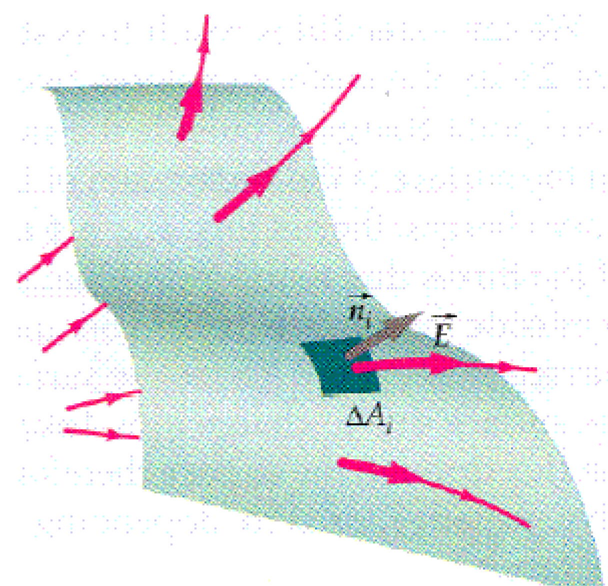
Physics 114 - February 7, 2006

- My office hrs today 2–3:30, 4:30 - 5:00
- Computer visualizations
- Work Shop Room change — Thurs 6:15 (Kleckner) was B+L 108A NOW B+L 208
- Prob Sets in Box outside My office

Last Time:

Important

$$\text{Electric Flux} = \Phi = \int_{\text{Surface}} \vec{E} \cdot d\vec{A}$$



$$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{enclosed}}{\epsilon_0}$$

Gauss' Law

Important

Johann Carl Friedrich Gauss
(1777-1855, Germany)

Very Smart
Plus
A mad cool sense of fashion!

When a philosopher says something that is true then it is trivial. When he says something that is not trivial then it is false

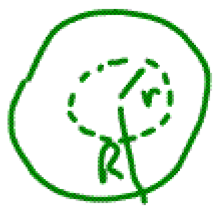
Gauss' law is useful under certain situations of symmetry

spherical symmetry

cylindrical symmetry

planar symmetry

PRS problem



Spherical Distribution w/ const. charge density ρ

Gauss' Law gives:

① $|\vec{E}|\, 4\pi R^2 = \frac{\rho}{\epsilon_0} \frac{4}{3}\pi r^3$

② $|\vec{E}|\, 4\pi r^2 = \frac{\rho}{\epsilon_0} \frac{4}{3}\pi r^3$

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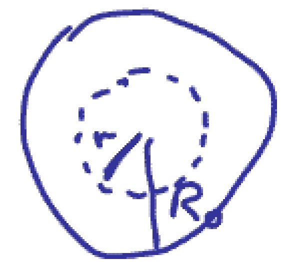
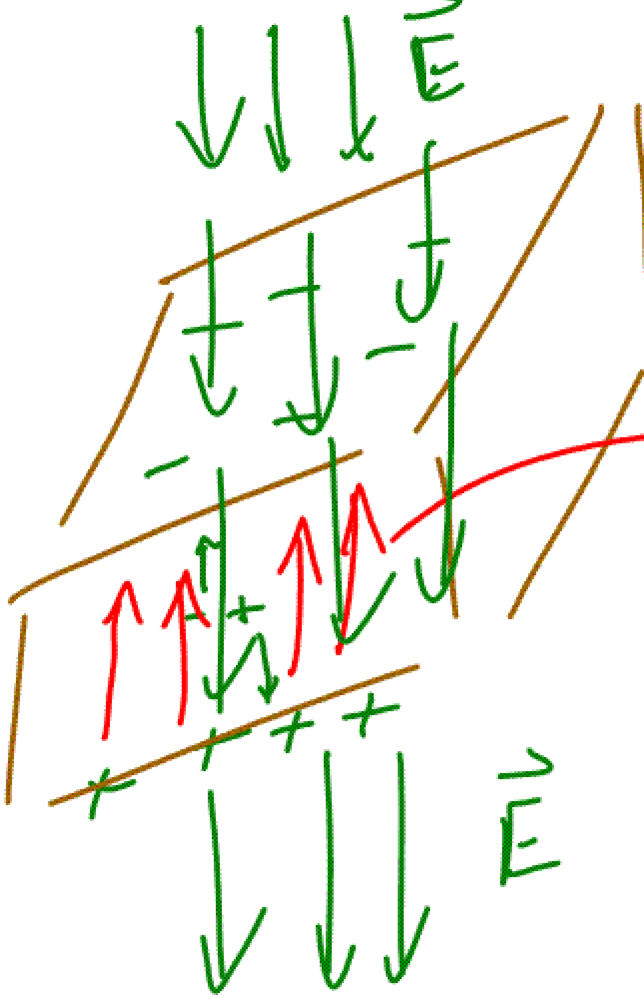


