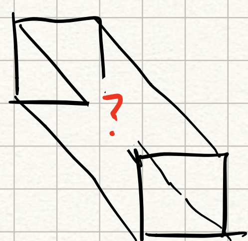
GAUSS'S LAW

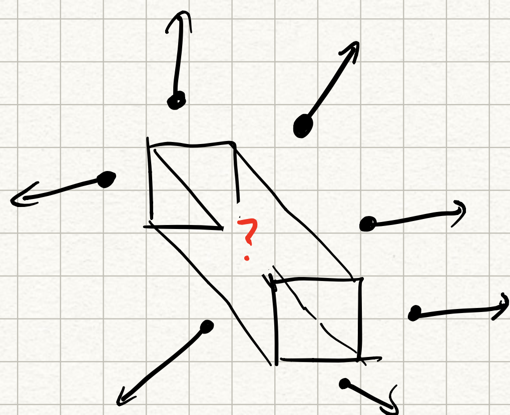
- given <u>any</u> distribution of charge, surround it with imaginary surface enclosing charge

$$\Phi = \frac{Q_{enc}}{\varepsilon_0} = \underbrace{\oint \vec{E} \cdot d\vec{A}}_{\text{the field at all points on surface}}$$

- if the electric field pattern is known in a given region, how do we determine the charge distribution?



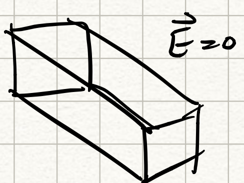
how is charge distributed in this box?



- use point charges to probe how much charge is inside box
- we only need to measure on surface of box.

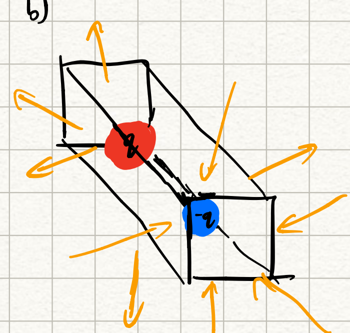
When is flux zero?

a)



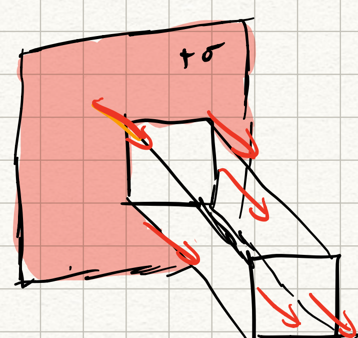
no charge inside

b)

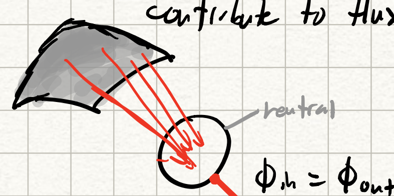


zero net charge, $\Phi_{in} = \Phi_{out}$

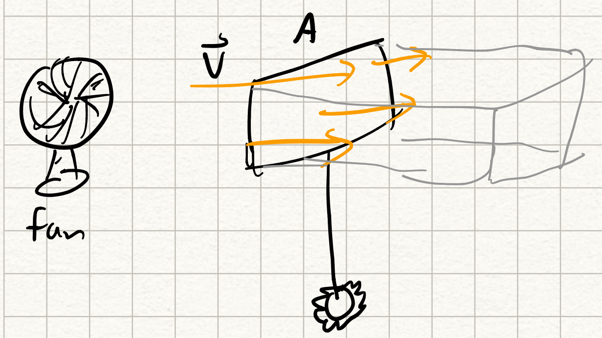
c)



external charges don't contribute to flux



bubble analogy



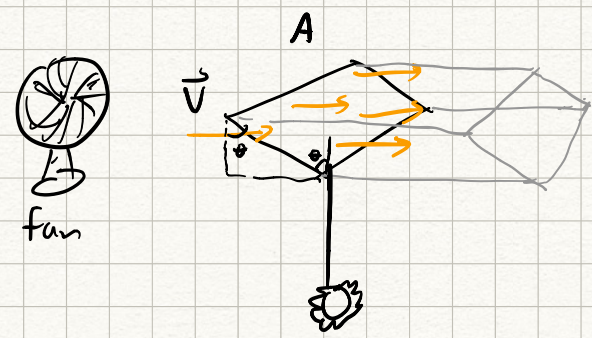
bubble blower w/ area A

Volume of bubble formed:

$$\frac{dV}{dt} = vA$$

$$dV = \vec{v}\vec{A}\,dt$$

$$V = \int_0^T \vec{v}\vec{A}\,dt$$



tilted @ angle θ

Volume of bubble formed!

$$\frac{dV}{dt} = \vec{v}\vec{A}\cos\theta$$

$$dV = \vec{v}\vec{A}\cos\theta\,dt$$

$$V = \oint \vec{v}\vec{A}\cos\theta\,dt$$

in general, $V = \int_0^T \vec{v}\cdot\vec{A}\,dt$

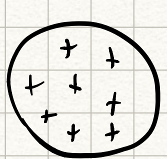
Similarly, flux is

$$\Phi = \oint \vec{E}\cdot d\vec{A}$$

for a uniform electric field (same # of lines thru every dA)

$$\Phi = EA$$

ex: field on uniformly charged sphere



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

$$\Phi = \frac{Q_{enc}}{\varepsilon_0} = \oint \vec{E}\cdot d\vec{A}$$

r < R!

