SAFALTA CLASS™

An Initiative by अमर उजाला

Physics Intro & Kinematics

- Quantities
- Units
- Vectors
- Displacement
- Velocity
- Acceleration
- Kinematics
- Graphing Motion in 1-D

Some Physics Quantities

Vector - quantity with both magnitude (size) and direction

Scalar - quantity with magnitude only

Vectors:	Scalars:
• Displacement	• Distance
• Velocity	• Speed
• Acceleration	• Time
• Momentum	• Mass
• Force	• Energy

Mass vs. Weight

Mass

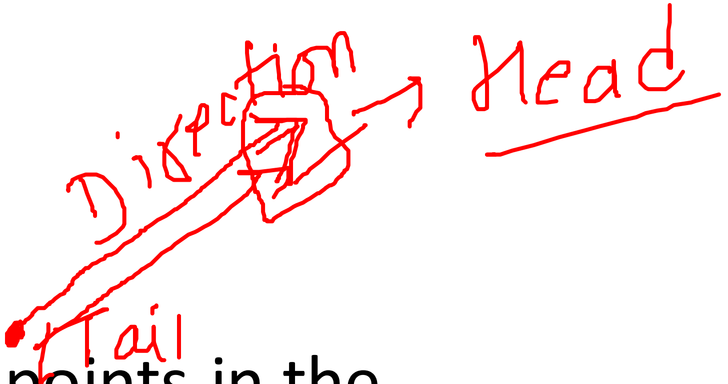
- Scalar (no direction)
- Measures the amount of matter in an object

Weight

- Vector (points toward center of Earth)
- Force of gravity on an object

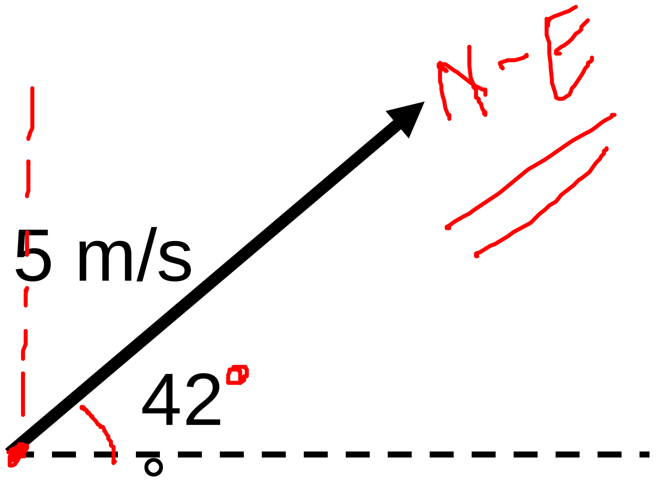
On the moon, your mass would be the same, but the magnitude of your weight would be less.

Vectors



Vectors are represented with arrows

- The length of the arrow represents the magnitude (how far, how fast, how strong, etc, depending on the type of vector).
- The arrow points in the directions of the force, motion, displacement, etc. It is often specified by an angle.



UNIT → Phy. Quant. measure

① Fund. Unit → independ ⇒ 7

② Derived Unit → Depend (fun. unit)

① Length → meter (m)

② mass → kg

③ Time → sec

④ Temp → k

⑤ E. current → amp

⑥ L. Intensity → cd

⑦ Am of sub → mol

(2) Supp. Units :- (i) Rad → Angle

(b) π → R

(ii) St rad → Gaussian Th. → Solid Angle

(3) Derived → Speed = Dist / Time = m / s

Force = m · a =

a → Δu / Δt

① Small Length :-

m → L

cm → 10^{-2} m

μm → 10^{-6} m

mm → 10^{-3} m

nm → 10^{-9} m

fm / Fermi → 10^{-15} m (nucleus Rad)

1 Fermi

1 Å = 10^{-10} m

↓

λ (wavelength)

(2) Large Length :-

AU → Astro. Unit → sun → earth

$c = 3 \times 10^8$ m/s

LY = Distance (c) → 1 year

Solar

Parsec = (Largest unit)

P. > LY > AU

1 LY = 9.47×10^{15} m

1 Parsec = 3.46 LY

1 AU = 1.496×10^{11} m

* mass: Kg ⇒ 1 chandrsh. Limit (mass)

✓ White Dwarf ⇒ 1 C.L ⇒ 1.4 × (mass of Sun)

* Time:-

$1 \mu s = 10^{-6} s$

$1 ms = 10^{-3} s$

$1 ns = 10^{-9} s$

$1 ps = 10^{-12} s$

Dimension (विमा) ⇒ [ ] math.

