Measurement

Basic physical quantities:

1. Length (L) → SI units ≡ meter (m).
2. Mass (m) → SI units = Kilogram (Kg)
3. Time (t) → SI units ≡ second (s)

atomic mass unit
$1u = 1.66053886 \times 10^{-27}$ Kg

$$\boxed{\rho = \frac{Mass}{Volume} \quad \text{SI units} \Downarrow Kg/m^3}$$

Order of magnitude → Estimation

Example: ① Estimate how many times your heart beats in 10 years?

$70 * 10 * 365 * 24 * 60 \approx 3.68 \times 10^{8}$

→ order of magnitude 8

→ hundred of millions

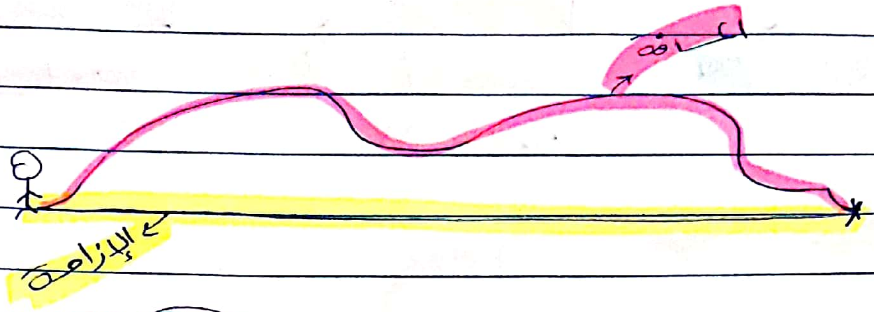
② " " " " " " beats from brith to death an average person?

$3.68 \times 10^{8} \times 7$ → thousand of millions

"Motion along a straight Line"

→ **Displacement** $(\vec{\Delta x})$ → vector $\left(\vec{\Delta x} = x_f - x_i\right)$

→ **distance** (d) → scalar



$$* \ \vec{\Delta x} = x_2 - x_1$$

كمية متجهة ✓ Average velocity ⇒ $\vec{V}_{avg} = \dfrac{\vec{\Delta x}}{\Delta t}$

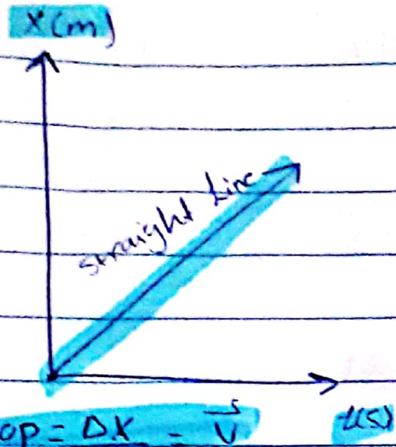
كمية قياسية ✓ Average speed ⇒ $S_{avg} = \dfrac{\text{total distance}}{\Delta t}$

SI units meter/second (m/s)

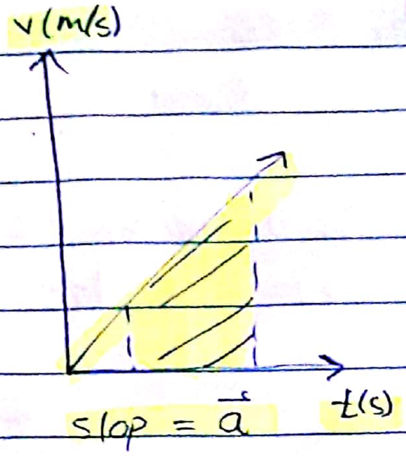
Instantaneous velocity: السرعة اللحظية ⇒ $\vec{V} = \dfrac{dx}{dt}$, أو slope at a certain point.

