□ Lecture 1 - brushup:

- scalars have magnitude only, mass and speed are always +ve [the speedometer will show +ve number when you drive in reverse], temperature might be ±ve.
- vectors have both mag. and direction.

In graphical method, the vector sum of vectors is represented by the closing side of the polygon.

□ Today's lecture: the 2nd method of vector addition:

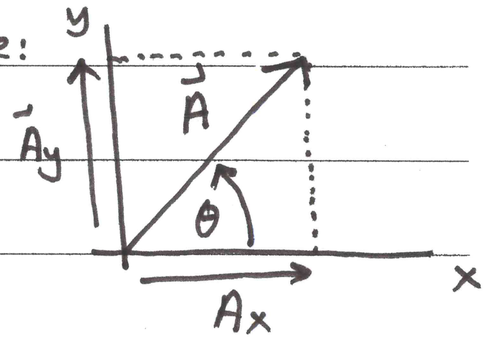
The vector's components (مُرَكَّبَات المتجِه):

$\vec{A}$ has 2 components in the xy plane:

$\vec{A} = \vec{A}_x + \vec{A}_y$ → (إسقاط)

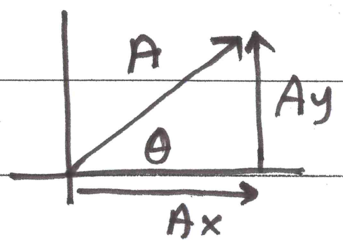
$\vec{A}_x$ = projection of $\vec{A}$ onto the x-axis.

$\vec{A}_y$ = " " " " " y-axis



Our convention for θ: C.C.W. with respect to the +ve x-axis

<u>Recall</u> Pythagorean theorem:



$A_x = A\cos\theta$, $A_y = A\sin\theta \Rightarrow A^2 = A_x^2 + A_y^2$

$\tan\theta = \dfrac{A_y}{A_x}$, $A = \sqrt{A_x^2 + A_y^2}$

$\theta = \tan^{-1}\left[\dfrac{A_y}{A_x}\right]$

- If $\vec{A}$ has 3 components, : $\vec{A} = \vec{A}_x + \vec{A}_y + \vec{A}_z$, then $A = \sqrt{A_x^2 + A_y^2 + A_z^2}$. Cartesian coordinates (x, y)

- Example: Take $\vec{A} = (+3, -3)$, $\vec{B} = (+1, -4)$, $\vec{C} = (-2, +5)$. Let $\vec{D} = -\vec{A} - \vec{B} + \vec{C}$. Calculate $|\vec{D}|$ and determine its direction: $\vec{D} = \vec{D}_x + \vec{D}_y \Rightarrow \vec{D}_x = -\vec{A}_x - \vec{B}_x + \vec{C}_x = -6$

$\vec{D}_y = -\vec{A}_y - \vec{B}_y + \vec{C}_y = +12 \Rightarrow \therefore |\vec{D}| = \sqrt{D_x^2 + D_y^2} \cong 13.4$

$\theta = \tan^{-1}\left(\frac{D_y}{D_x}\right) = \tan^{-1}\left(\frac{+12}{-6}\right) = \tan^{-1}(-2) \cong -63.4°$; hmm....!

$\vec{D} = (-6, +12) \Rightarrow \vec{D}$ lies in the 2^{nd} quadrant, thus

$\theta = 180° + (-63.4°) = 116.6°$.

- Assignment: do problem 3.9 (i.e. chapter 3 problem 9).

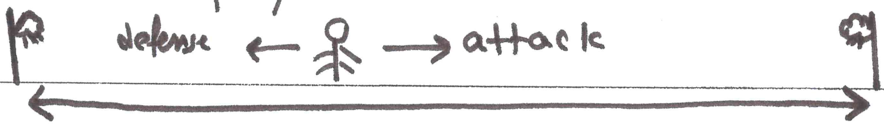
Chapter 2: Kinematics & Chapter 4: Dynamics

Kinematics: How objects move? Description of motion: $\vec{x}, \vec{v}, \vec{a}$

Dynamics: Why objects move? Cause of motion: $\vec{F}$

The main theme of ch2 is to study the kinematics in 1 dimension. One dimension $\equiv$ Two directions.