(1)

- * Length ⇒ m ⇒ [L]
- * Mass ⇒ Kg ⇒ [M]
- * Time ⇒ sec ⇒ [T]
- * Temp ⇒ kel ⇒ [θ, K]
- * Current ⇒ amp ⇒ [A]
- * L. I. ⇒ cd ⇒ [cd]
- * A. of S. ⇒ mol ⇒ [mol]

$v = \frac{D}{t} = \frac{[L]}{[T]} = [LT^{-1}]$

$P = \frac{F}{A} = \frac{[MLT^{-2}]}{[L^2]} \quad [L^{-2}]$

$= [ML^{-1}T^{-2}]$

Area = $l \times b$

$= [L][L]$

Force = ma = $[M][LT^{-2}]$

$= [MLT^{-2}]$

$a = \frac{\Delta v}{\Delta t} = \frac{[LT^{-1}]}{[T]} = [LT^{-2}]$

* Electric current, charge

$q = it$

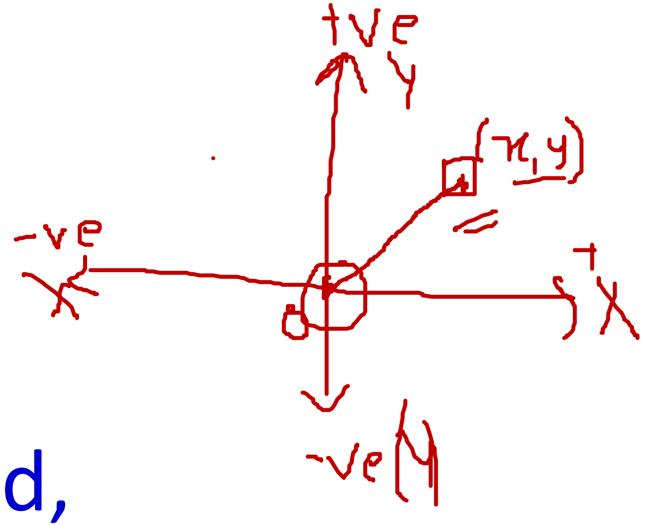
$\Rightarrow i = \frac{q}{t} \Rightarrow$

$= [A]$

Kinematics definitions

- Kinematics – branch of physics; study of motion

- Position (***x***) – where you are located

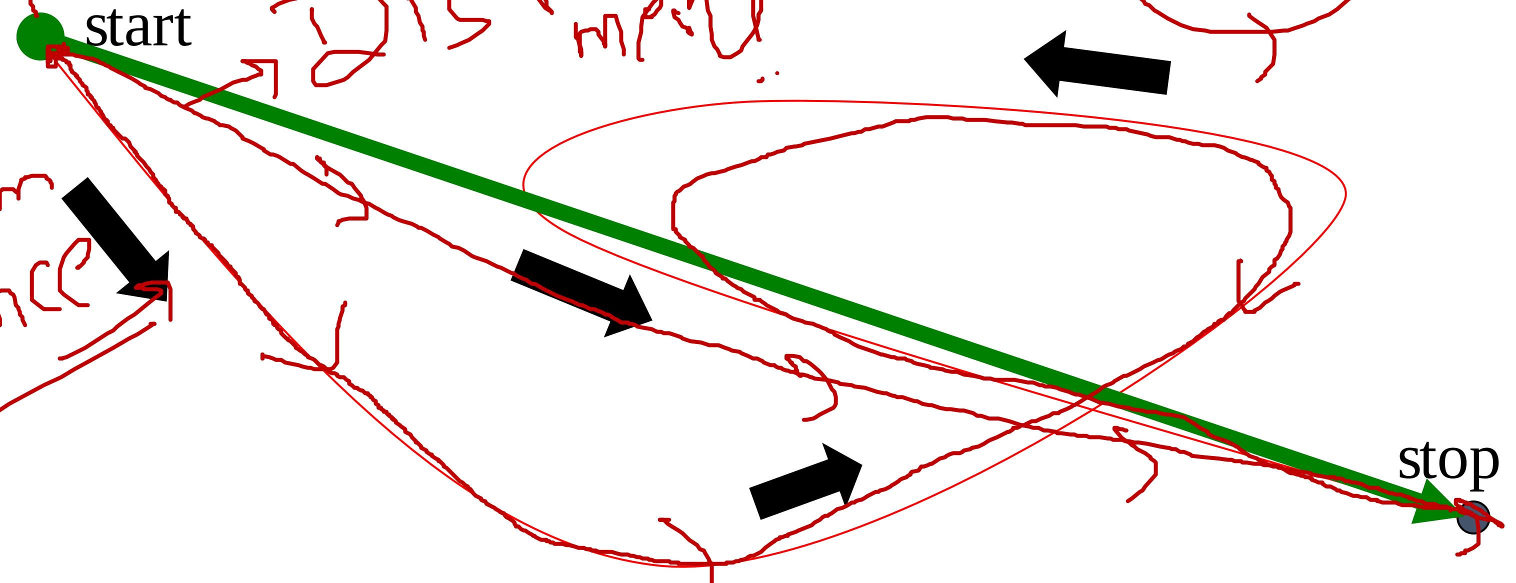


- Distance (*d*) – how far you have traveled, regardless of direction

- Displacement (Δ***x***) – where you are in relation to where you started

Distance vs. Displacement

- You drive the path, and your odometer goes up by 8 miles (your distance).
- Your displacement is the shorter directed distance from start to stop (green arrow).
- What if you drove in a circle?