acceleration: التسارع ⇒ $\vec{a}_{avg} = \dfrac{\Delta \vec{V}}{\Delta t}$

Instantaneous acceleration: التسارع اللحظي ⇒ $\vec{a} = \dfrac{dv}{dt}$

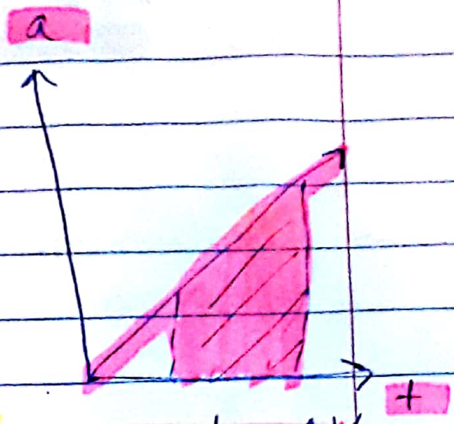


slop = $\frac{\Delta x}{\Delta t} = \vec{v}$



slop = $\vec{a}$

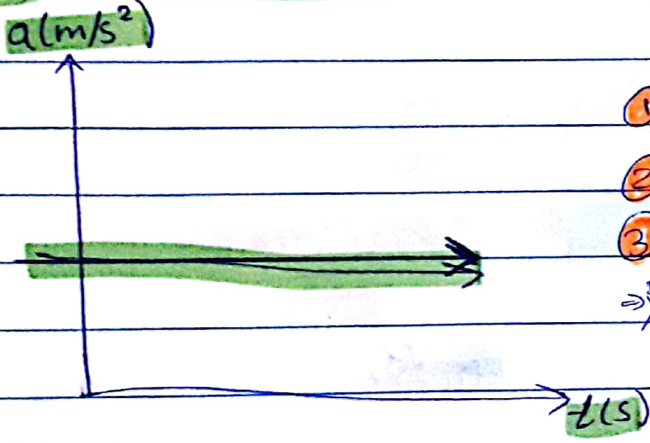
$V * t = \Delta X$



$a * t = \Delta V$

Special Case :-

→ Constant acceleration :- التسارع الثابت



1. $V - V_0 = at$
2. $X - X_0 = V_0 t + \frac{1}{2} a t^2$
3. $V^2 - V_0^2 = 2a \Delta X$

$\Rightarrow \cancel{X} \rightarrow \Delta X = \frac{1}{2} * \frac{V_0 + V}{t} \Rightarrow \Delta X = \frac{t(V_0 + V)}{2}$

$\rightarrow \Delta X = Vt - \frac{1}{2} a t^2$

prove! $a \equiv$ Constant

$\Delta V = \int a(t) \cdot dt$

$\Delta V = at$

Free fall → $V_0 = 0$ m/s

→ $g = 9.8$ dawnward $= -9.8 \ m/s^2$

↓ - y ⇐ 0 لذا

Vectors

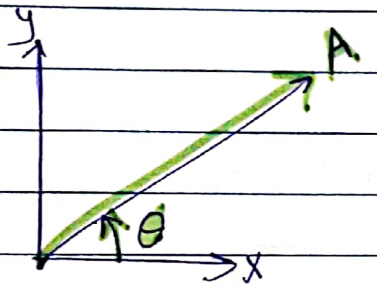
physical quantity

magnitude — direction

(Displacement
velocity / acceleration
force)

vector

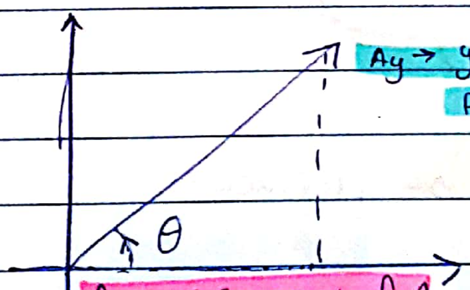
tail → head



counter clockwise
عكس عقارب الساعة

with clockwise
مع عقارب الساعة

* Companents of vectors :-



A_y → y component of A
projection A on y-axis

A_x → x component of A
projection A on x axis

$\vec{A}$: $A_x = |\vec{A}| \cos\theta$

$A_y = |\vec{A}| \sin\theta$

$|A| = \sqrt{A_x^2 + A_y^2}$

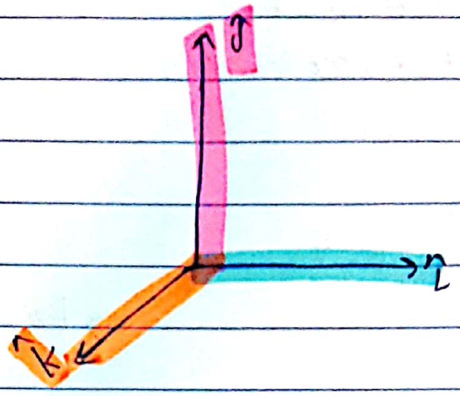
$|A|$ = طول vector A
"magnitude"

$\hat{i}$: unit vector along the x-axis

$\hat{j}$: unit vector along the y-axis

$\hat{k}$: unit vector along the z-axis

* $|\hat{i}| = |\hat{j}| = |\hat{k}| = 1$



Assume: $\vec{B} = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}$

$$|B| = \sqrt{(B_x)^2 + (B_y)^2 + (B_z)^2}$$

Multiplication of Vectors :-

① Scalar product or Dot product :

