Chapter 3:Kinematics in Two Dimensions: Vectors

Lecture 1
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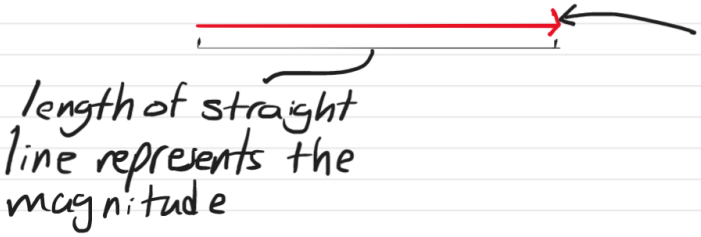
3.1 : Vectors and Scalars

Vector: has magnitude and direction.
eg: Displacement, Velocity, Acceleration, Force, Weight, ...

Scalar: has magnitude ONLY.
e.g: distance, speed, mass, temperature.

How do we represent a vetor ?

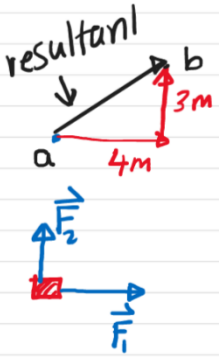
A force of magnitude 20 N acts on an object along the positive x-direction. Represent this vector.



We write a vector as $\vec{A}$, $\vec{b}$, $\vec{c}$, $\vec{d}$ etc.
In book a vector is written using bold face font.

The magnitude of a vector $\vec{A}$ is written as $|\vec{A}|$.

3.2 : Addition of Vectors; Graphical Method

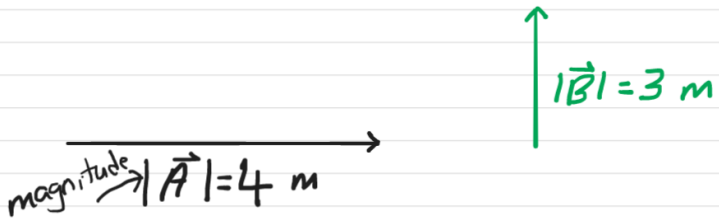


We use simple arithmetic to add scalars. For example the sum of two masses $m_1 = 2\,kg$ and $m_2 = 5\,kg$ is $M = m_1 + m_2 = 2 + 5 = 7\,kg$.

Adding vetors is different because we must take the magnitude and direction into account.

Example: Ali moved 4m along the positive x-axis and then 3m along the positive y-direction. What is his resultant displacement?

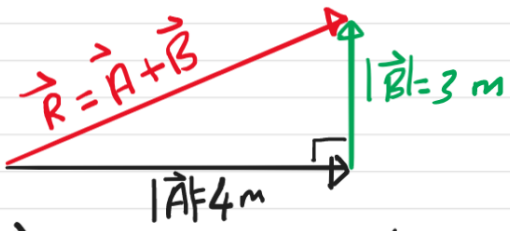
① draw both vectors



② Need to find $\vec{R} = \vec{A} + \vec{B}$

↑ resultant vector

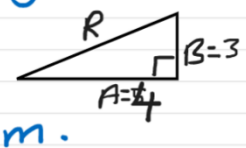
③ Draw the first vector $\vec{A}$. Place the tail of the second vector $\vec{B}$ on the tip of $\vec{A}$.



④ The resultant $\vec{R}$ starts from the tail of $\vec{A}$ and ends on the tip of $\vec{B}$.

This is called the triangular method of addition, because $\vec{A}$, $\vec{B}$ and $\vec{C}$ form a triangle.

