: C/m^3). Calculate the electric field magnitude at distance $R/2$ from the axis of the cylinder.

Gauss's law $\oint \vec{E}\cdot d\vec{A} = \frac{q}{\varepsilon_0}$



$q = \rho A = \rho \pi r^2 L$

$\Rightarrow E \cdot 2\pi r L = \frac{\rho \pi r^2 L}{\varepsilon_0}$

$\Rightarrow E = \frac{\rho r}{2\varepsilon_0}$

at $r = \frac{R}{2} \Rightarrow E = \frac{\rho R}{4\varepsilon_0}$

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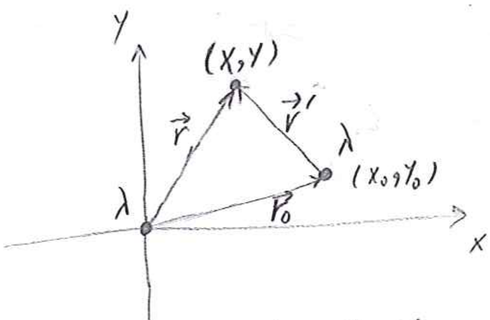
Q. The electric field on the xy-plane of an infinitely long, uniformly charged wire along the z-axis is

$$\vec{E} = \frac{\lambda}{2\pi\epsilon_0 r}\hat{r}.$$

where λ is the line charge density and $\vec{r} = (x, y)$. What is the electric field at $\vec{r}$ if a second wire parallel and identical to the first one, passing through the point $\vec{r}_0 = (x_0, y_0)$ is added?

first wire $\vec{E}_1 = \frac{\lambda}{2\pi\varepsilon_0 r}\hat{r}$

second wire $\vec{E}_2 = \frac{\lambda}{2\pi\varepsilon_0 r'}\hat{r}'$



$\vec{r}' = \vec{r} - \vec{r}_0$

$$\vec{E} = \vec{E}_1 + \vec{E}_2 = \frac{\lambda}{2\pi\varepsilon_0}\left(\frac{\hat{r}}{r} + \frac{\hat{r}'}{r'}\right)$$

where $\vec{r} = (x, y)$, $r' = (x - x_0, y - y_0)$

$$\Rightarrow \vec{E} = \frac{\lambda}{2\pi\varepsilon_0}\left(\frac{\vec{r}}{|\vec{r}|^2} + \frac{\vec{r} - \vec{r}_0}{|\vec{r} - \vec{r}_0|^2}\right)$$

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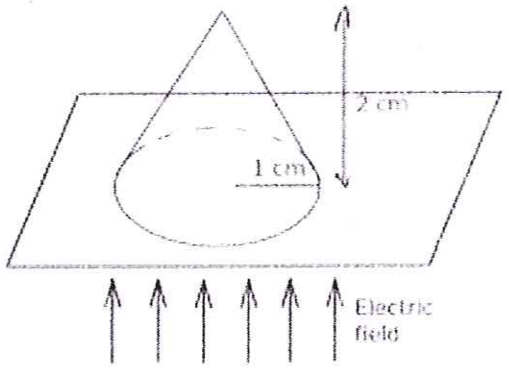
Q. A cone is resting on a tabletop as shown in the figure with its face horizonal. The radius of the cone's circular base is 1.0 cm. and its height is 2.0 cm. A uniform electric field of magnitude 4.0×10^3 N/C points vertically upward. How much electric flux passes through the sloping side surface area of the cone?

Hint: Use Gauss's Law by considering the side surface and the base of the cone together as a closed Gauss surface.



Gauss's law ⇒ Total flux through the cone is zero

Total flux = flux through the flat surface
+ flux through the sloping surface = 0

⇒ $flux_{flat\ surface} = flux_{sloping\ surface}$

$$\Rightarrow \Phi_{sloping} = E \cdot A_{flat} = 4 \times 10^3 \times 3 \times (1 \times 10^{-2})^2 = 1.2 \ \frac{N \cdot m^2}{C}$$

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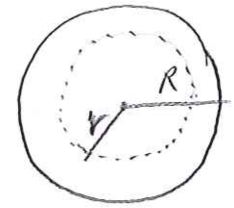
Q. A solid nonconducting sphere of radius R carries a uniform charge density throughout its *volume*. At a radial distance $r_1 = R/4$ from the center, the electric field has magnitude E_0. What is the magnitude of the electric field at a radial distance $r_2 = 2R$? Give your answer in terms of E_0.

Hint: The electric field strength *inside* the sphere is linearly dependent on the distance from the center.

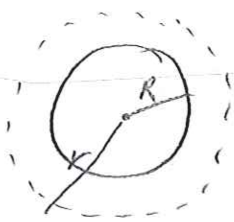
$$\oint E.dA = \frac{q}{\varepsilon} \Rightarrow E.\,4\pi r^2 = \frac{Q\, r^3/R^3}{\varepsilon_0}$$



$$r < R \Rightarrow E = \frac{1}{4\pi\varepsilon}\frac{Qr}{R^3}$$

$$q = Q\frac{r^3}{R^3}$$

$$\text{at } r = r_1 = \frac{R}{4} \Rightarrow E_0 = \frac{1}{4\pi\varepsilon}\frac{Q}{4R^2}$$



$$E.A = \frac{Q}{\varepsilon_0} \Rightarrow E.\,4\pi r^2 = \frac{Q}{\varepsilon}$$

$$r > R \Rightarrow E = \frac{1}{4\pi\varepsilon}\frac{Q}{r^2}$$

$$\text{at } r_2 = 2R \Rightarrow E = \frac{1}{4\pi\varepsilon}\frac{Q}{4R^2} = E_0$$