$\Rightarrow \vec{a}\cdot\vec{b} \equiv$ Scalar

$\Rightarrow |\vec{a}|\,|\vec{b}|\cos\theta = \vec{a}\cdot\vec{b}$ $\qquad$ θ: between $\vec{a}, \vec{b}$

Ex: $\vec{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$

$\vec{b} = b_x\hat{i} + b_y\hat{j} + b_z\hat{k}$

$\vec{a}\cdot\vec{b} = (a_x \cdot b_x) + (a_y \cdot b_y) + (a_z \cdot b_z)$

* $\hat{i} \cdot \hat{i} = \hat{j} \cdot \hat{j} = \hat{k} \cdot \hat{k} = 1$
* $\hat{i} \cdot \hat{j} = \hat{j} \cdot \hat{k} = \hat{k} \cdot \hat{i} = \text{zero}$

* ناتج الضرب النقطي عدد (مقدار) وليس متجه

② Vector product or Cross product :

$\vec{a} \times \vec{b} = \text{vector}$

$a \times b = |\vec{a}|\,|\vec{b}| \sin\theta \; \vec{C} \Rightarrow \vec{C} \perp \vec{a}$

$\vec{C} \perp \vec{b}$

* ناتج الضرب التقاطعي متجه عمودي على كلا المتجهين

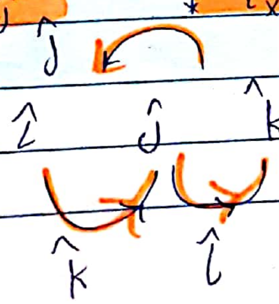
Ex: $\vec{a} = a_x \hat{i} + a_y \hat{j} + a_z \hat{k}$

$\vec{b} = b_x \hat{i} + b_y \hat{j} + b_z \hat{k}$

$$\vec{a} \times \vec{b} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ a_x & a_y & a_z \\ b_x & b_y & b_z \end{vmatrix}$$

$$\vec{a} \times \vec{b} = (a_y \times b_z - a_z \times b_y)\hat{i} - (a_x \times b_z - a_y \times b_x)\hat{j} + (a_x b_y - a_y b_x)\hat{k}$$

* $\hat{i} \times \hat{i} = \hat{j} \times \hat{j} = \hat{k} \times \hat{k} = \text{zero}$
* $\hat{i} \times \hat{j} = \hat{k}$
* $\hat{j} \times \hat{k} = \hat{i}$
* $\hat{k} \times \hat{i} = \hat{j}$
* $\hat{j} \times \hat{i} = -\hat{k}$
* $\hat{j} \times \hat{k} = -\hat{i}$
* $\hat{i} \times \hat{k} = -\hat{j}$



يمكنك إيجاد النواتج المقابلة منه خلال قاعدة اليد اليمنى.

$\boxed{*}$ find the angle between $\vec{R}$ & x-axis

$R = 2\hat{i} - 4\hat{j} - 2\hat{k}$

$\vec{R} \cdot \hat{i} = |R|\,|\hat{i}| \cos\theta \longrightarrow (1)$

$2 = \sqrt{4+16+4} * 1 * \cos\theta$

$\cos\theta = \frac{2}{\sqrt{24}} = 0.40824829$

$\theta \approxeq 66^\circ$

Ex. $\vec{A} \cdot (\vec{A} \times \vec{B}) = ??$

$\vec{A} \times \vec{B} = C \quad , \quad C \perp A$

$C \perp B$

so $\Rightarrow \vec{A} \cdot (\vec{A} \times \vec{B}) = \text{zero}$

Motion in 2D & 3D

Q3
$$\vec{\Delta r} = 2\hat{i} - 4\hat{j} - 8\hat{k}$$
$$\vec{r} = 4\hat{j} - 5\hat{k}$$
$$\vec{\Delta r} = \vec{r_f} - \vec{r_i}$$
$$2\hat{i} - 4\hat{j} + 8\hat{k} = 4\hat{j} - 5\hat{k} - \vec{r_i}$$
$$\vec{r_i} = -2\hat{i} + 8\hat{j} - 13\hat{k}$$

project motion

* it is a motion in 2 direction

x- motion, horizantal ($\hat{i}$)

- velocity V_x
  - $* \; V_x = V_0 \cos\theta_0$ « constant »
- Δx, $x - x_0$
  - $* \; x - x_0 = V_x t$
  - $\Rightarrow x - x_0 = V_0 \cos\theta_0 t$

y- motion, vertical ($\hat{j}$)

