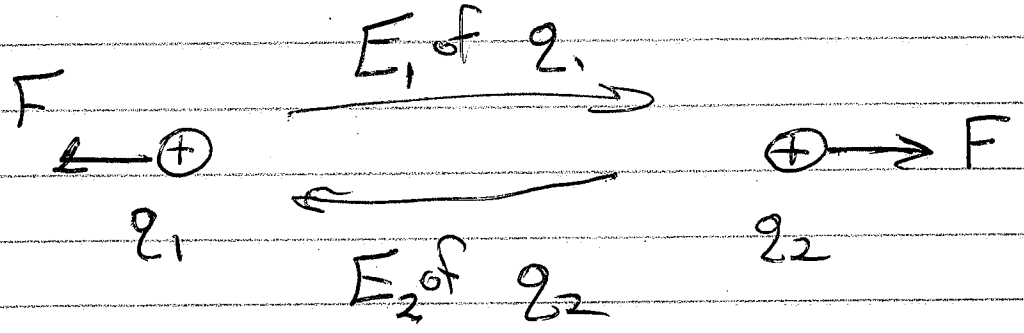
 Phys 1402 2017-09-07 Lec 2

Charge - strength of electric effect of a particle or object, with sign.

Coulomb Force - Long-range attraction or repulsion between charges.

Alternative to Coulomb force: Electric Field



Logical Process for force on q_2:
- q_1 generates E_1
- q_2 "sits in E_1" and feels force.

Old Rule: $F = \frac{k q_1 q_2}{R^2}$

New Rules:

$$E_1 = \frac{k q_1}{R^2} \qquad F = E_1 q_2$$

Compare: $F = mg$

What is E?

Can solve for it: $E = \frac{F}{q_0}$

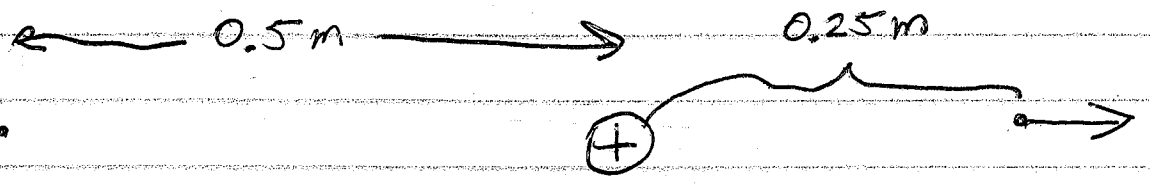
F = force felt by a charge
q_0 = charge feeling the force

(Gasoline is $2.40/gal)

Electric Field is force per unit charge.
(per charge "feeling" the field).

$\vec{E}$ is a vector.
- Strength = $F/q_0 = E$
- Direction is same direction as force on a positive q_0

E_x:



$\vec{E}$ = 180 N/C toward left

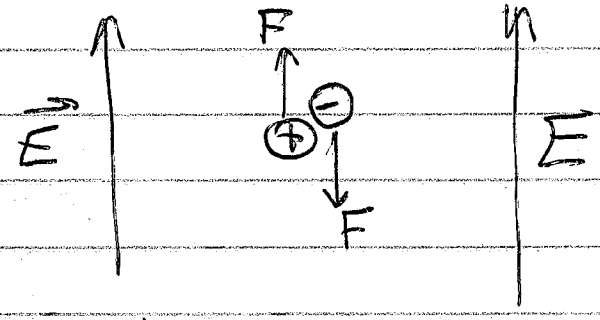
$\vec{E}$ points "away" from ⊕

$q_1 = 5$ nC

nano = 10^{-9}

$E = kq_1/R^2$
$= \frac{(9\times10^9)(5\times10^{-9})}{(0.25)^2}$
$= 720$ N/C
$= 720$ V/m

$\vec{E}$ on an atom:



$\vec{E}$ points "up"