Let's Practice!

REMEMBER:

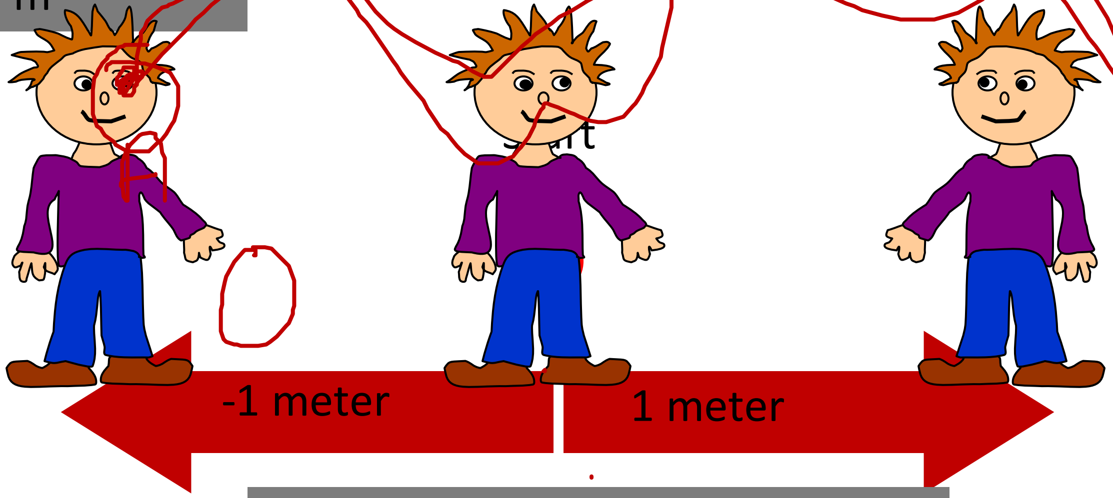
- "Distance" is how far you have gone
- "Displacement" is how far you are from the starting point

Distance = 3 m

Displacement = - 1 m

Distance = 1 m

Displacement = + 1 m



Dis Distance = 4 m

Dis Displacement = 0 m

Speed, Velocity, & Acceleration

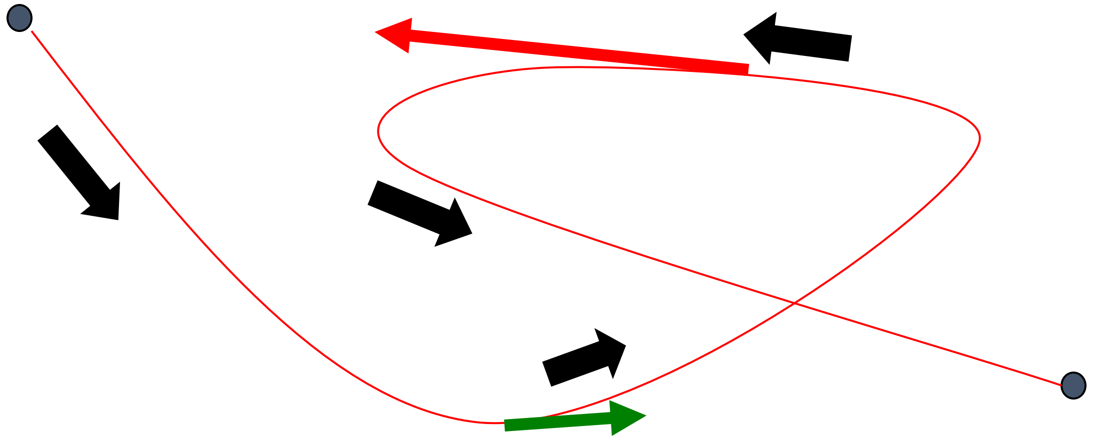
- Speed (v) – how fast you go
- Velocity ($\boldsymbol{v}$) – how fast and which way; the rate at which position changes
- Average speed (v) – distance/time
- Acceleration ($\boldsymbol{a}$) – how fast you speed up, slow down, or change direction; the rate at which velocity changes

Speed vs. Velocity

- Speed is a scalar (how fast something is moving regardless of its direction).
  Ex: v = 20 mph
- Speed is the magnitude of velocity.
- Velocity is a combination of speed and direction. Ex:
  $\mathbf{v}$ = 20 mph at 15° south of west
- The symbol for speed is v.
- The symbol for velocity is type written in bold: $\mathbf{v}$ or hand written with an arrow: $\vec{v}$

Speed vs. Velocity

- During your 8 mi. trip, which took 15 min., your speedometer displays your instantaneous speed, which varies throughout the trip.
- Your average speed is 32 mi/hr.
- Your average velocity is 32 mi/hr in a SE direction.
- At any point in time, your velocity vector points tangent to your path.
- The faster you go, the longer your velocity vector.