$a_y = g$

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

- Velocity V_y
  - $* \; V_{0y} = V_0 \sin\theta_0$
  - $* \; V_y\big|_t = V_{0y} - gt$
  - $* \; V\big|_{\text{maximm } y} = 0$
- Δy, $y - y_0$
  - $* \; y - y_0 = V_{0y} t + \frac{1}{2} a_y t^2$
  - $\Rightarrow y = V_0 \sin\theta_0 t - \frac{1}{2} g t^2$

$$* \; \vec{V} = V_x \hat{i} + V_y \hat{j}$$

$* \; y = V_0 \sin\theta_0 t - \frac{1}{2} g t^2$

$* \; x = V_0 \cos\theta_0 t$

$\rightarrow y = V_0 \sin\theta_0 \left(\frac{x}{V_0 \cos\theta_0}\right) - \frac{1}{2} g \frac{x^2}{V_0^2 \cos^2\theta}$

$\rightarrow y = \tan\theta_0 x - \left(\frac{g \, x^2}{2 V_0^2 \cos^2\theta_0}\right)$

* horizantal range:

$\Rightarrow R = V_x t = V_0 \cos\theta_0 t_{hight}$

to find it $\Rightarrow y - y_0 = V_{0y} t + \frac{1}{2} a_y t^2$

$0 = V_0 \sin\theta_0 t_f + \frac{1}{2} * -g t_f^2$

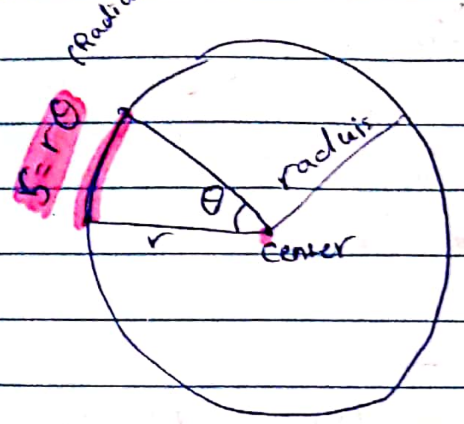
$t_f = \frac{2 V_0 \sin\theta_0}{g}$

$\Rightarrow R = V_0 \cos\theta_0 \frac{2 V_0 \sin\theta_0}{g}$

$\Rightarrow R = \frac{V_0^2 \sin 2\theta_0}{g}$ → the biggest « max range » is when $2\theta = 90°$, $\theta = 45°$

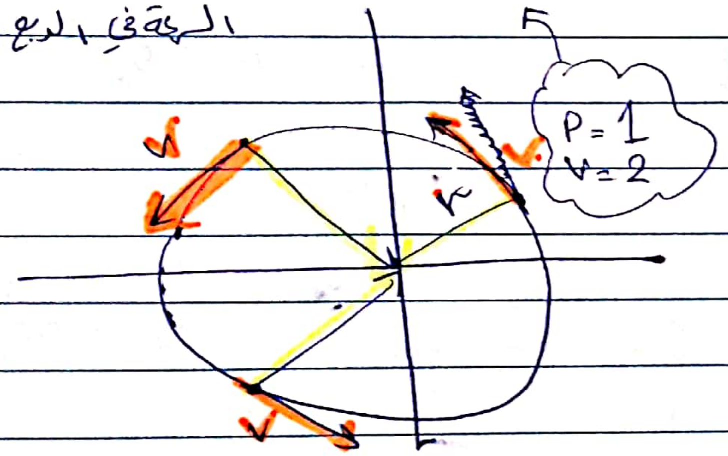
Uniform Circular Motion

حركة دائرية منتظمة



→ Circumference = $2\pi r$ ⇒ One revolution

أي أن موضع النقطة في الربع الأول ولكن متجه
السرعة في الربع الثاني



* V: Constant in magnitude
Changing in direction
* a: toward the Center of the Circle

$\vec{a} \perp \vec{V}$ always

$a = \frac{V^2}{r}$

Period ≡ الزمن الدوري

→ $T = \frac{2\pi r}{V}$

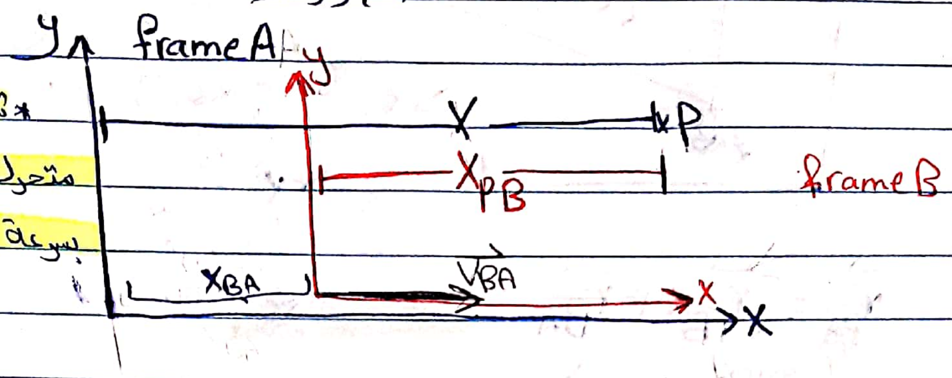
* T: periodic time

⇒ frequency = $\frac{1}{T}$

Relative Motion (1D)

