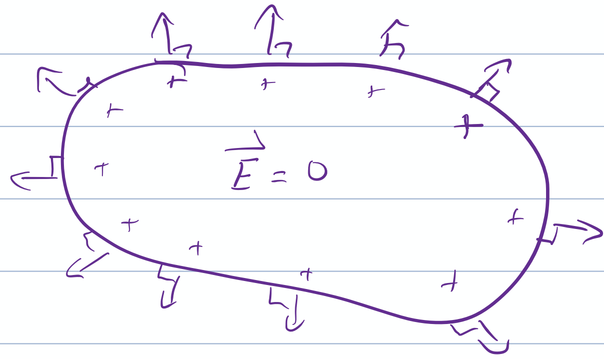
20.6 Conductors and Electric Fields

Conductor ⇒ charges can move freely.



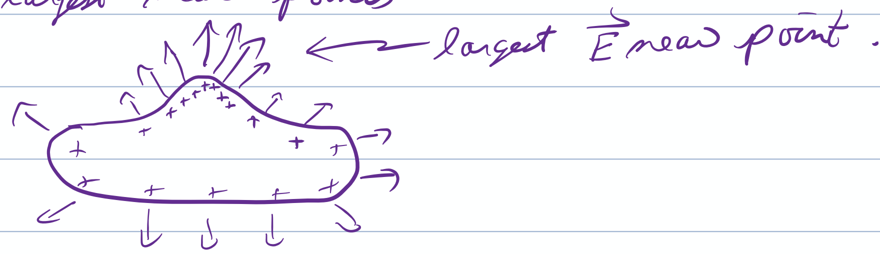
$\vec{E} = 0$ inside a conductor

Any excess charge lies on the surface

$\vec{E} \perp$ surface

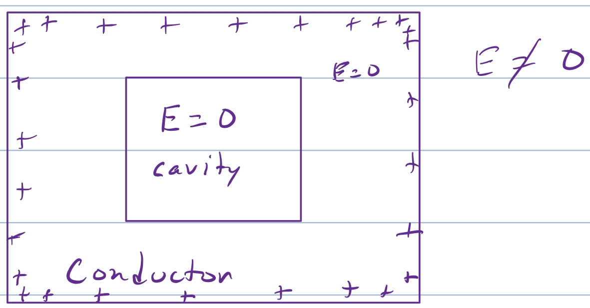
$|\vec{E}| = \sigma/\epsilon_0$ adjacent to the surface (σ = charge density)

E & σ largest near points



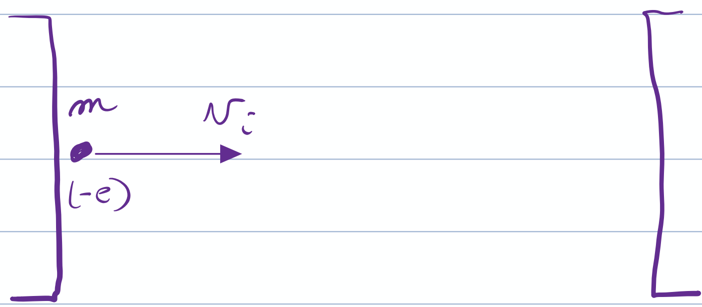
Shielding / Faraday cage

Consider a conductor with excess charge.



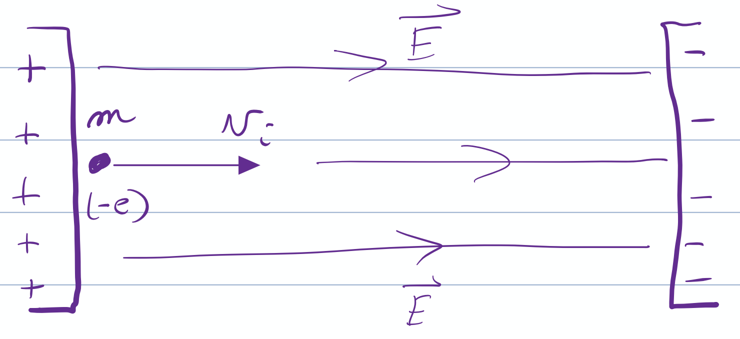
Forces: Use $\vec{F} = m\vec{a}$, where $\vec{F} = q\vec{E}$ for a charge q in an electric field $\vec{E}$. .

Example: Use parallel plates to stop an electron: An electron has an initial speed of 3.00×10^6 m/s, what magnitude and direction of electric field would be needed to bring it to rest in 0.0500 m?



Charge one plate +Q the other −Q.

Poll: what orientation of charges do we need?



$\vec{F} = q\vec{E}$. Since $q = -e$, $\vec{F} = -e\vec{E}$,
so a field to the right creates a force to the left.

Use $$F = ma$$
$$qE = ma$$
$$(-e)E = ma$$

what a do you want?

$$v_f^2 = v_i^2 + 2ad$$
$$a = \frac{v_f^2 - v_i^2}{2d} = \frac{0 - v_i^2}{2d}$$

$$\therefore \quad (-e)E = -\frac{m v_i^2}{2d}$$

$$E = \frac{m v_i^2}{2ed} = \frac{(9.11\times10^{-31}\,\text{kg})(3.0\times10^{6}\,\text{m/s})^2}{2(1.602\times10^{-19}\,\text{C})(\sout{0.01}\ 0.05\,\text{m})}$$

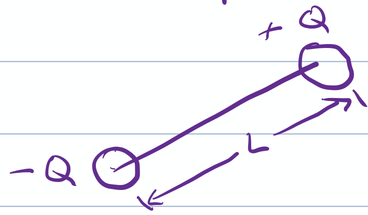
$$\boxed{E \approx 512\ \text{N/C}}$$

(We will later see how to approach this problem using energy.)

See Example 20.15.

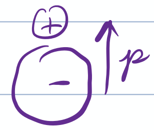
Forces and Torques on a Dipole

Dipole

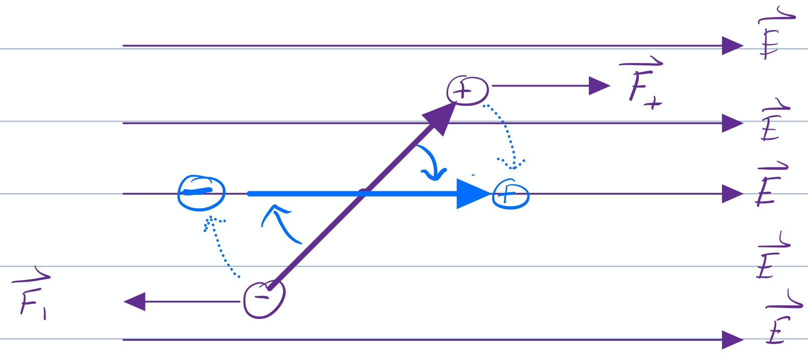


Dipole moment $p = Q \cdot L$

e.g. HCl $p \simeq 3.4 \times 10^{-30}$ C·m



What happens to $\vec{p}$ in an imposed uniform electric field $\vec{E}$?



Net force = 0

But.... tends to rotate to align with E.

Torque: $|\tau| = pE \sin\theta$

(no quantitative calculations).