□ Consider a basketball player shares duties in attack and defense :



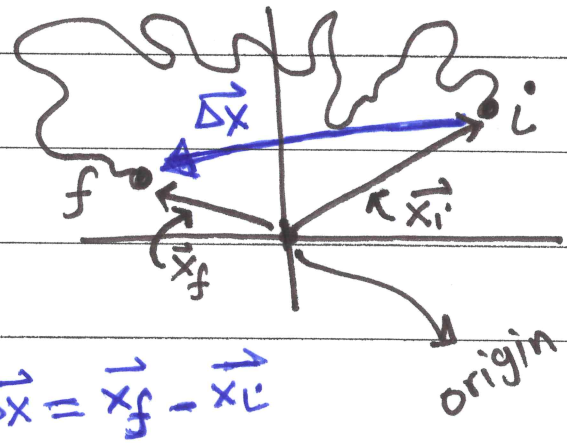
d = length of the court

• The "distance" traveled [or travelled !] by = $d + d$ = $2d$ m. We define the distance as a scalar, and it is always +ve. However, the "displacement" (الإزاحة) of = d (east, right, +ve x-axis) → during attack
$\oplus$ d (west, left, −ve x-axis) → during defense
= zero ! $\oplus$ is a vector sum ! $\oplus$ is algebraic sum

Displacement is a vector quantity ≡ represents the change in position of an object.

$\Delta\vec{x}$ ≡ displacement of = 0 ⇒ because returned back to the place where (he/she) began.

• $\vec{x}_i$ = initial position vector
• $\vec{x}_f$ = final position vector
• distance = the length of the wiggly path ⇒ always +ve.



• displacement ≡ $D\vec{x}$: ($\Delta\vec{x}$) ⇒ $\Delta\vec{x} = \vec{x}_f - \vec{x}_i$

if $D\vec{x}$ ⇒ right ⇒ +ve, if $D\vec{x}$ ⇒ left ⇒ −ve

- Speed is the time rate of distance, $v = \frac{\text{distance traveled}}{\text{time}}$
  ⇒ speed is always +ve, SI unit = m/sec.
- Velocity is the time rate of displacement, $\boxed{\vec{V} = \frac{\Delta\vec{x}}{\Delta t}}$
  if $\Delta\vec{x}$ +ve (⚽ is in attacking position), then $\vec{v}$ is +ve, while if $\Delta\vec{x}$ is −ve (⚽ is in defending position), $\vec{v}$ is −ve.
- $\vec{V} = \frac{\Delta\vec{x}}{\Delta t}$ is the "average" velocity during the time interval Δt. The "instantaneous" velocity is calculated at certain instant "moment". The instantaneous velocity is the theme of sec 2.3. It can be determined by using calculus. PHY 105 is algebra-based course, so we can safely skip section 2.3!
- Past exam: The position of an object of mass 3 kg is given by $x(t) = 3 - 4t + 2t^2$, where x is in m, and t is in sec. Calculate the average velocity during the time from $t_i = 1$ sec to $t_f = 3$ sec.

* Before tackling the problem, what is the unit of the number "4" in the function x(t)?

⇒ Read sec 1.8 in your text.

$\vec{V}_{ave} = \frac{\Delta \vec{X}}{\Delta t} = \frac{X(3) - X(1)}{3-1} = +4 \frac{m}{sec}$. You better consult your 4th grade math teacher; Ms. Dalal, if you have different answer! What about the mass?

- Acceleration (التسارع): If a driver is speeding up or slowing down, then it is said that the driver is accelerating. The acceleration $\vec{a}$ is defined as the time rate of velocity; $\Delta \vec{V}$.

$\vec{a} = \frac{\Delta \vec{V}}{\Delta t}$, the SI unit $= m/sec^2$.