More About Velocity

- **Average Velocity**: the overall displacement covered in a given time period

$$v_{avg} = \frac{displacement}{time} = \frac{\Delta d}{t}$$

- Units = $^{m}/_{s}$ = $m \cdot s^{-1}$

  *<u>Note</u>: average speed = total ***distance*** per unit time

- **Instantaneous Velocity**: The speed and direction of a moving object at a particular instant in time
  - Initial velocity → $\boldsymbol{v}_1$ (or $\boldsymbol{v}_i$ or $\boldsymbol{v}_o$)
  - Final velocity → $\boldsymbol{v}_2$ (or $\boldsymbol{v}_f$ or $\boldsymbol{v}$)

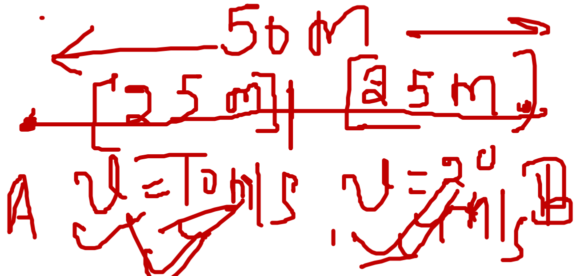
11:30 - 1 pm

Special Cases :-

$Av.\ Sp. = \frac{\text{Total Distance}}{\text{Total Time}}$

20 m/s   15 m/s

$Av.\ Vel. = \frac{\text{Total Disp.}}{\text{Total Time}}$



* $S_1 = S_2 \Rightarrow$

$\left[\frac{v_1 + v_2}{2}\right]$

$Av.\ Sp. \Rightarrow \left[\frac{2 v_1 v_2}{v_1 + v_2}\right] = \frac{2 \times 10 \times 20}{20 + 10}$

$\Rightarrow \frac{2 \times 20 \times 15}{35} = \frac{120}{7}$

$= \frac{400}{30} = \frac{40}{3}$ m/s

Acceleration

Acceleration – how fast you speed up, slow down, or change direction; it's the rate at which velocity changes. Two examples:

t (s)	*v* (mph)
0	55
1	57
2	59
3	61

$a = +2 \text{ mph/s}$

t (s)	*v* (m/s)
0	34
1	31
2	28
3	25

$a = -3 \dfrac{\text{m/s}}{\text{s}} = -3 \text{ m/s}^2$

Acceleration

- **Acceleration** (Vector): ANY change in velocity
  - Speeding up (final velocity is a larger magnitude than the initial velocity)
  - Slowing down (final velocity is a smaller magnitude than the initial velocity)
  - Changing directions (the direction of the vector is changing)
- **Average Acceleration**: the rate at which velocity is changing
- Units = $^{m}/_{s^2}$ = $m \cdot s^{-2}$

$$a = \frac{\Delta v}{t} = \frac{v_2 - v_1}{t}$$

Velocity & Acceleration Sign Chart

		VELOCITY	
		+	-
ACCELERATION	+	Moving forward; Speeding up	Moving backward; Slowing down
	-	Moving forward; Slowing down	Moving backward; Speeding up

Acceleration due to Gravity

Near the surface of the Earth, all objects accelerate at the same rate (ignoring air resistance).

$\boldsymbol{a} = -\boldsymbol{g} = -9.8\ m/s^2$

This acceleration vector is the same on the way up, at the top, and on the way down!

Interpretation: Velocity decreases by 9.8 m/s each second, meaning velocity is becoming less positive or more negative. Less positive means slowing down while going up. More negative means speeding up while going down.

Kinematics Formula Summary

For 1-D motion with *constant* acceleration:

- $v_f = v_0 + at$
- $\bar{v} = (v_0 + v_f)/2$
- $\Delta x = v_0 t + \frac{1}{2}at^2$
- $v_f^2 - v_0^2 = 2a\Delta x$

Final vel.

initial vel.

$v = u + at$

$v^2 = u^2 + 2as$

$s = ut + \frac{1}{2}at^2$

$v^2 - u^2 = 2as$

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