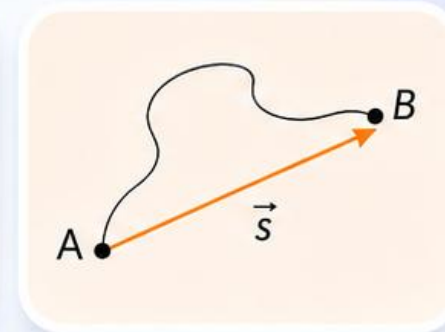
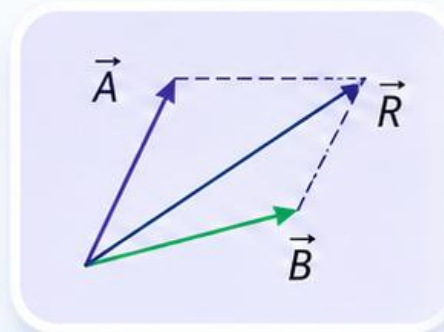
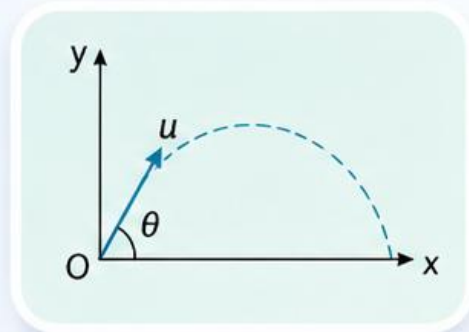
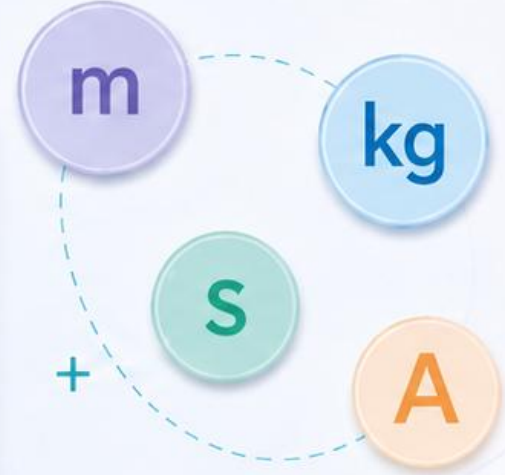


Chapter 3

Motion in a Plane

Projectile • Vectors • Trajectory



MOTION IN A PLANE

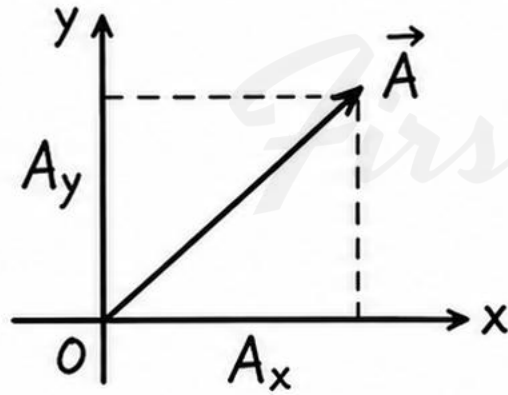
Two-dimensional motion needs both magnitude and direction, so vectors are the natural language of kinematics.

VECTOR LANGUAGE

$$\vec{r}, \Delta\vec{r}, \vec{v}, \vec{a}$$

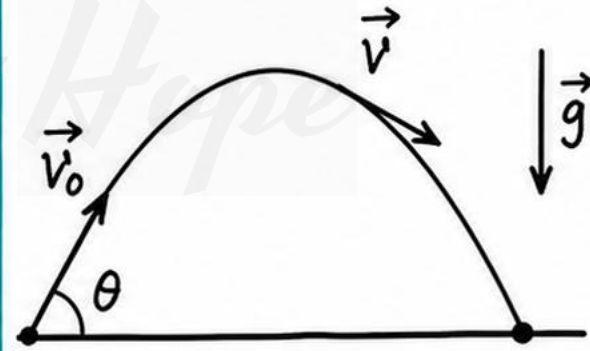
Scalars have magnitude only; vectors also obey vector addition

COMPONENT IDEA

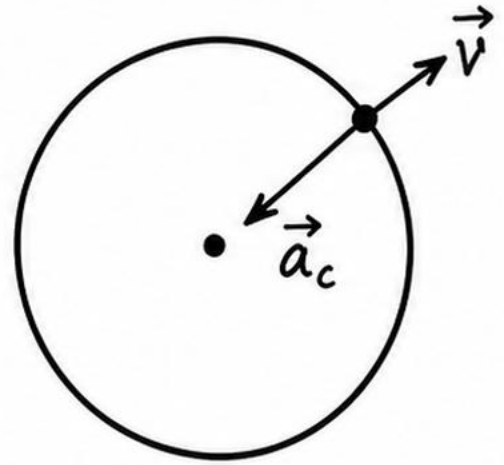


$$\vec{A} = A_x \hat{i} + A_y \hat{j}$$

PROJECTILE



CIRCULAR MOTION



vectors $\rightarrow$ planar kinematics $\rightarrow$ projectile motion $\rightarrow$ uniform circular motion