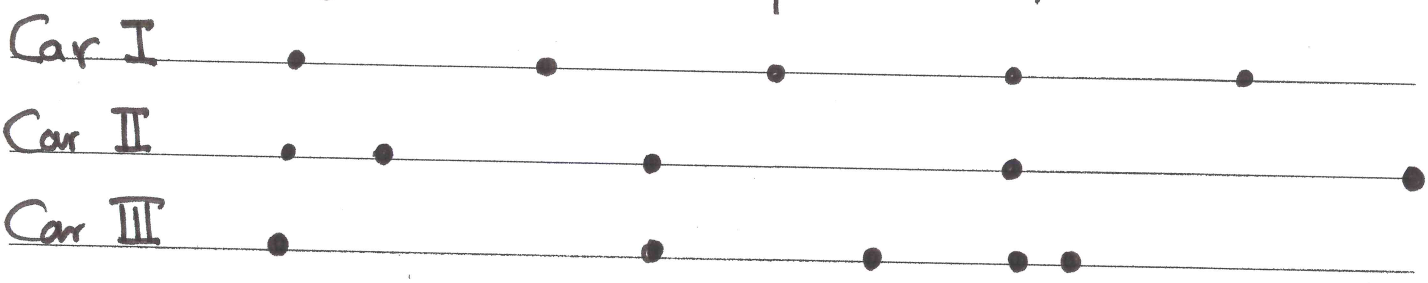
$\Rightarrow$ $\vec{a} = +5\, m/sec^2$ means that $\vec{V}$ increases every 1 sec by $5\, m/sec^1$. $\Rightarrow$ $\vec{a} = +5\, m s^{-2}$ and $\vec{V}$ at $t = 7 sec$ equals $+13\, m s^{-1}$, then $\vec{V}$ at $t = 8 sec$ is $13 + 5 = 18\, m s^{-1}$.

$\Rightarrow$ $\vec{a} = -4\, m s^{-2}$ and $\vec{V}$ at $t = 4 sec$ is $+43\, m s^{-1}$, then $\vec{V}$ at $t = 5 sec$ is: $+43\, m s^{-1} + (-4\, m s^{-1}) = 39\, m s^{-1}$.

$\Rightarrow$ if $\vec{a} = 0$, then $\Delta \vec{V} = 0$, $\vec{V}_f - \vec{V}_i = 0 \Rightarrow \vec{V}_f = \vec{V}_i$

$\Rightarrow$ Recall from lecture 1: two vectors are equal iff $|\vec{V}_f| = |\vec{V}_i|$ and both point to the same direction, i.e. if $\vec{a} = 0$, the object is moving with constant speed in a straight line (in one direction)!

□ Example: The positions of 3 cars, traveling towards east, every 1 second are represented by dots as shown.



Describe the motion for each car.

- $\Delta\vec{x}$ (for east) is +ve (all are traveling to the east).
- $\vec{v}$ at any time is +ve for the 3 cars.
- $\vec{a}$ for car I = zero $\Rightarrow$ $\vec{v}$ is constant. [$\vec{v}$ +ve, $\vec{a} = 0$]
- $\vec{a}$ for car II is +ve $\Rightarrow$ speeding up. [$\vec{v}$ +ve, $\vec{a}$ +ve]
- $\vec{a}$ for car III is −ve $\Rightarrow$ slowing down. [$\vec{v}$ +ve, $\vec{a}$ −ve].

$\Rightarrow$ If you press the gas pedal while driving in reverse i.e. speeding up to the west, then $\Delta\vec{v}$ = −ve and thus $\vec{a}$ = −ve! "Deceleration" is a misleading term!

∴ Deceleration does NOT necessarily mean that the acceleration is −ve: If you press the brake pedal while driving in reverse, then $\vec{a}$ is +ve!

■ Problem 2.9 :  is jogging 8 rounds, each = 400m, during time: 14.5 min. Calculate:

i) average speed = total distance traveled / time elapsed

$= 8 * 400\,m / 14.5 * 60\,sec = (\,)\,ms^{-1}$

ii) average velocity ⇒ right off = zero !!

Recall page 3 ⇒ basket ball player: displacement = zero.

■ Past exam : A car moves 40 km at an average speed of $80\,kmh^{-1}$ and then moves 40 km at an average speed of $40\,kmh^{-1}$. The average speed for this 80 km trip is:

[$40\,kmh^{-1}$, $53\,kmh^{-1}$, $48\,kmh^{-1}$, $80\,kmh^{-1}$, $45\,kmh^{-1}$] ?

⇒ speed = total distance / total time. ⇒ $V = \frac{80\,km}{t}$

∴ Apparently the problem is to calculate t.

$(40\,km, 80\,kmh^{-1}) \Rightarrow t = \frac{1}{2}h$, $(40\,km, 40\,kmh^{-1}) \Rightarrow t = 1h$,

then $V = (160/3)\,kmh^{-1} \simeq 53\,kmh^{-1}$.

■ Past exam : A jet flies at 300 mi/h south for 2h and then at 250 mi/h north for 750 miles. The average speed for the trip is:

260 mi/h, $\underbrace{\text{270 mi/h}}_{\checkmark}$, 275 mi/h, 280 mi/h