$* \frac{m}{s} = m/s = m \cdot s^{-1}$ AND $\frac{m}{s^2} = m/s^2 = m \cdot s^{-2}$

Notes

PHYSICS 11

KINEMATICS

Kinematics is a branch of physics that studies the motion of objects without considering the forces that caused the motion.

- Kinematics of an objects are the features or properties of motion of that object
- Kinematics is a branch of mechanics

Motion of an object can be described using words, diagrams, graphs, equations, vectors, and/or numbers with appropriate units.

Kinematics Quantities:

Name	Symbol	Base unit	S = scalar/V=vector
displacement	$\vec{d}$	meter [m]	V
distance	d	meter [m]	S
speed	$v = V$	$\frac{\text{meter}}{\text{second}} = [\frac{m}{s}]$	S
velocity	$\vec{v} = \vec{V}$	$\frac{\text{meter}}{\text{second}} = [m \cdot s^{-1}]$	V
acceleration	a and $\vec{a}$	$\frac{\text{meter}}{\text{second}^2} = [m/s^2]$	S and V
time	t	second = [s]	S

Displacement

- Displacement describes how far and where an object is from the reference point or from its initial position.
- Displacement is a vector quantity.
- When an object moves without changing direction the magnitude of the displacement is distance.
- When an object moves while changing its direction the magnitude of the displacement vector may be very different from the distance covered.
- Displacement can be positive, negative or zero.

To calculate (change in) displacement:

$$\Delta\vec{d} = \vec{d_f} - \vec{d_i}$$

! Consider South the positive direction

Positive displacement	Negative displacement	Zero displacement
(A) - the objects ends further in positive direction (B) ! - the object ends closer in negative direction	(A) - The object ends further in negative direction. (B) - The object ends closer in positive direction.	(A) the object ends where it started from. (B) object remains at rest
(A) $\vec{d_i} = 5m\ [S]$ $\vec{d_f} = 15m\ [S]$ $\Delta\vec{d} = +10m\ [S]$ (B) $\vec{d_i} = -13m\ [S] = 13m\ [N]$ $d_f = -2m\ [S] = 2m\ [N]$ $\Delta\vec{d} = +11m\ [S]$	(A) $\vec{d_i} = -2m\ [S] = 2m\ [N]$ $\vec{d_f} = -10m\ [S] = 10m\ [N]$ $\Delta\vec{d} = -8m\ [S] = 8m\ [N]$ (B) $\vec{d_i} = 4m\ [S]$ $\vec{d_f} = 1m\ [S]$ $\Delta\vec{d} = 1-4 = -3m\ [S] = 3m\ [N]$	(A) going for a 5.0km jog from your house and returning to your home (B) Staying at home sitting on a sofa

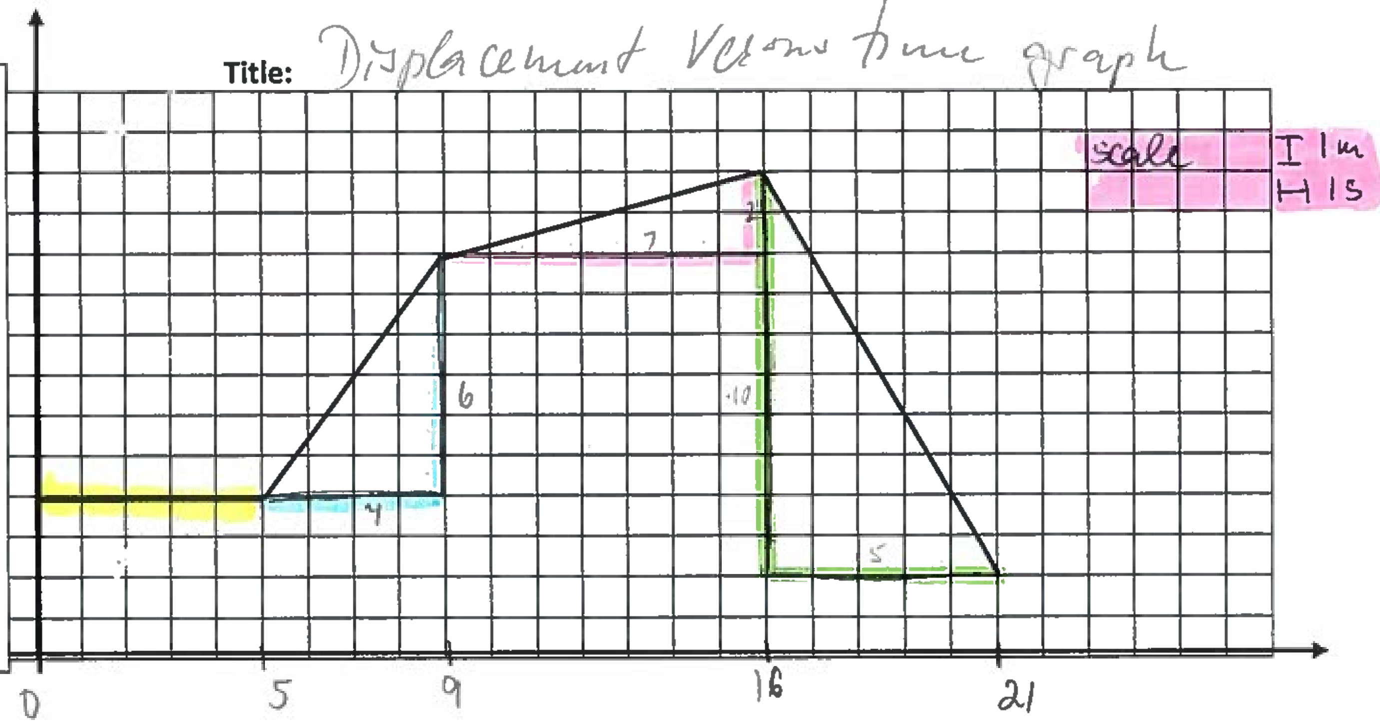
Displacement versus Time Graphs (d/t graphs)

