~~First we play catch — Nerf Ball game~~

benevolent dictatorship

Asic Name

So you must be an expert on gravity

⇒ What is Muss?
⇒ How many kinds of mass ... inertial, gravitational?
⇒ What is the gravitational force?
... The essence of it?
⇒ What other forces occur Naturally?

Lodestone, Magnetite black rock attracts iron
Known by ancient Greeks + Chinese
Thales of Miletus (625-546) BC - rubbed Amber
ATTACT bits of straw
Greek word for Amber: elektron
(from TEXT)

According to Aristotle, Thales was the 1st philosopher to try to discover the underlying Material source of things
Many consider him the founder of the philosophical and Scientific tradition of the Western World.

William Gilbert (in 1600) English physician
Noted that other Materials wax, glass, sulfer behaved like amber in attracting light objects
called objects "electrics"
Thought effects must be due to some kind of Fluid passing from one object to another

Charles Dufay frenchman 1730's

Concluded there are two kinds of electricities

two types of fluid

Accounts for observed Attraction and repulsion

Benjamin Franklin

1st American physicist

one fluid

excess – excess repel

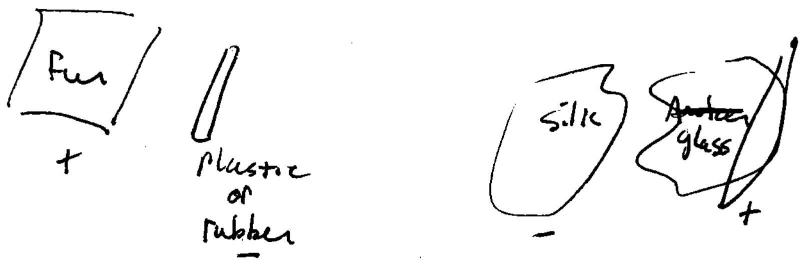
excess – deficient ATTRACT

defficient – defficient repel

excess touch deficient fluid flows no effect

Positive ⇒ excess of fluid

Negative ⇒ deficit of fluid



Convention of Franklin

Actual "flow" is electrons from glass to silk

Too bad Benjie + all ~~stu~~ Modern students of physics

demo

1 Approach pith ball – induced Attraction

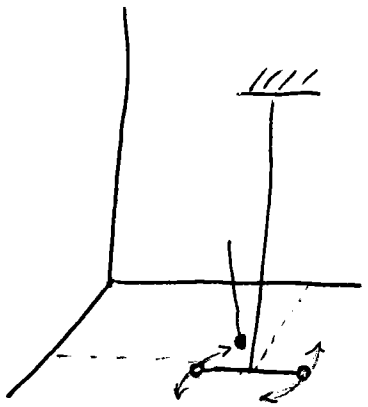
2 Touch it – charge it up

⇒ electroscope demo → quantify charge

⇒ ~~Van de Graaff generator demo~~

Charles Augustin de Coulomb (1785) French

Measure dependence of this attraction and repulsion as a fn of distance + quantity of charge



Torsion Balance

$F \propto \frac{q_1 q_2}{r^2}$

Coulomb's law

$k = \frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \frac{N \cdot m^2}{C^2}$

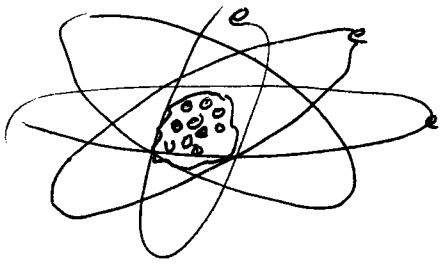
$\vec{F}_{12} = \frac{k q_1 q_2}{r_{12}^2} \hat{r}_{12}$

ϵ_0 = permittivity of free space $= 8.85 \times 10^{-12} \frac{C^2}{N \cdot m^2}$

So much for history

Skip a little – come to Modern atomic model

neutral ATOM



Z protons +

Z electrons −

A-Z neutrons 0

protons = # electrons + and − cancel

↳ neutral

P charge = +e

e charge = −e ← Ben Franklin got it wrong

+ current is direction of + charge even though − charges move!

e fundamental unit of charge

so small graininess does not show up under normal circumstances

Charge is quantized in units of $|e|$.

