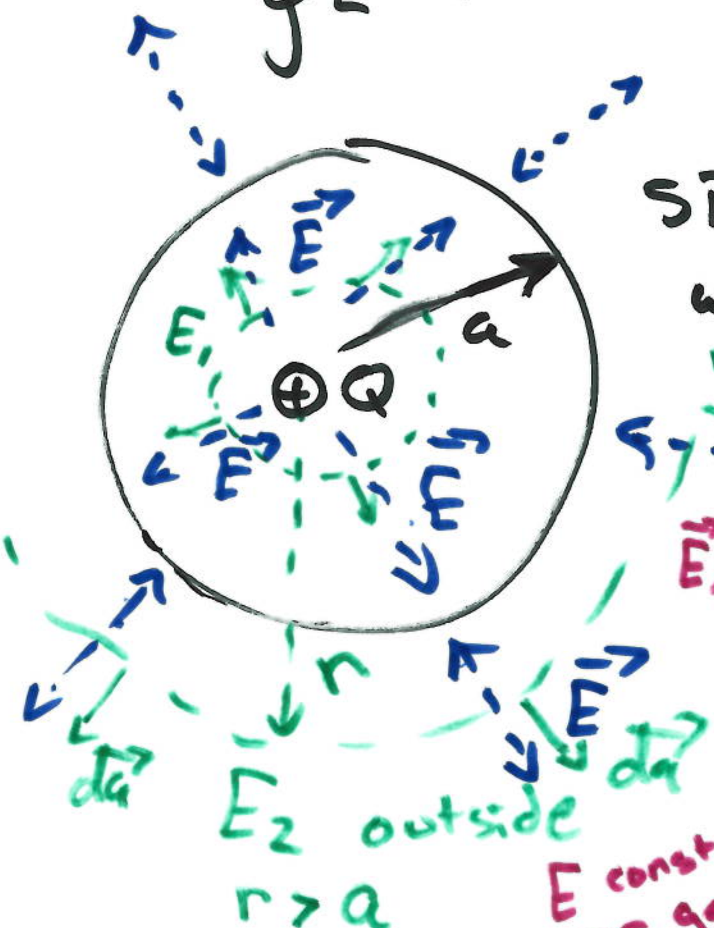
Yet More Gauss' Law!

$$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{IN}}{\epsilon_0}$$

Find $\vec{E}(r)$

Given: a, Q, picture, constants



sphere radius a with $-2Q$

$d\vec{a}$

outside

$\vec{E} \parallel d\vec{a}$

$$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{IN}}{\epsilon_0}$$

$$\oint E\, da \underbrace{\cos 0}_{1} = \frac{-Q}{\epsilon_0} = \frac{Q - 2Q}{\epsilon_0}$$

E const. over gaussian surface

$$E \underbrace{\oint da}_{\text{sphere}} = \frac{-Q}{\epsilon_0}$$

$$E\, 4\pi r^2 = -\frac{Q}{\epsilon_0}$$

$$E_{\text{outside } (r>a)} = \frac{-Q}{4\pi\epsilon_0 r^2} = \frac{-kQ}{r^2}$$

inside $(r<a)$

$$\oint \vec{E} \cdot \vec{da} = \frac{Q_{IN}}{\epsilon_0}$$

$\vec{E} // \vec{da}$

$$\oint E\,da = \frac{+Q}{\epsilon_0}$$

$$E \oint da =$$

$$E\, 4\pi r^2 = \frac{+Q}{\epsilon_0}$$

$$E = \frac{+kQ}{r^2} = \frac{+Q}{4\pi\epsilon_0 r^2}$$

Solid Cylinder full of $\rho = \frac{+1\,nC}{m^3}$

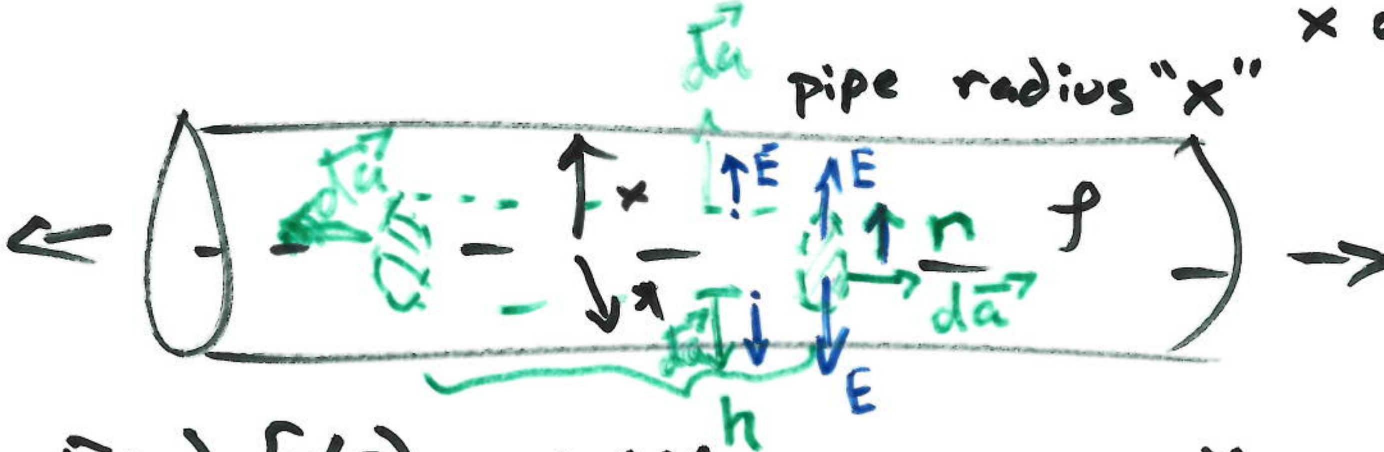
3 cm radius, long.