$$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_0}$$

$$|E|\, 4\pi r^2 = \frac{\int_{\text{gaussian surf}} \rho \, dv}{\epsilon_0}$$

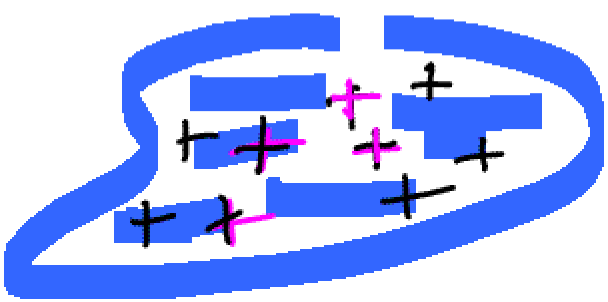
$$\boxed{|E|\, 4\pi r^2 = \frac{\rho}{\epsilon_0} \frac{4}{3}\pi r^3}$$

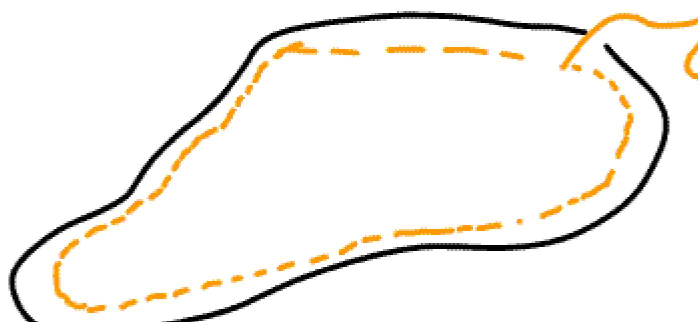


External field induces a charge separation that creates an "internal" field that cancels out external field $\Rightarrow E=0$

Induced field of separated charges

$\Rightarrow \vec{E}=0$ inside a conductor





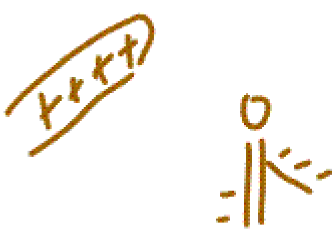
Gaussian Surface

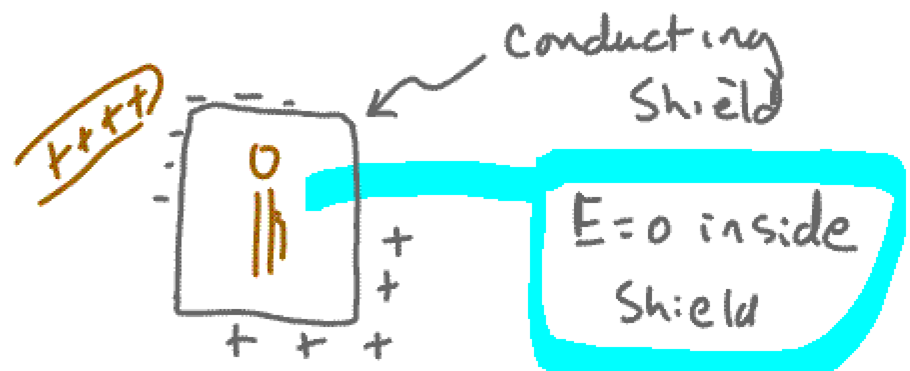
$$\underbrace{\oint \vec{E}\cdot d\vec{A}}_{0} = \frac{Q_{encl}}{\epsilon_0} \qquad Q_{encl} = 0$$