We don't know why

SI unit of Charge ⇒ Coulomb
MKS

def Amount of charge flowing thru wire in 1 second
When ~~current~~ current in wire is 1 ampere

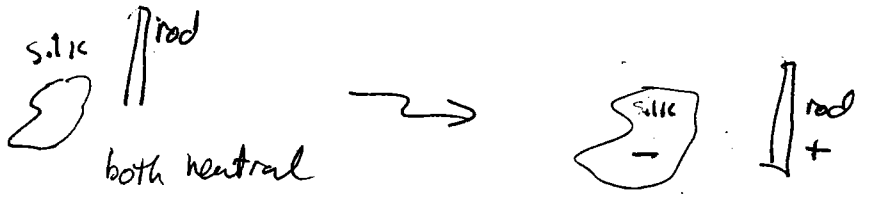
$$e = 1.602177 \times 10^{-19}\ C$$

The "fluid" is electrons

⇒ pith ball DEMO

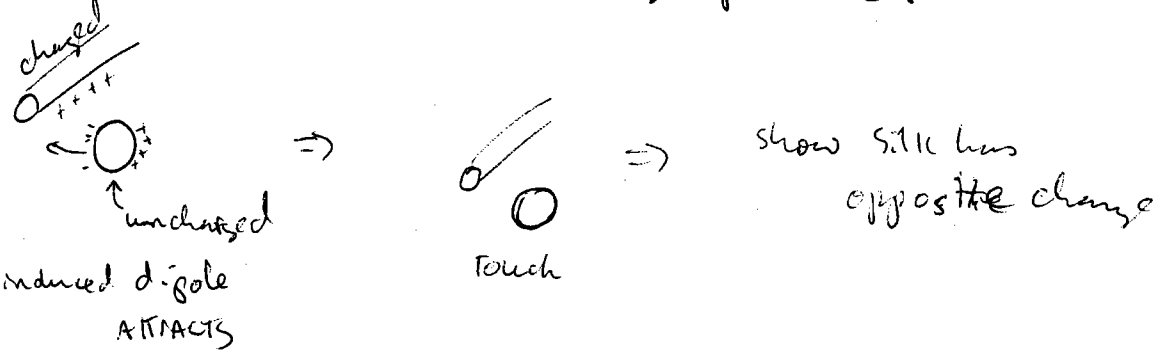
Conductor electrons free to move about
insulator electrons locally bound

electric charge is conserved.



Expts at large scale and "quantum scale"
Find this to be true to a very high precision

Ask why



Return to Coulomb

Coulomb's Law

$$\vec{F}_{1,2} = \frac{k\, q_1 q_2}{r_{12}^2}\, \hat{r}_{12}$$

in MKS ~~$k = 8.99 \times 10^9 \; N \cdot m^2 / C^2$~~

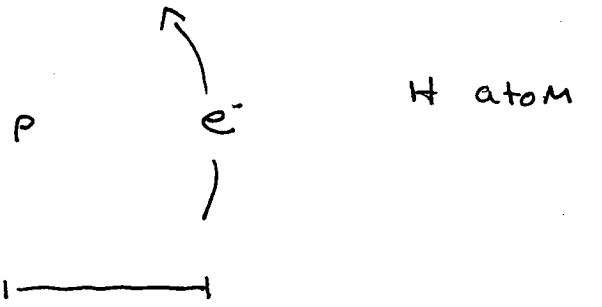
⇒ what would units of k be in MKS system?

$$k = 8.99 \times 10^9 \; N \cdot m^2 / C^2$$

⇒ what's up w/ the vectors? why needed

⇒ what does the little "^" mean?

Examples –



H atom

Bohr radius (see later in semester)

$= 5.29 \times 10^{-11}$ m

$m_p = 1.67 \times 10^{-27}$ kg

$m_e = 9.11 \times 10^{-31}$ kg

$$F_{gravity} = \text{attractive} = -\frac{G m_p m_e}{r^2}$$

$$= -\frac{\left(6.67\times10^{-11}\ \frac{N\cdot m^2}{kg^2}\right)(1.67\times10^{-27}\ kg)(9.11\times10^{-31}\ kg)}{(5.29\times10^{-11}\ m)^2}$$

⇒ What are units of a Newton? How do you figure it out?

$$= 3.6\times10^{-47}\ N$$

$$F_{em} = \frac{\left(8.99\times10^{9}\ \frac{N\cdot M^2}{C^2}\right)(1.6\times10^{-19}\ C)(-1.6\times10^{-19}\ C)}{(5.29\times10^{-11}\ m)^2}$$

$$= -8.2\times10^{-8}\ N$$

CHECK UNITS

⇒ neg sign means what?

$$\frac{F_{em}}{F_{grav}} = 2\times10^{39}\ !!$$

⇒ Steve's Trick about signs!!

(b) Calculate velocity of e^-

⇒ How do I do this?

~ centripetal acceleration

$$|F_{em}| = \frac{m v^2}{r}$$

⇒ circular motion $F = \frac{mv^2}{r}$!!

$$\frac{8.2\times10^{-8}\ N\ (5.29\times10^{-11}\ m)}{(9.11\times10^{-31}\ kg)} = v^2$$

$$v = 2.2\times10^{6}\ m/s$$