Units

MKS system

- M → Meters
- K → Kilograms
- S → Seconds

Property	Unit	Other Name for Unit	Abbreviation
length	meter		m
mass	kilogram		kg
time	second		s
force	kilogram $\frac{\text{meter}}{\text{second}^2}$	Newton	N
energy	kilogram $\frac{\text{meter}^2}{\text{second}^2}$	Joule	J

Motion in 1 Dimension

x = position of an object

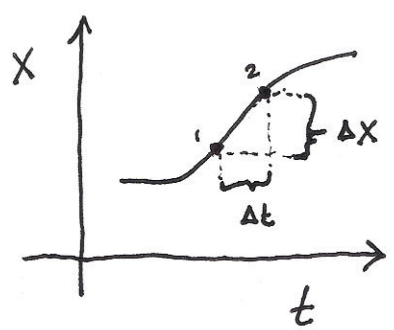
$\Delta x = x_2 - x_1$ = displacement [Δ = "change in"]

$\Delta t = t_2 - t_1$ = time interval

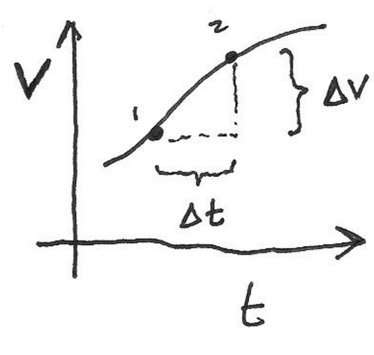
v = velocity $= \dfrac{\Delta x}{\Delta t}$

Δv = change in velocity $= v_2 - v_1$

a = acceleration $= \dfrac{\Delta v}{\Delta t}$



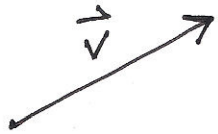
$v = \dfrac{\Delta x}{\Delta t}$ = slope of x vs. t graph



$a = \dfrac{\Delta v}{\Delta t}$ = slope of v vs. t graph

Vectors

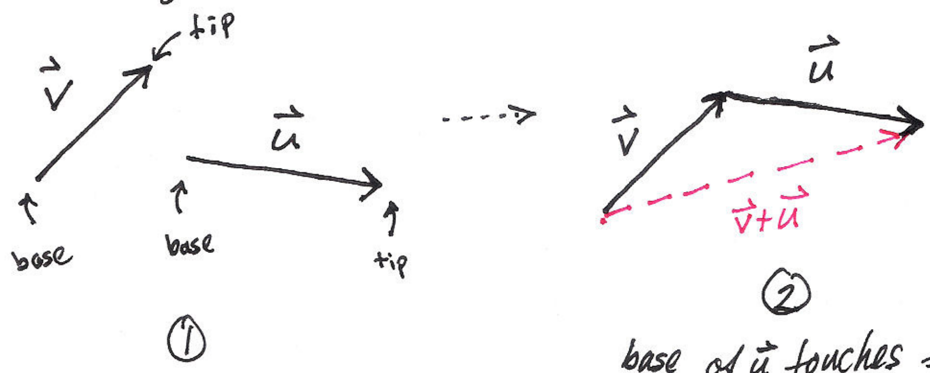
A mathematical entity possessing both a magnitude and a direction



magnitude of vector $\vec{v}$ is its length.
direction is direction in which $\vec{v}$ points

Addition

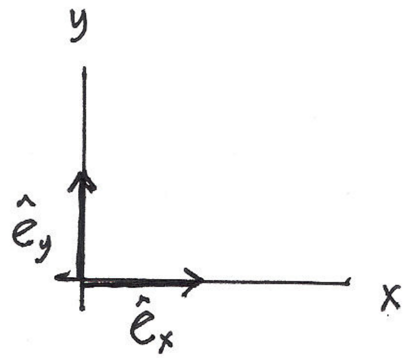
To add $\vec{v}$ and $\vec{u}$, slide $\vec{u}$ (without changing the direction in which it points) so that its base touches the tip of $\vec{v}$.



$\vec{v}+\vec{u}$ (red) is the vector joining the base of $\vec{v}$ and the tip of $\vec{u}$.

$\vec{v}+\vec{u} = \vec{u}+\vec{v}$ for any vectors $\vec{v}$ and $\vec{u}$.

Unit Vectors



$\hat{e}_x$ = unit vector pointing in x direction

$\hat{e}_y$ = " " " " y "

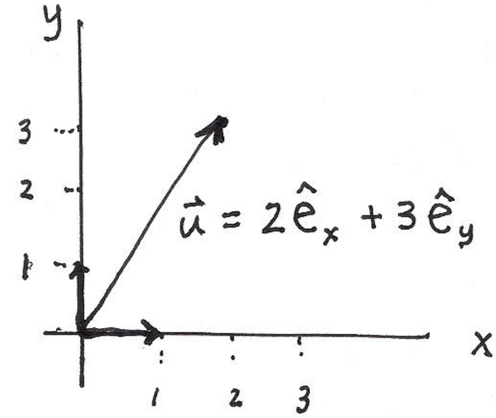
$$|\hat{e}_x| = |\hat{e}_y| = 1,$$

where $|\vec{v}| = v$ = length of $\vec{v}$

Any vector can be expressed in terms of unit vectors.

$$\vec{v} = v_x \hat{e}_x + v_y \hat{e}_y$$

where v_x and v_y are numbers called, respectively, the x and y components of $\vec{v}$ [Technically, $v_x \hat{e}_x$ and $v_y \hat{e}_y$ are the true components]



Addition Again

$$\vec{v} = v_x \hat{e}_x + v_y \hat{e}_y \quad , \quad \vec{u} = u_x \hat{e}_x + u_y \hat{e}_y$$

$$\vec{v} + \vec{u} = (v_x + u_x)\hat{e}_x + (v_y + u_y)\hat{e}_y$$

Example $\quad \vec{v} = -\hat{e}_x + 2\hat{e}_y , \quad \vec{u} = 4\hat{e}_x - 3\hat{e}_y$

$$\vec{v} + \vec{u} = (-1 + 4)\hat{e}_x + (2 - 3)\hat{e}_y$$

$$= 3\hat{e}_x - \hat{e}_y$$

Kinematic Equations

Describe motion of objects that undergo a constant acceleration

① Position as a function of time

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

x_0 = position at $t=0$

v_0 = velocity at $t=0$

a = constant acceleration

② Velocity as a function of time

$$v = v_0 + at$$

③ Velocity as a function of position

$$v = \sqrt{v_0^2 + 2a(x - x_0)}$$

Derived from ① & ②.

Useful forms ($x_0 = 0$, $v_0 = 0$)

$x = \frac{1}{2} a t^2$

$v = at$

$v = \sqrt{2ax}$

When an object is accelerated by gravity near the surface of the earth,

$$a = g = 9.8\ m/s^2$$