- Displacement of an object often changes over time.
- Displacement versus Time or Position versus Time graphs are often used to describe the motion of an object.
- When describing the motion of an object using a graph focus on the following:
  1. Units associated with the horizontal axis (time)
  2. Units associated with the vertical axis (displacement)
  3. Direction of the positive vertical axes (North - N, South - S, West - W, East -E, down - D, up - U, right - R, left - L).
  4. Scale on the horizontal axis.
  5. Scale on the vertical axis.
  6. Initial = starting position of the object = how far and at what direction from the origin (or another reference point) was the object at the beginning of the time interval.
  7. Final = end position of the object = how far and at what direction from the origin (of another reference point) was the object at the end of the time interval.
  8. The length of the time interval: $\Delta t = t_f - t_i$
  9. Any possible changes in the direction of motion.
  10. Any possible changes in the steepness of the line: flat line = no motion, steep line = fast motion, shallow line = slow motion.
  11. Change in displacement.

d/t OR p/t

Title: Displacement versus time graph

y-axis label: quantity, units and direction displacement [m] WEST



x-axis label: quantity and unit time [s]

$* \vec{v} = 2 m/s$ [E]

Descriptor	Value	Descriptor	Value
Initial displacement	$\vec{d}_i = 4m$ [W]	Velocity for the first 5 s	$\vec{v} = 0 m/s$ [W]
Final displacement	$\vec{d}_f = 2m$ [W]	Velocity for t=(5,9]s	$\vec{v} = \frac{6}{4} = \frac{3}{2} = 1.5 m/s$ [W]
Initial time	$t_i = 0s$	Velocity for t=(9,16]s	$\vec{v} = \frac{2}{7} \doteq 0.29 m/s$ [W]
Final time	$t_f = 21s$	Velocity for t=(16,21]s	$\vec{v} = \frac{-10}{5} = -2 m/s$ [W] *
Change in displacement	$\Delta\vec{d} = 2-4 = -2m$ [W] $= 2m$ [E]	Object at rest.	yes; t=[0,5]s
Time interval	$\Delta t = 21-0 = 21s$	Object moves in positive direction.	yes; t=[0,16]s
Uniform or non-uniform motion?	non-uniform	Object moves in negative direction	yes; t=(16,21]s

Further notes: Uniform motion = motion without changes in direction and/or speed.

Non-uniform motion = motion with changes in either speed or direction or both.

Velocity

- **<u>Velocity is the rate of change in displacement</u>**.
- Velocity is a vector quantity.
- Magnitude of the velocity vector is speed.
- Velocity can be positive, negative or zero (zero displacement = object at rest).

