Name: _____

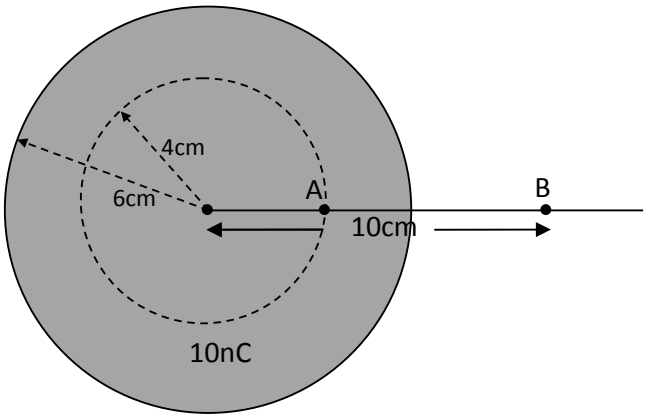
P PHY 232 Summer 2015 Class Work

Class 2. Coulomb's Law for extensive charge

But this class work is still in the use of Gauss's Law.

Given $\varepsilon_0 = 8.8542\times10^{-12}\ \mathrm{C^2m^{-2}N^{-1}}$ and $\dfrac{1}{4\pi\varepsilon_0} = 8.9876\times10^{9}\ \mathrm{C^{-2}m^2N^1}$.

Consider a *solid* sphere of 6cm in radius. It is *uniformly charged* to a total charge of 10nC.



(a) Calculate the charge density, in $\mathrm{Cm^{-3}}$, of the inner sphere.

$$\rho = \frac{\mathrm{C}}{\mathrm{V}} = \frac{\mathrm{C}}{\frac{4}{3}\pi\mathrm{R}^3}$$

$$= \frac{10\times10^{-9}}{\frac{4}{3}\pi\times(0.06)^3}$$

$$= \underline{\underline{1.105\times10^{-5}\ \mathrm{C/m^3}}}$$

(b) Calculate the charge enclosed by a 4cm concentric sphere (dotted line).

$$\mathrm{Q} = \rho\mathrm{V} = 1.105\times10^{-5}\times\frac{4}{3}\pi\times(0.04)^3$$

$$= \underline{\underline{2.962\times10^{-9}\ \mathrm{C}}}$$

(c) Calculatge the electric field at point A.

$$\varepsilon_0\Phi_{\mathrm{E}} = \mathrm{Q}_{\mathrm{enclosed}} \Rightarrow \varepsilon_0\cdot4\pi\,\mathrm{r}^2\mathrm{E} = \mathrm{Q}_{\mathrm{enclosed}} \Rightarrow \varepsilon_0\cdot4\pi\,\mathrm{r}^2\mathrm{E} = \mathrm{Q}_{\mathrm{enclosed}}$$

$$\Rightarrow \mathrm{E} = \frac{1}{4\pi\varepsilon_0}\frac{\mathrm{Q}_{\mathrm{enclosed}}}{\mathrm{r}^2}$$

with $\mathrm{Q}_{\mathrm{enclosed}} = 2.962\times10^{-9}\ \mathrm{C}$ (from psart (b))

$$\therefore\ \mathrm{E} = \frac{1}{4\pi\times8.854\times10^{-12}}\cdot\frac{2.962\times10^{-9}}{(0.04)^2} = \underline{\underline{1.66\times10^{4}\ \mathrm{N/C}}}$$

Direction: Radially outward (will repel a postive test charge).

(d) Calculate the electric field at point B by using Gauss's Law.

$$\varepsilon_0 \Phi_E = Q_{enclosed} \Rightarrow \varepsilon_0 \cdot 4\pi r^2 E = Q_{enclosed} \Rightarrow \varepsilon_0 \cdot 4\pi r^2 E = Q_{enclosed}$$

$$\Rightarrow E = \frac{1}{4\pi\varepsilon_0}\frac{Q_{enclosed}}{r^2}$$

with $Q_{enclosed}$ = charge of the whole sphere

$$\therefore E = \frac{1}{4\pi \times 8.854 \times 10^{-12}} \cdot \frac{(10 \times 10^{-9})(1 \times 10^{-6})}{(0.1)^2} = \underline{\underline{8.99 \times 10^3 \text{ N/C}}}$$

Direction: Radially outward (will repel a postive test charge).