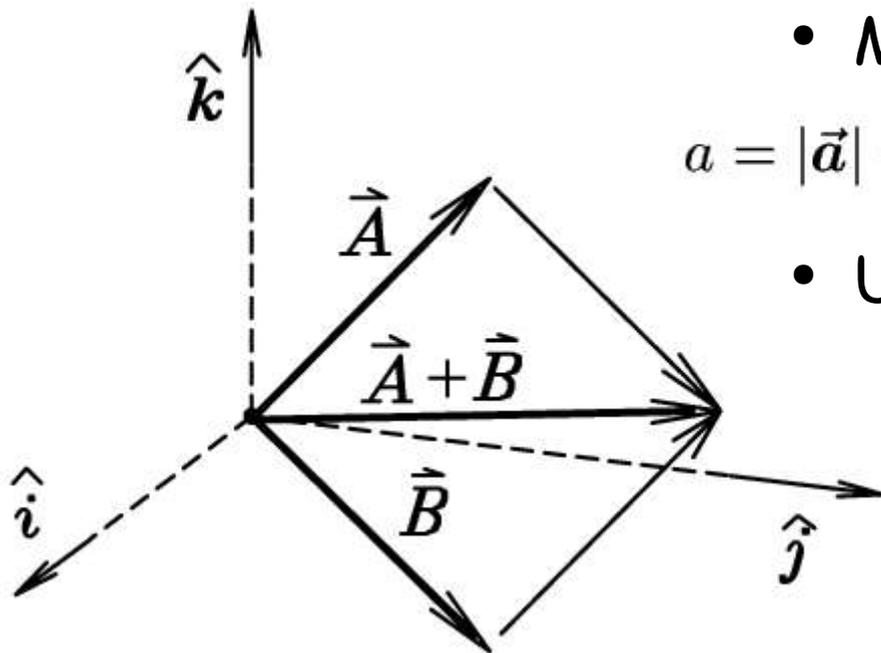


Vectors in 3 Dimensions

$$\vec{A} = \hat{i}A_x + \hat{j}A_y + \hat{k}A_z$$

- Addition

$$\begin{aligned}\vec{A} + \vec{B} &= \hat{i}(A_x + B_x) \\ &\quad + \hat{j}(A_y + B_y) \\ &\quad + \hat{k}(A_z + B_z)\end{aligned}$$



- Magnitude

$$a = |\vec{a}| = \sqrt{a_x^2 + a_y^2 + a_z^2}$$

- Unit Vector

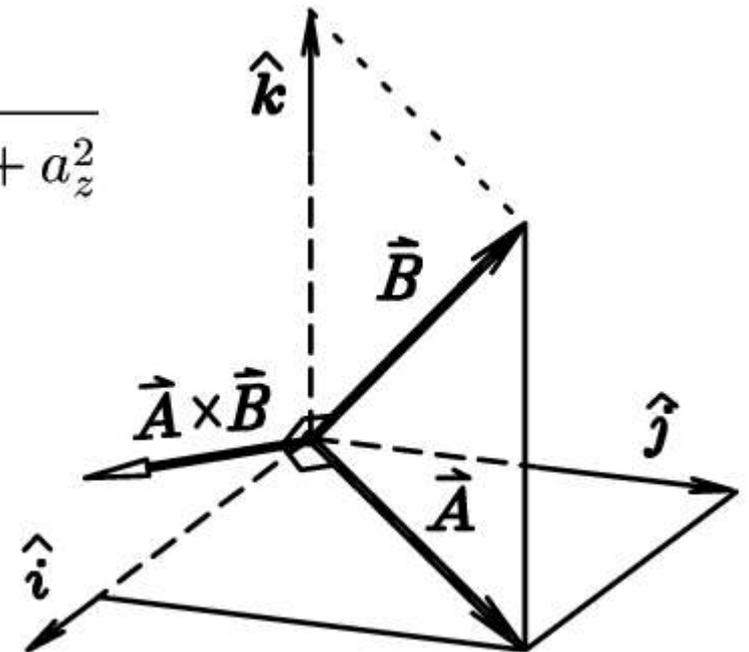
$$\hat{a} = \frac{\vec{a}}{a}$$

- Scalar ("Dot") Product

$$\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z$$

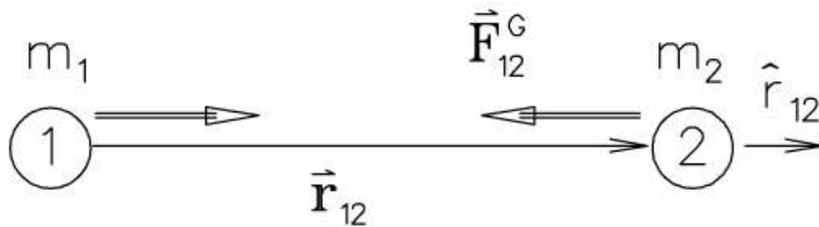
- Vector ("Cross") Product

$$\begin{aligned}\vec{A} \times \vec{B} &= \hat{i}(A_y B_z - A_z B_y) \\ &\quad + \hat{j}(A_z B_x - A_x B_z) \\ &\quad + \hat{k}(A_x B_y - A_y B_x)\end{aligned}$$



CHARGE!

Gravitational force:

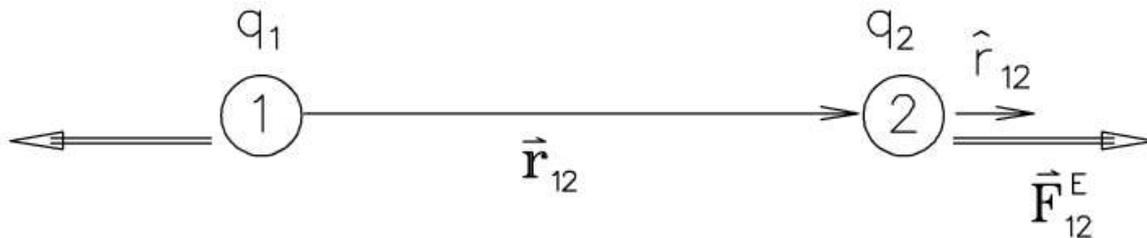


$$G = 6.67259 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$$

$$\vec{F}_{12}^G = -G \frac{m_1 m_2}{r_{12}^2} \hat{r}_{12}$$

$$m_e = 9.10939 \times 10^{-31} \text{ kg}$$

Electrostatic force:



$$k_E = 8.98755 \times 10^9 \text{ V m C}^{-1}$$

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

$$q_e = 1.60217733 \times 10^{-19} \text{ C}$$

Between 2 electrons, $F^G/F^E = 2.4 \times 10^{-43}$

Fundamental Constants

$$c \equiv 2.99792458 \times 10^8 \text{ m/s}$$

$$k_E \equiv 1/4\pi\epsilon_0 = c^2 \times 10^{-7} = 8.9875518 \times 10^9 \text{ V}\cdot\text{m}\cdot\text{C}^{-1}$$

$$\epsilon_0 = 10^7 / 4\pi c^2 = 8.8542 \times 10^{-12} \text{ C}^2\cdot\text{N}^{-1}\cdot\text{m}^{-2}$$