$\vec{E} = 0$ inside conductor

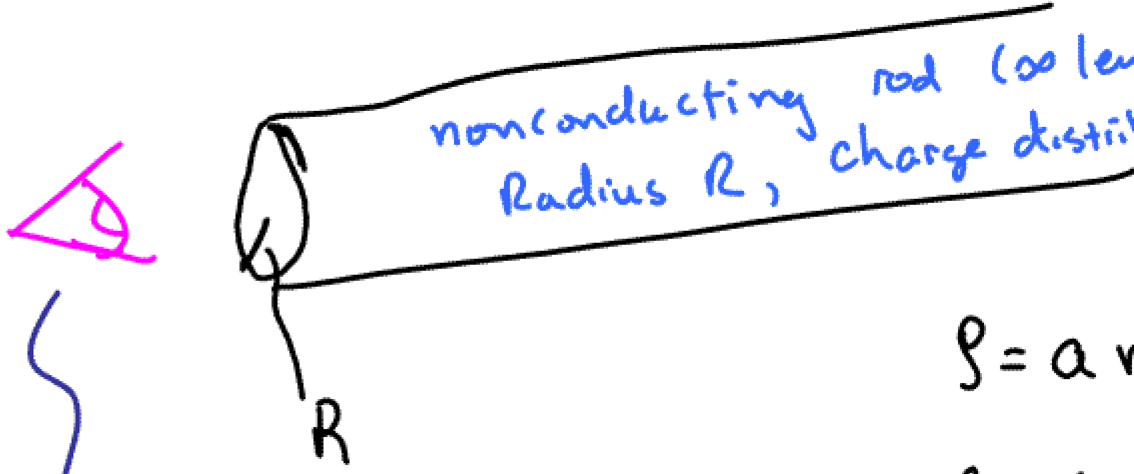
⇒ All net charge resides on surface of conductor

Electrostatic Shielding





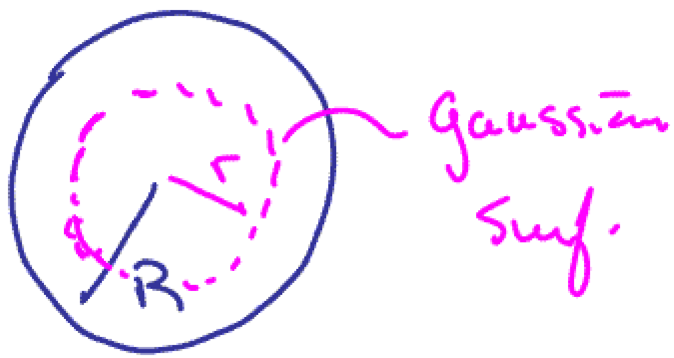
nonconducting rod (∞ length)
Radius R, charge distributed as $\rho = ar$ for $r<R$

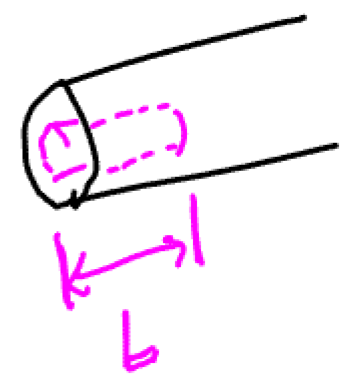


$\rho = ar \qquad r<R$

Total chg/length of $+\lambda$

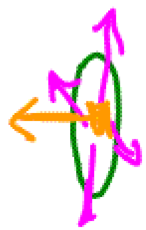
what is $\vec{E}$ for $r<R$



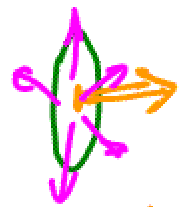


$$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_0}$$

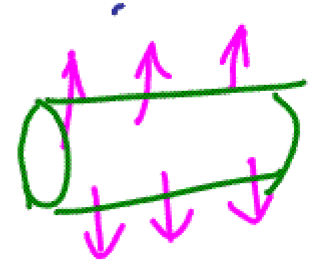
$$\int_{\text{endcap 1}} \vec{E}\cdot d\vec{A} + \int_{\text{endcap 2}} \vec{E}\cdot d\vec{A} + \int_{\text{pipe}} \vec{E}\cdot d\vec{A} = \frac{Q_{enc}}{\epsilon_0}$$



$\vec{E}\cdot d\vec{A} = 0$



$\vec{E}\cdot d\vec{A} = 0$



$$|\vec{E}|\int_{\text{pipe surf}} dA = |\vec{E}|\, 2\pi r L = \frac{Q_{encl}}{\epsilon_0}$$

