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Electrostatics

Stationary electrical charges

Charge: 2 varieties
+ and − = positive and negative Charge

Divided into 2 classes (+/−)

Members of same Class repel each other

Members of opposite Class attract each other

Charge is conserved

empty box

Total electric Charge in an isolated system is conserved

Charge is quantized

electric charge comes in units of one magnitude only $\equiv e$

Units of Charge

define in terms of
what charge does
= Force of electric
Charge - inverse square to distance

Similar to Gravity
1785 electric force
by Coulomb for
2 charges q_h, q_h'
separated by r

$$F = k\frac{|q_h q_h'|}{r^2}$$

k = Proportionality Constant,
Electric force a vector

Force on charge q_{h2} from charge q_{h1}

$$\hat{r}_{21} = \frac{\vec{r}_{21}}{|\vec{r}_{21}|}$$

$$\vec{F}_2 = k\frac{q_{h1} q_{h2}}{r_{21}^2}\hat{r}_{21}$$

$$|\hat{r}_{21}| = 1$$

Switch $1 \Leftrightarrow 2$

$$\vec{F}_1 = k\frac{q_{h2} q_{h1}}{r_{12}^2}\hat{r}_{12}$$

$\hat{r}_{12} = -\hat{r}_{21}$

$\vec{F}_2 = -\vec{F}_1$

(Newton: Action-reaction pair!)

Notice Product

$q_1 \cdot q_2 = +$ if signs same

$= -$ if sign opposite

Unit of Charge = Coloumb. = C

1 C = std unit along w/ Meter, sec, kg

$\Rightarrow k = 8.98755 \times 10^9 \frac{N m^2}{C^2}$

$\approx 9 \times 10^9 N m^2 C^{-2}$

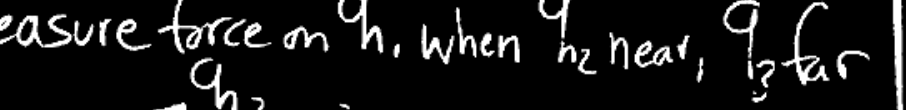
$\Rightarrow e = 1.60219 \times 10^{-19} C$

$\approx 1.60 \times 10^{-19} C$

1 Coulomb of electron charge = 6.25×10^{18} electrons.

3 Charged Particles: q_1, q_2, q_3

Measure force on q_1 when q_2 near, q_3 far



q_1 measure with q_2 far, q_3 near:

measure q_1 with both near

= sum of 2 previous forces.

Principle of Superposition

Combine 2 sets of sources of charge into one system by adding them

⇒ Total Force is the Vector sum of forces from each set of Charges

$$\vec{F}_3 = k\frac{q_3 q_1 \hat{r}_{13}}{r_{13}^2} + k\frac{q_3 q_2 \hat{r}_{23}}{r_{23}^2}$$

Electric Field

Arrangement of Charges $q_1, q_2, q_3, \ldots, q_n$ fixed in space → exert force on another q_0.

Calculate resultant force on q_0 at $\vec{r}_0$.

$$\vec{F}_0 = k\frac{q_0 q_1 \hat{r}_{01}}{r_{01}^2} + k\frac{q_0 q_2 \hat{r}_{02}}{r_{02}^2} + \cdots + k\frac{q_0 q_n \hat{r}_{0n}}{r_{0n}^2}$$

$$= q_0\left(k\frac{q_1 \hat{r}_{01}}{r_{01}^2} + k\frac{q_2 \hat{r}_{02}}{r_{02}^2} + \cdots k\frac{q_n \hat{r}_{0n}}{r_{0n}^2}\right)$$

Define $\vec{E}(\vec{r}_0) = k\frac{q_{n1}\hat{r}_{01}}{r_{01}^2} + k\frac{q_{n2}\hat{r}_{02}}{r_{02}^2} + \dots + k\frac{q_n\hat{r}_{0n}}{r_{0n}^2}$

$\vec{E}(\vec{r}_0)$ = electric field at point $\vec{r}_0$

Force on q_0: $\vec{F} = q_0\vec{E}(\vec{r}_0)$

$\vec{E}(\vec{r}_0)$ = function of position

Field of vectors changing in magnitude & direction w/ location