To calculate change in velocity:

$$\Delta \vec{v} = \vec{v}_f - \vec{v}_i$$

To calculate final velocity:

$$\vec{v}_f = \vec{v}_i + at \equiv \vec{v}_i + a\Delta t$$

To calculate initial velocity:

$$\vec{v}_i = \vec{v}_f - at \equiv \vec{v}_f - a\Delta t$$

- Velocity is slope of the line in a displacement versus time graph.
  - Recall:

$$slope = m = \frac{rise}{run} = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$

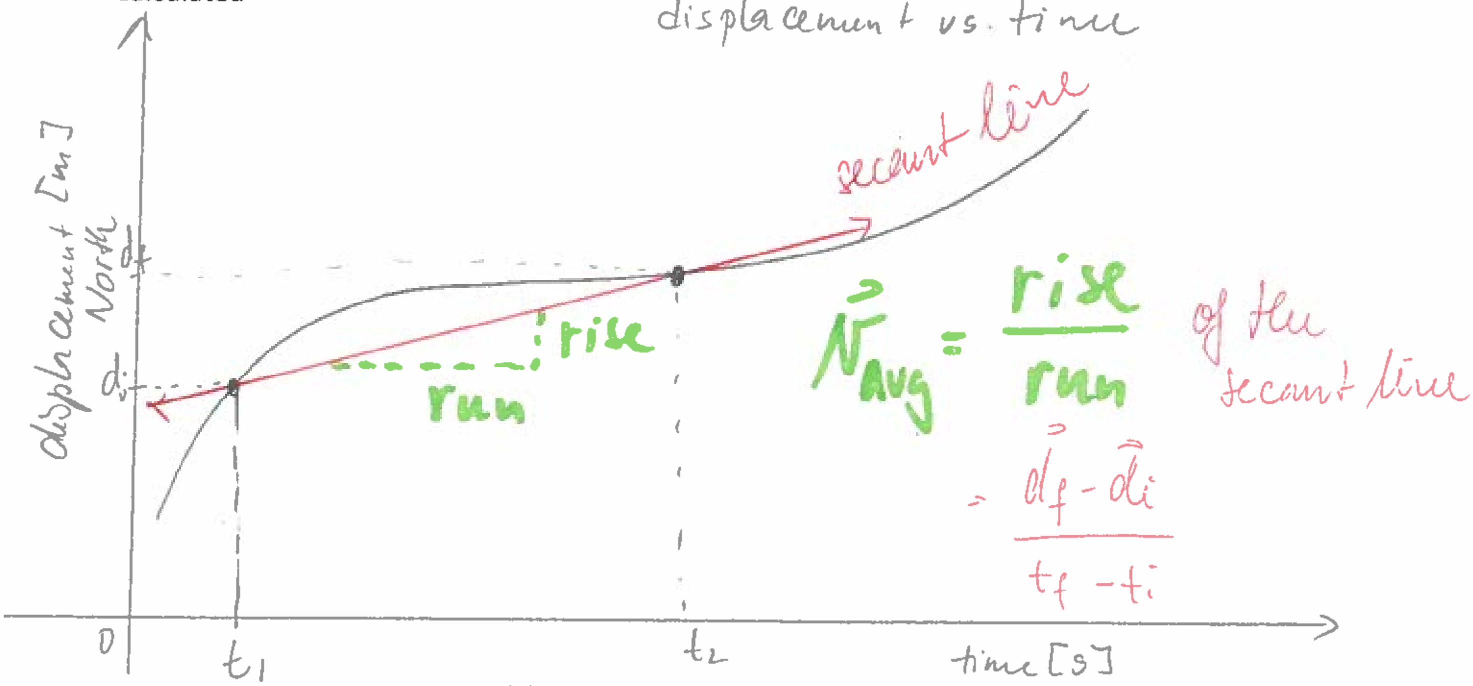
  - In kinematics:

$$\vec{v} = \frac{rise}{run} = \frac{\Delta \vec{d}}{\Delta t} = \frac{\vec{d}_f - \vec{d}_i}{t_f - t_i}$$

from a d/t graph

AVERAGE VELOCITY

- Average velocity is the slope of the secant line on the displacement vs. time graph
- When describing average velocity, it must be clear over what time interval was the average calculated



INSTANTANEOUS VELOCITY

- Instantaneous velocity is the slope of a tangent line on the displacement vs. time graph at a particular point (=time).
- Instantaneous velocity is measured at a particular instant in time.
- When describing instantaneous velocity, it must be clear what at what time was the instantaneous velocity measured.