direction changes can produce acceleration even at constant speed

SCALARS, VECTORS, POSITION & DISPLACEMENT

SCALARS

magnitude only;
ordinary algebra
applies when units
are compatible

Examples:

mass, time, temperature,
distance, speed, density

VECTORS

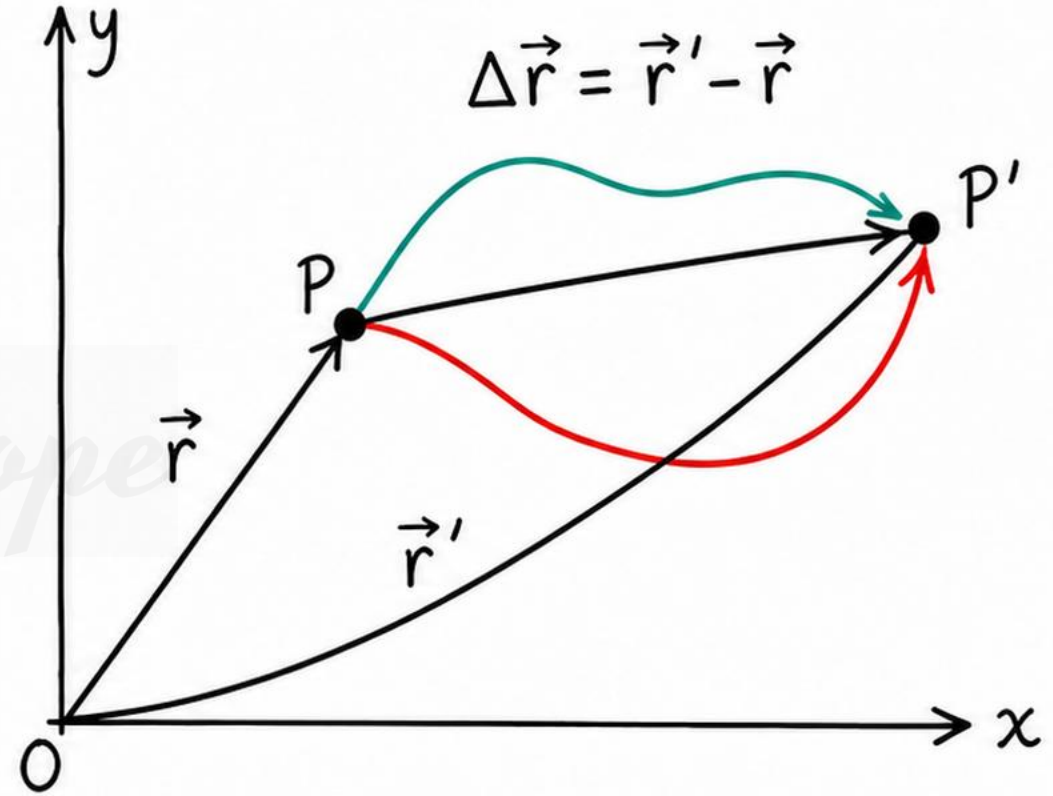
magnitude plus direction
and obey triangle/
parallelogram addition

Examples:

displacement, velocity,
acceleration, force

$\vec{A}$ - vector

$$|\vec{A}| = A$$



$$|\text{displacement}| \leq \text{path length}$$

displacement depends only on endpoints

VECTOR EQUALITY, SCALING & SUBTRACTION

EQUALITY

A $\longrightarrow$

B $\longrightarrow$

$A = B$ iff same magnitude
and same direction

- free vectors may be shifted parallel to themselves; some physical vectors are localised by a point or line of action