* Reference frame : إطار مرجعي

* ثابت بالنسبة له ^هم
متحرك بالنسبة لـ frame B
بسرعة $\vec{V}_{BA}$



$\vec{V}_{BA}$: relative velocity of the two france
or velocity of frame B relativ. to A.

* الإزاحة السينية لـ P بالنسبة لـ frame A هو X
* " " " P " frame B هو X_{PB}
* الإزاحة الصادية لـ P بالنسبة لـ frame (B & A) هو نفسه
في الحالتين لأن $\vec{V}_{BA}$ باتجاه محور السينات
↓
السرعة النسبية

* X_{BA} : الإزاحة بين frame B عن frame A

$$X_{PB} + X_{BA} = X_{PA}$$

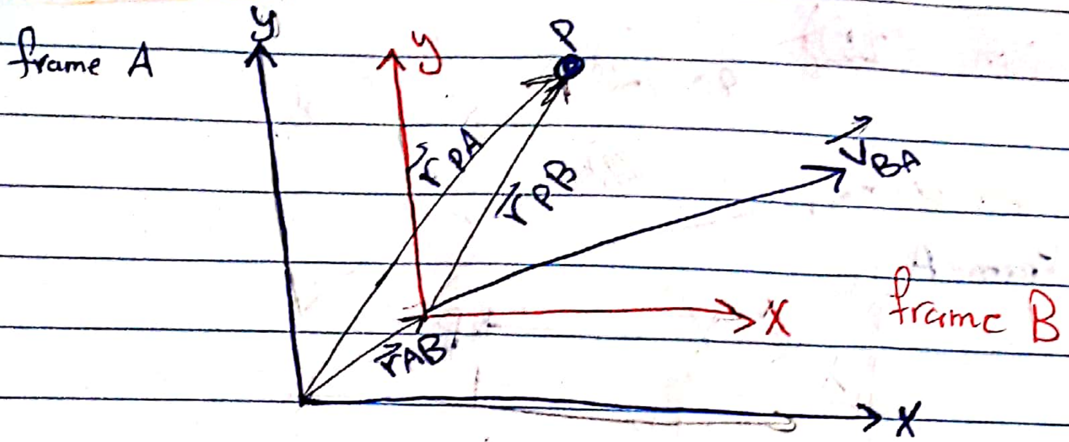
$$\frac{dx_{PB}}{dt} + \frac{dx_{BA}}{dt} = \frac{dx_{PA}}{dt}$$

$$V_{PB} + V_{BA} = V_{PA}$$

$$\frac{dV_{PB}}{dt} + \underbrace{\frac{dV_{BA}}{dt}}_{zero} = \frac{dV_{PA}}{dt}$$

$$\vec{a}_{PA} = \bar{a}_{PB}$$, لأن السرعة النسبية ثابتة

"2D"



$$\vec{r}_{PA} = \vec{r}_{PB} + \vec{r}_{BA} \longrightarrow *$$

$$\vec{V}_{PA} = \vec{V}_{PB} + \vec{V}_{BA} \longrightarrow *$$

$$\bar{a}_{PA} = a_{PB} \longrightarrow *$$

Because $\vec{V}_{BA}$ is Constant!

Force & motion I

* Newton's laws:

Newton's first law

* if no net force acts on a bodys the body's Velocity Can't be chang
* the body Can't change its State.
* This law called "the law of inercta".

Newton's second law

* $\vec{F}_{net}$ Causes the change in $\vec{V}$.
* F_{net} Causes the Chang in body's State
* $\vec{F}_{net} = m\vec{a}$, $\frac{kg.m}{s^2}$

$\rightarrow \vec{a} = \frac{\Delta\vec{V}}{\Delta t}$

Newton's third law

* For every action there's a reaction equalsin magntuid and opposite in direction.

Forces

1. weight $= mg$

$\vec{W} = m\vec{g}$

2. normal force.

3. friction force

4. Tension force.