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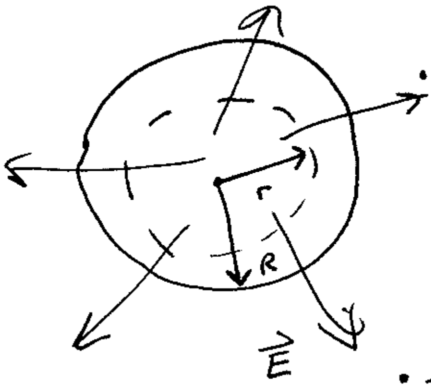
QUIZ 2

Use Gauss's law to find the electric field $\vec{E}(r<R)$ inside a uniformly charged sphere (radius R, total charge Q, charge density ρ). Verify at the surface ($r=R$), $\vec{E}(R)$ is the same as that of a point charge.

$$A_{sphere} = 4\pi r^2 \qquad V_{sphere} = \frac{4}{3}\pi r^3$$

• use a gaussian surface with radius $r<R$



• first, find charge density of entire sphere

$$\rho = \frac{Q_{total}}{V_{total}} = \left(\frac{Q}{\frac{4}{3}\pi R^3}\right)$$

• for our gaussian sphere

$$Q_{inside} = \rho V_{inside} = \rho\left(\tfrac{4}{3}\pi r^3\right) = \left(\frac{Q}{\frac{4}{3}\pi R^3}\right)\left(\tfrac{4}{3}\pi r^3\right)$$

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

and $A = 4\pi r^2$

Gauss's Law: $EA = \dfrac{Q_{inside}}{\epsilon_0}$

$$E(4\pi r^2) = \frac{Q}{\epsilon_0}\frac{r^3}{R^3}$$

$$E = \frac{Q}{4\pi\epsilon_0}\frac{r}{R^3}$$

we know this is radially outward $\Rightarrow$ $\boxed{\vec{E} = \frac{Q}{4\pi\epsilon_0}\frac{r}{R^3}\hat{r}}$

at $r=R$, $\vec{E}(R) = \frac{Q}{4\pi\epsilon_0}\frac{R}{R^3}\hat{r} = \frac{Q}{4\pi\epsilon_0}\frac{1}{R^2}\hat{r}$

which is the same as a point charge.