Physics 142 Sept 1

Electric charge + Electroscopes

Lucite rod
rubbed w silk

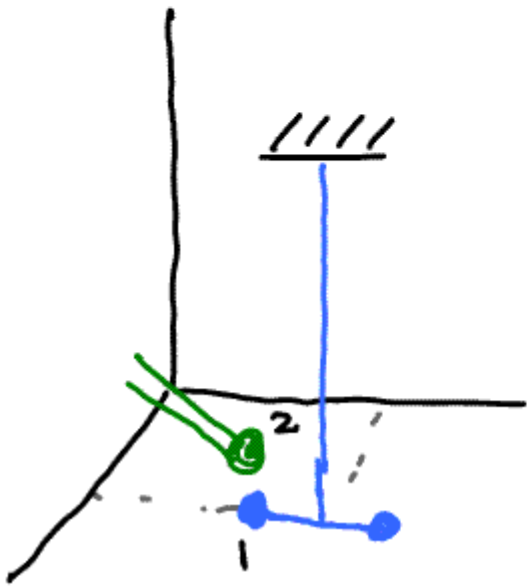
rubber rod
rubbed w/ fur

Vice versa we start w/ other rod

Electric charge

Two types — like types repel / unlike types attract

Charles Augustin Coulomb 1785 (1736–1806)

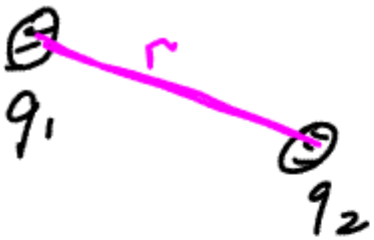


Torsion balance

Studied force as fn of charge + distance

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

Coulomb's Law



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

Force of q_1 on q_2

Vector

$\hat{r}$ unit vector along $\vec{r}$

k constant: Sets the scale

$$k = \frac{1}{4\pi\epsilon_0}$$

$$8.99 \times 10^9 \ \frac{N\,m^2}{c^2}$$

$$\vec{F} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}\,\hat{r}$$

MKS units

F in Newtons

r in m

q in Coulomb

$$\epsilon_0 = 8.85 \times 10^{-12} \ \frac{c^2}{N\,m^2}$$

↳ Permittivity of free space

H atom

$Q = 1.6 \times 10^{-19}$ Coulombs

$= +1|e|$ C

Charge is quantized

Bohr Atom

e^- moves in a circle abt the proton

Proton is stationary

$Q = -1.6 \times 10^{-19} C$

$-1|e|$

$1.6 \times 10^{-19} C \equiv e$

$|e|$

Only integral charge (multiples of $|e|$) found in Nature.

Quarks – which are constituents of particles like Protons – have fractional charge but are NOT seen in Nature because they are confined by the Strong Nuclear force.

How does F_{em} compare to $F_{gravity}$?

1.6×10^{-19} C

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

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

Electrostatic

$r_0 \equiv$ Bohr radius $\equiv 5.29 \times 10^{-11}$ m

$$F_{em} = \frac{k q_1 q_2}{r^2} = \frac{8.99 \times 10^9 \frac{N m^2}{C^2} \left(1.6 \times 10^{-19} C\right)^2}{\left(5.29 \times 10^{-11} m\right)^2}$$

$$F_{em} = 8.2 \times 10^{-8} N$$

$$|F_{grav}| = \left| -\frac{G m_p m_e}{r^2} \right| = 3.6 \times 10^{-47} N$$

$$\frac{F_{em}}{F_{grav}} = 2.3 \times 10^{39}$$

(b) what is the speed of e^-?

$$F_{centripetal} = F_{em} = \frac{m_e v_e^2}{r_0}$$

$$v_e = 2.2 \times 10^6 \, m/s \sim 1\% \text{ speed of light}$$