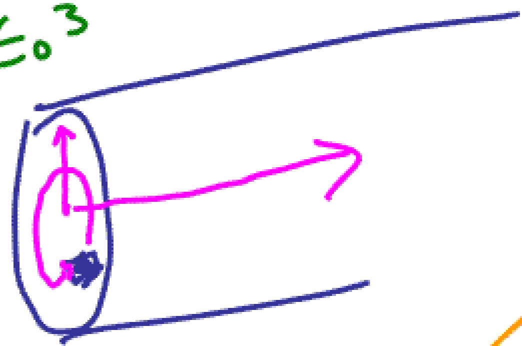
Recall
$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta$

over volume of Gaussian surface

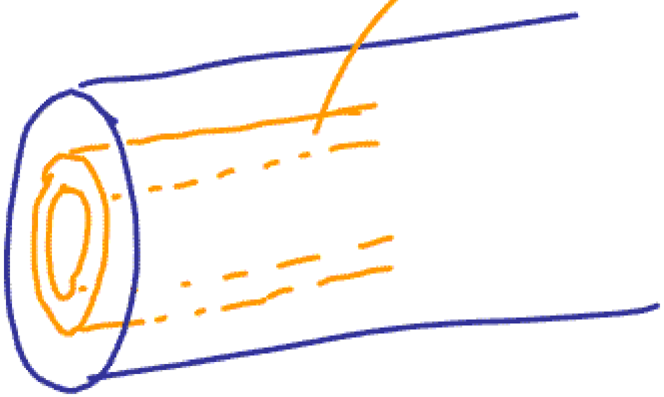
$$|\vec{E}|\, 2\pi r L = \frac{\int \rho\, dv}{\epsilon_0} = \frac{\int \rho\, 2\pi r L\, dr}{\epsilon_0} = \frac{2\pi L}{\epsilon_0}\int_0^r a r^2\, dr$$

$$|\vec{E}| = \frac{a r^2}{\epsilon_0 3} \text{ out radially}$$

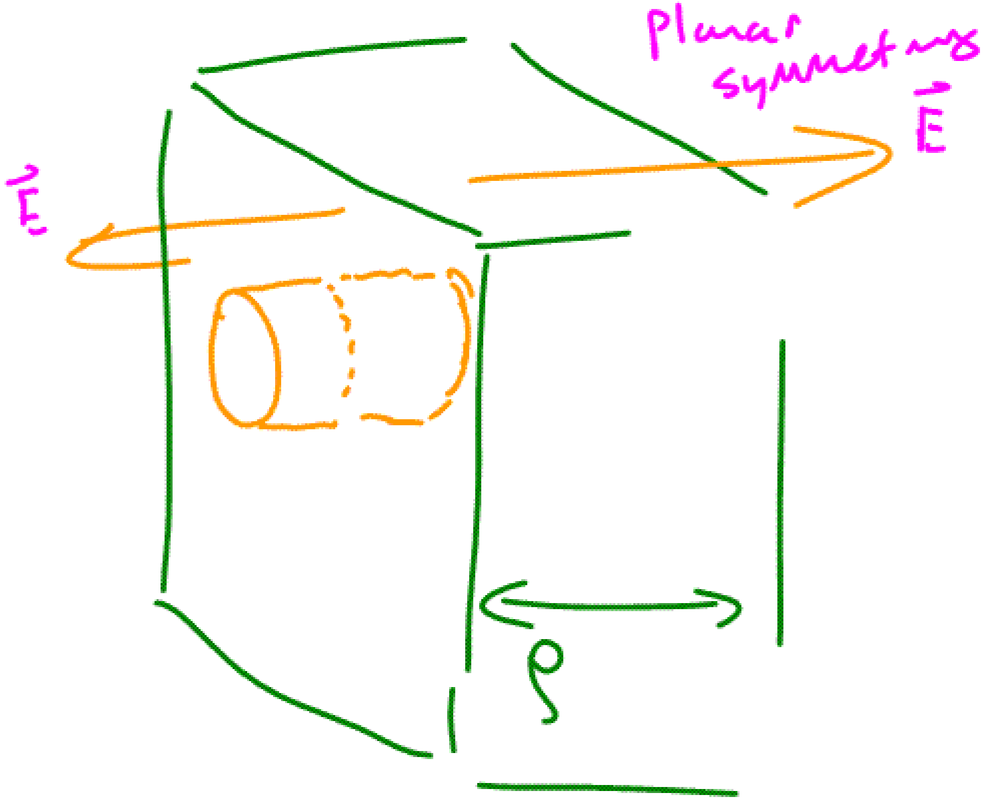
$$|\vec{E}| 2\pi r L = \frac{2\pi L a}{\epsilon_0} \frac{r^3}{3}$$



$$dV = 2\pi r L \, dr$$



$$\int x^n = \frac{x^{n+1}}{n+1}$$



Next time: Potential

Bring your friends!!