MULTIPLY BY A REAL NUMBER

A $\longrightarrow$

$2A$ $\longrightarrow$

$-A$ $\longleftarrow$

$-1.5A$ $\longleftarrow$

$$|\lambda A| = |\lambda| |A|$$

- direction reverses when $\lambda < 0$

ZERO & SUBTRACTION

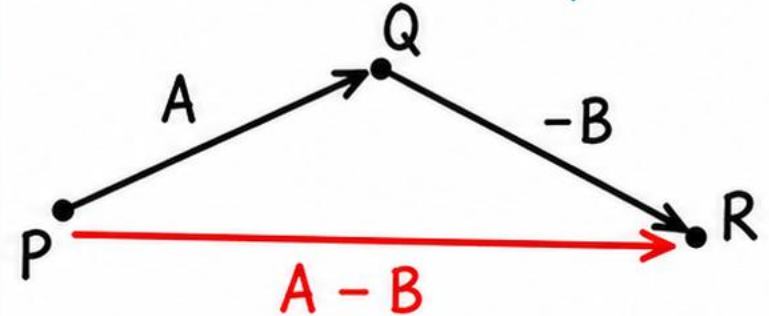
$$A + (-A) = 0$$

$$|0| = 0$$

$$A - B = A + (-B)$$

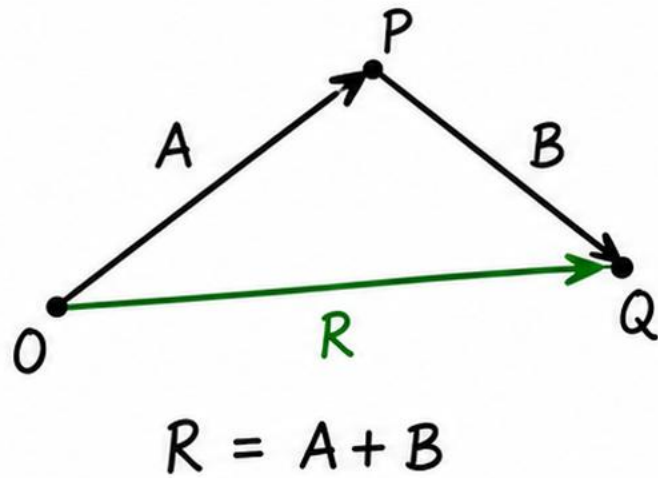
- the zero vector has no specified direction

Head-to-tail construction for $A - B$:

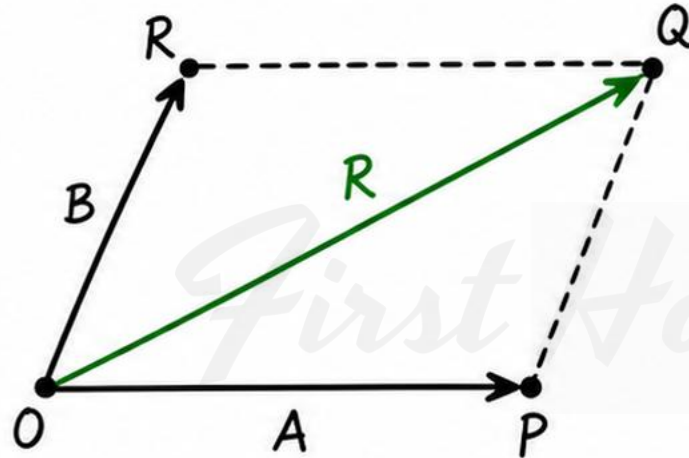


GRAPHICAL VECTOR ADDITION

HEAD-TO-TAIL / TRIANGLE LAW

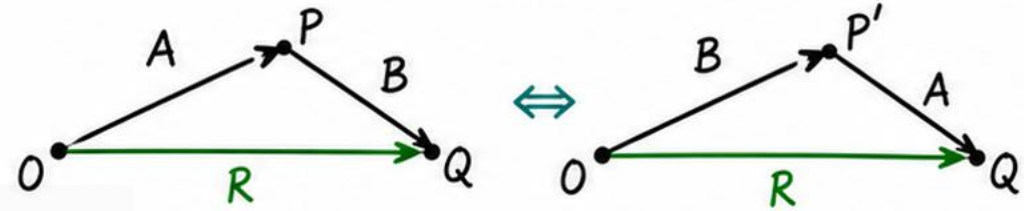


PARALLELOGRAM LAW

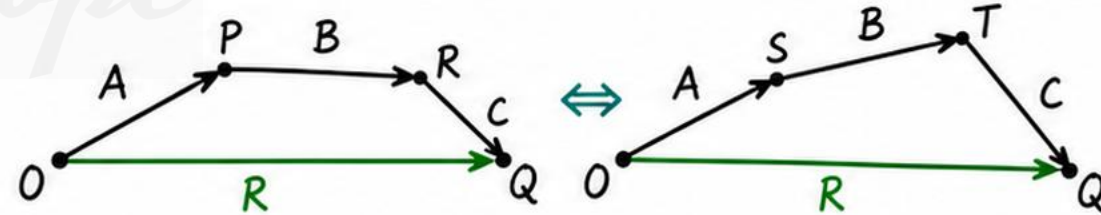


ALGEBRAIC LAWS

$$A + B = B + A$$

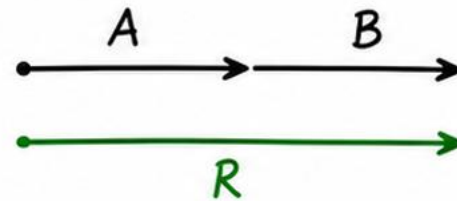


$$(A + B) + C = A + (B + C)$$

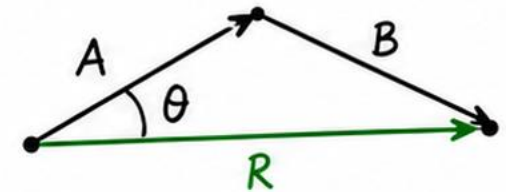


DO NOT ADD MAGNITUDES BLINDLY

$|A+B|$ depends on the angle; it equals $A+B$ only when the vectors point in the same direction.



$$|R| = A + B$$



$$|R| = \sqrt{A^2 + B^2 + 2AB \cos \theta}$$

(Equals $A+B$ only when $\theta = 0^\circ$)

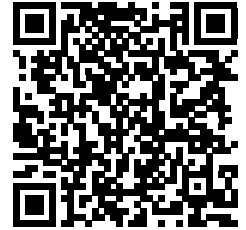


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