

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, ...

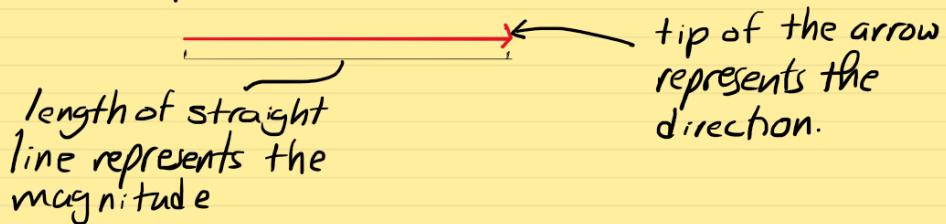
Scalar: has magnitude ONLY.

eg: distance, speed, mass, temperature.

How do we represent a vector ?

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

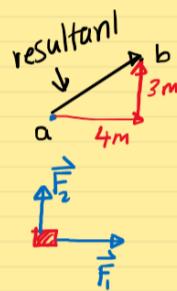


We write a vector as \vec{A} , \vec{b} , \vec{c} , \vec{d} etc.
In book a vector is written using bold face font.

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

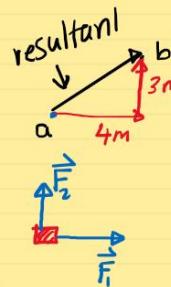
3.2 : Addition of Vectors; Graphical Method

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



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Adding vectors 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?

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① draw both vectors

$$\xrightarrow{\text{magnitude}} |\vec{A}| = 4\text{ m}$$

$$|\vec{B}| = 3\text{ m}$$

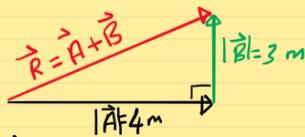
② Need to find $\vec{R} = \vec{A} + \vec{B}$

↑ resultant vector

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

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 ↓ resultant vector

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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: $4-3 < R < 4+3$
 $1 < R < 7$

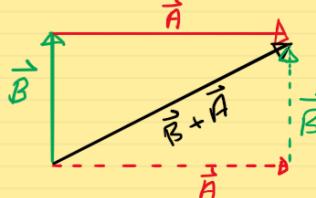
In general $|A-B| \leq R \leq A+B$

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

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).

(or more).

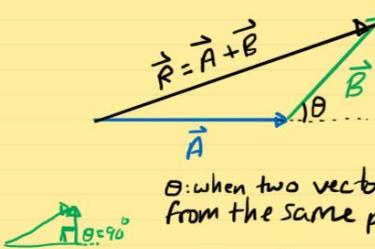
$$\vec{A}$$

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

$$\vec{B}$$

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

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



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

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

$$R = A+B \quad \vec{A} \text{ parallel to } \vec{B} \quad \overrightarrow{R = A+B} \quad R = 4+3=7 \text{ m.}$$

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

$$R = |A-B|$$

$$R = 4-3 = 1 \text{ m}$$

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

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

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

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

Addition of more than two vectors

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