In this case $\vec{A}$, $\vec{B}$ and $\vec{R}$ formed a right-angle triangle. According to Pythagoras' theorem



$$R = \sqrt{A^2+B^2} = \sqrt{(4)^2+(3)^2} = \sqrt{25} = 5 \text{ m}.$$

NOTE: $4-3 < R < 4+3$

$1 < R < 7$

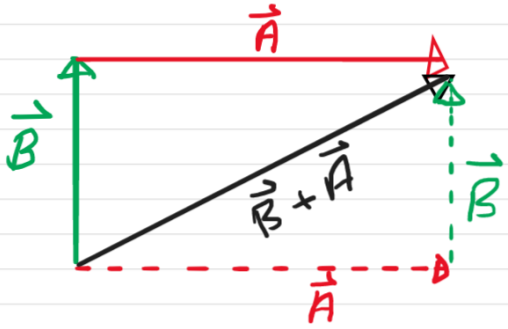
question:
$A = 10$ m, $B = 6$ m
$\vec{R} = \vec{A} + \vec{B}$
$4 \leq R \leq 16$

In general $|A-B| \leq R \leq A+B$

72%

Find $\vec{B}+\vec{A}$.
Draw $\vec{B}$. Place the tail of $\vec{A}$ on the tip of $\vec{B}$. The resultant starts from the tail of $\vec{B}$ and ends on the tip of $\vec{A}$.

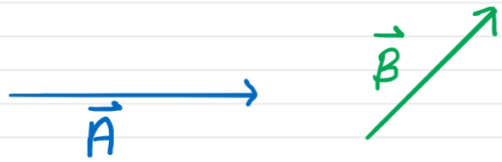
$\vec{R} = \vec{B} + \vec{A}$



NOTE: $\vec{A}+\vec{B} = \vec{B}+\vec{A}$

This is the commutative law of addition.

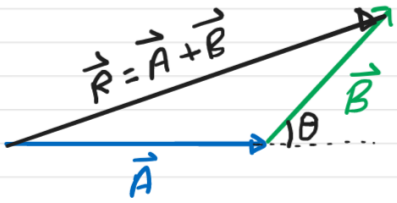
This method of addition applies to any two vectors (or more).



Find $\vec{R} = \vec{A} + \vec{B}$

$\vec{R} = \vec{A} + \vec{B}$

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



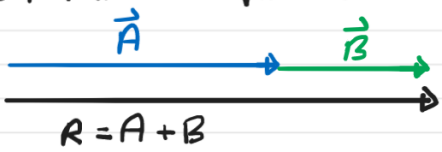
θ: when two vectors originate from the same point.

when $\theta = 90^\circ \Rightarrow \cos\theta = 0 \Rightarrow R = \sqrt{A^2 + B^2}$ Pythagoras' theorem considered above

$A = 4m,\ B = 3m \Rightarrow R = 5m.$

$\theta = 0 \Rightarrow \cos\theta = 1 \Rightarrow R = \sqrt{A^2 + B^2 + 2AB} = \sqrt{(A+B)^2} = A + B$

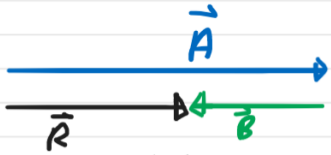
$R = A + B$ $\vec{A}$ parallel to $\vec{B}$



$R = 4 + 3 = 7\ m.$

$\theta = 180^\circ \Rightarrow \cos\theta = -1 \Rightarrow R = \sqrt{A^2 + B^2 - 2AB} = \sqrt{(A-B)^2} = |A - B|$

$R = |A - B|$ $\quad R = 4 - 3 = 1\ m$



$\vec{A}$ and $\vec{B}$ are antiparallel

$|\vec{R}| = |\vec{A} + \vec{B}| = 4 - 3 = 1m$

$\therefore |A - B| \leq R \leq A + B$

$R_{max} = A + B$ when two vectors are parallel $(\theta = 0)$

$R_{min} = A - B$ when two vectors are antiparallel $(\theta = 180^\circ)$.

Addition of more than two vectors

$\vec{R} = \vec{A} + \vec{B} + \vec{C} + \vec{D}$