find: E at 9cm radius (outside) $= E_1$

and 1 cm radius (inside). $= E_2$

Find general eq. 1st.

$x \propto a_0$



Find $E(r)$ $\quad r < x$

$\qquad\qquad\quad r > x$

inside

gaussian

$$\oint \vec E \cdot d\vec a = \frac{Q_{IN}}{\epsilon_0} = \frac{\rho V_{IN}}{\epsilon_0} = \rho \frac{\pi r^2 h}{\epsilon_0}$$

$$\underset{\text{ends}}{\int} \vec E \cdot d\vec a + \underset{\text{side}}{\int} \vec E \cdot d\vec a = \rho \frac{\pi r^2 h}{\epsilon_0}$$

$\vec E \perp d\vec a$ $\qquad$ $\vec E \,//\, d\vec a$

$$0 + \underset{\text{side}}{\int} E\, da =$$

E const side

$$E \underset{\text{side}}{\int} da =$$

$$E\, 2\cancel{\pi} r \cancel{h} = \rho \frac{\cancel{\pi}\, r^{\cancel{2}} \cancel{h}}{\epsilon_0}$$

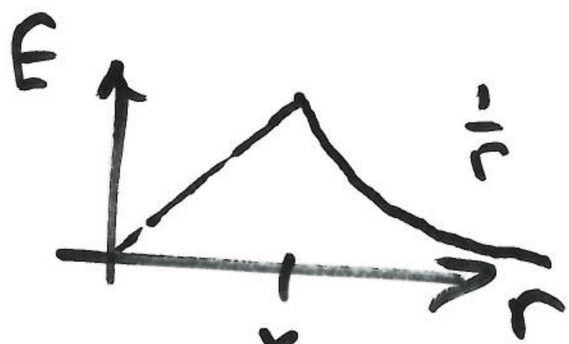
$$\boxed{E = \frac{\rho r}{2\epsilon_0}} \quad (r < x)$$

$\vec E \cdot d\vec a = E\, da \cos\theta$ $\qquad$ θ ∡ between $\vec E$ and $d\vec a$

E at $r = 1\,\text{cm}$ $\quad \rho = \frac{+1\,\text{nC}}{\text{m}^3}$

$$E = \frac{1\times10^{-9}\,\frac{C}{m^3} \times 1\times10^{-2}\,m}{2 \times 8.85\times10^{-12}\,\frac{C^2}{N\cdot m^2}}$$

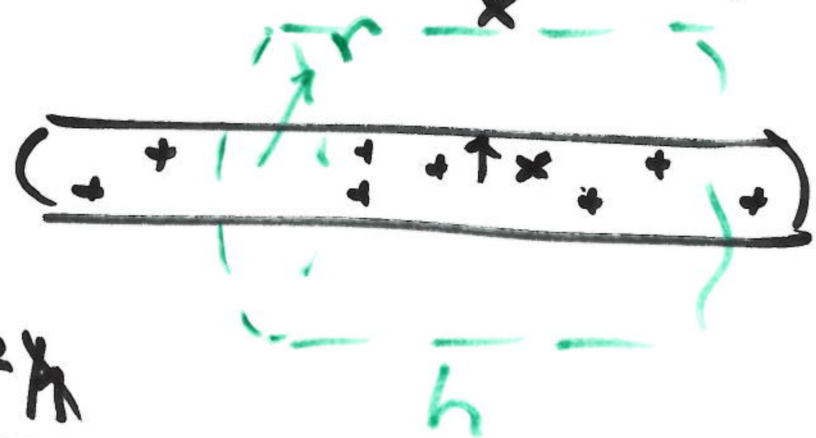
$$= 0.565\,\frac{N}{C}$$



Outside:

$r > x$

$$\oint \vec{E}\cdot d\vec{a} = \frac{Q_{in}}{\epsilon_0}$$



<u>Same</u> $= \rho \frac{V}{\epsilon_0}$

$$E\, 2\pi r \cancel{h} = \rho \frac{\pi x^2 \cancel{h}}{\epsilon_0}$$

$$E = \rho \frac{x^2}{2 r \epsilon_0}$$