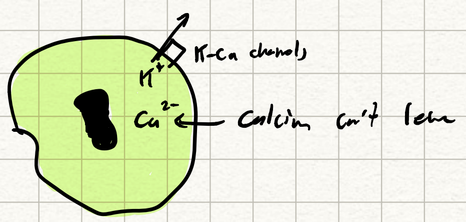
$$\frac{\left(\frac{\cancel{3}Q}{\cancel{4}\pi R^3}\right)\left(\frac{\cancel{4}}{\cancel{3}}\pi r^3\right)}{\varepsilon_0} = \vec{E}(4\pi r^2)$$

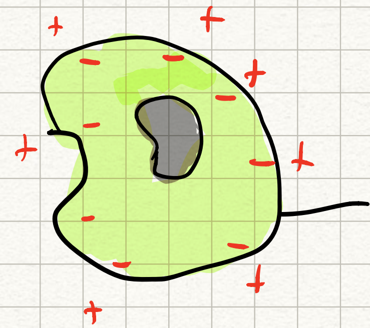
$$\frac{Qr}{4\pi\varepsilon_0 R^3} = \vec{E}$$

<u>$r \geq R$:</u>

$$\vec{E} = \frac{Q}{4\pi\varepsilon_0 r^2}$$

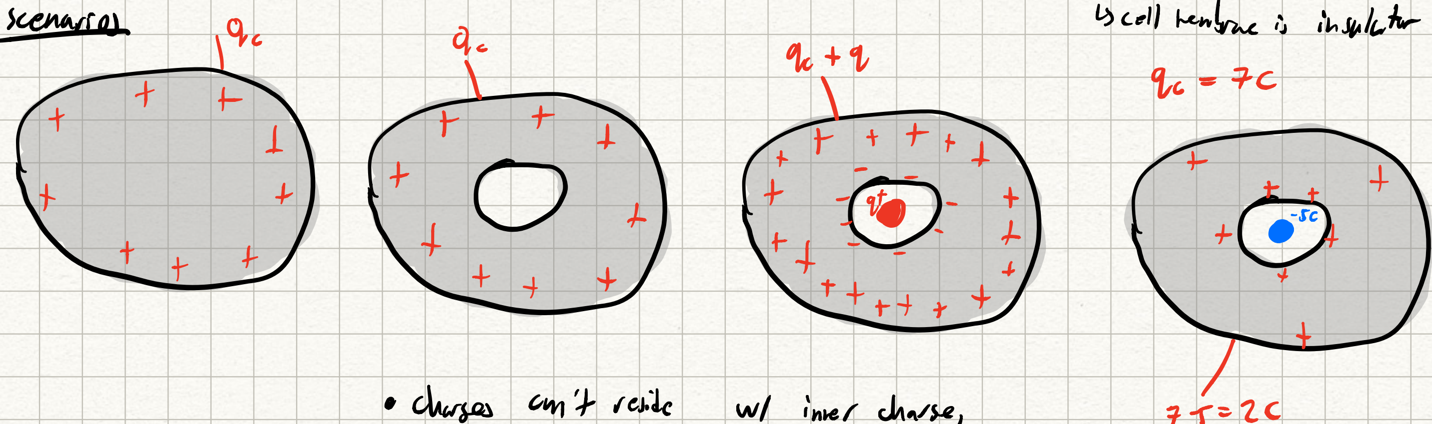
<u>ex:</u> nerve cell





inside fluid is good conductor, Ca^{2-} redistributes along edges of cell.
↳ true no matter the shape
↳ not affected by outside +
↳ cell membrane is insulator

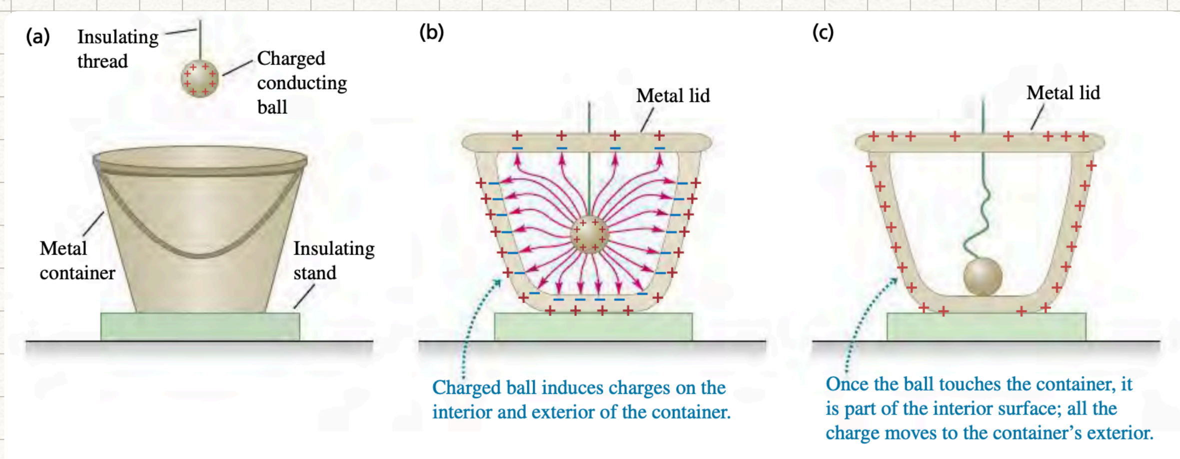
<u>scenarios</u>



- charges can't reside on inner cavity since Q_{enc} must $= 0$ inside all $r < R$.

w/ inner charge,
- inside is negatively charged
- outside is more positively charged

Faraday's Icepail Experiment



Charged ball induces charges on the interior and exterior of the container.

Once the ball touches the container, it is part of the interior surface; all the charge moves to the container's exterior.