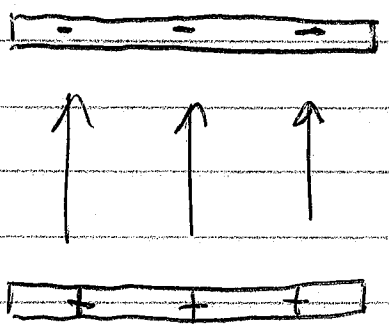
The charges in an atom feel $\vec{F} = q_0 \vec{E}$

The ⊕ nucleus is pushed along $\vec{E}$.
The ⊖ electrons are pulled against $\vec{E}$.
E is trying to tear apart the atom.

IF E is more than about 1 000 000 N/C,
Air is torn apart. This is lightning.

Electric field is easy to study if it is Uniform.
- Same Strength everywhere
- Same Direction everywhere

How? Capacitor. — metal plates



$E = \frac{\sigma}{\varepsilon_0} = 4\pi k \sigma$ $\quad 9 \times 10^9$

(4)

$\varepsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{N m^2}$ $\quad k = 9 \times 10^9 \, N m^2/C^2$

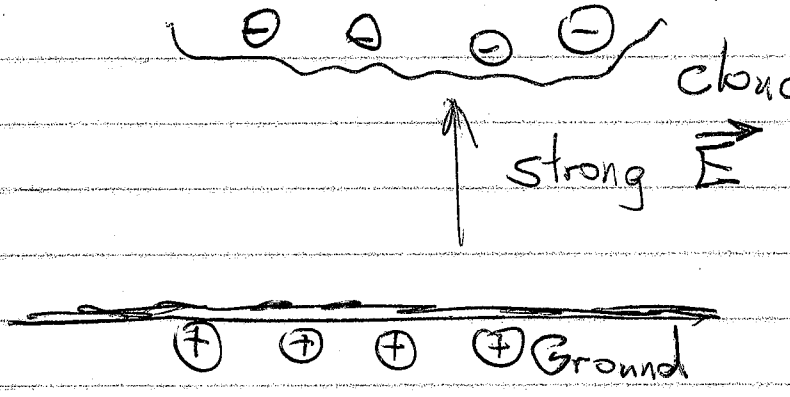
$\varepsilon_0 = \frac{1}{4\pi k}$ $\quad k = \frac{1}{4\pi \varepsilon_0}$

$\frac{1}{\varepsilon_0} = 4\pi k$

What is σ? Charge Per Area.

Capacitors create Electric Field.

A thunderstorm Cloud forms a capacitor.



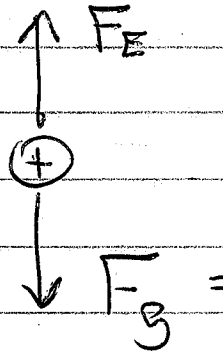
The electrons in air get pulled to cancel the ⊕ side of the capacitor.
The nuclei in air get pushed up to cancel the ⊖ side.
Eventually the original ~~proton~~ ⊖ get to move.

(15)

Consider a styrofoam ball $m = 1.68$ mg.
Say it has a charge of $+0.171$ nC.

What $\vec{E}$ will levitate it?

mega
kilo
–
milli
micro
nano



base unit is kg

$$F_g = mg = (1.68 \times 10^{-6}\ \text{kg})(9.8\ \text{N/kg})$$

million times smaller

million times larger than mg

$$F_g = 1.65 \times 10^{-5}\ \text{N}$$

$$F_E = qE \rightarrow E = \frac{F_E}{q} = \frac{1.65 \times 10^{-5}\ \text{N}}{0.171 \times 10^{-9}\ \text{C}}$$

$$= 96500\ \text{N/C}$$

$\vec{F}_g$ is (down)
$\vec{F}_E$ is (up)

$\vec{F}_E = q\vec{E}$
(up) = (+)(up)

same as $\vec{F}_E$ because +