L01 – Distance, Position, Displacement, and Velocity

Agenda:
- Scalars and Vectors
- Definitions
- Equations and Number Lines
- Distance, Position and Displacement
- Velocity and Change in Position
- Acceleration as Change in Velocity

Scalars and Vectors

| Scalar – Measurement that has magnitude only.		Vector – Measurement that has both magnitude and direction.	
Symbol	Name	Symbol	Name
d	distance (m)	$\vec{d_i}$	Initial position
		$\vec{d_f}$	Final position
		$\Delta \vec{d}$	Change in position (Displacement)
v	Speed (m/s)	$\vec{v}$	velocity (m/s)
t	time (s)	$\vec{a}$	acceleration (m/s^2)

Position, Distance, and Displacement

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

$$\vec{\Delta d_{tot}} = \vec{\Delta d_1} + \vec{\Delta d_2} + \ ...$$

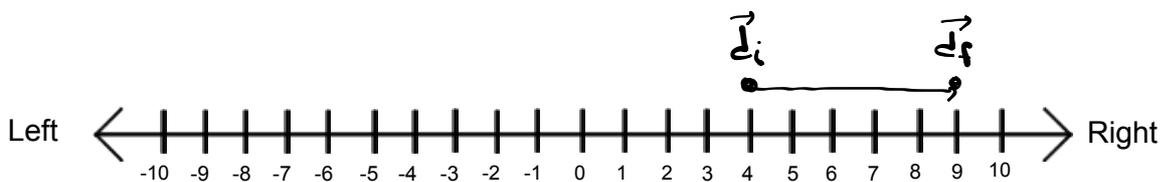**Q1:** A cat starts 2m [right] of a fire hydrant, then walks 5m [right].

Left ⟵———————————————⟶ Right
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10
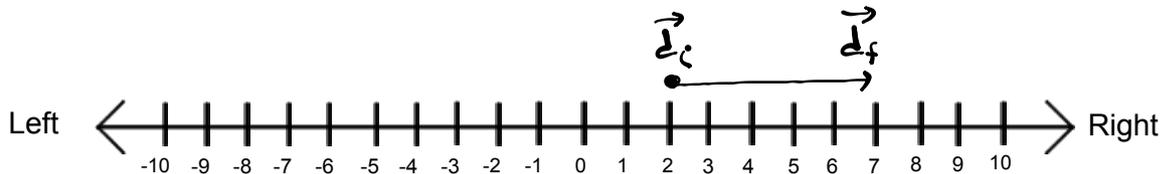
Initial Position: $\vec{d_i} = 2m\,[R]$

Final Position: $\vec{d_f} = 7m\,[R]$

Distance: $d = 5m$

Displacement: $\vec{\Delta d} = 5m\,[R]$

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

$5m[R] = \vec{d_f} - 2m[R]$

$5 = \vec{d_f} - 2$

$+2 \qquad +2$

$7 = \vec{d_f}$

$\vec{d_f} = 7m[R]$

Q2: A cat starts 4m [right] of a fire hydrant, then walks until reaching 9m [right].

Left ⟵———————————————⟶ Right
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10

Initial Position: $\vec{d_i} = 4m\,[R]$

Final Position: $\vec{d_f} = 9m\,[R]$

Distance: $d = 5m$

Displacement: $\vec{\Delta d} = 5m\,[R]$

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

$\vec{\Delta d} = 9m[R] - 4m[R]$

$\vec{\Delta d} = 5m\,[R]$

Q3: A cat starts at the fire hydrant. It walks 4m [right], then 3m [right], then another 1m [right].

$\vec{d_i}$

Left ← |-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10| → Right
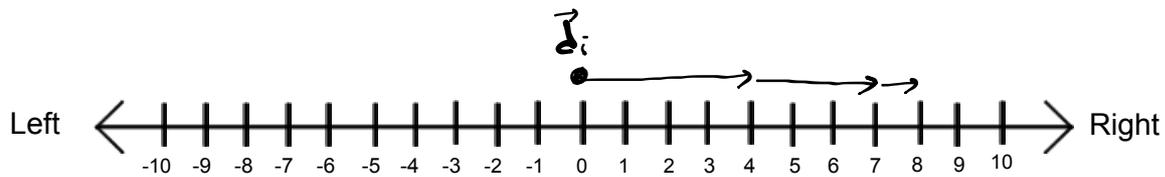
Initial Position: $\vec{d_i} = 0m\ [R]$

Final Position: $\vec{d_f} = 8m\ [R]$

Distance: $d = 8m$

Displacement: $\Delta\vec{d}_{TOT} = 8m\ [R]$

$\Delta\vec{d}_{TOT} = \Delta\vec{d_1} + \Delta\vec{d_2} + \Delta\vec{d_3} + ...$

$= 4m[R] + 3m[R] + 1m[R]$

$= 8m[R]$

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

$8m[R] = \vec{d_f} - 0m[R]$

$\qquad +0 \qquad\qquad +0$

$8m[R] = \vec{d_f}$

Q4: A cat starts 5m [left] of the fire hydrant, then walks 3m [left].

$\vec{d_f}$ $\vec{d_i}$

Left ← |-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10| → Right
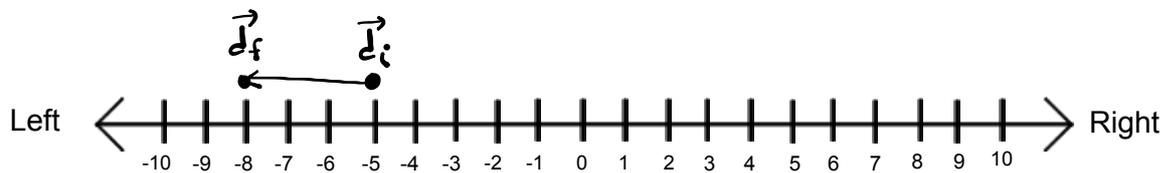
Initial Position: $\vec{d_i} = 5m\ [L]$

Final Position: $\vec{d_f} = 8m\ [L]$

Distance: $d = 3m$

Displacement: $\Delta\vec{d} = 3m\ [L]$

$\Delta\vec{d} = \vec{d_f} - \vec{d_i}$
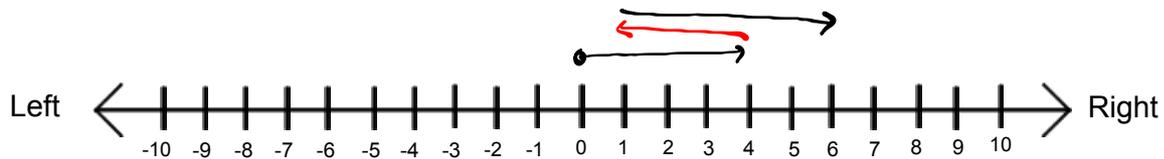
$3m[L] = \vec{d_f} - 5m[L]$

$\qquad +5 \qquad\quad +5$

$8m[L] = \vec{d_f}$

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Sign Convention: When we use vectors that are opposite in direction, for example [East] and [West], it is convenient to designate these directions as either positive or negative. It is common to call east positive (+) and west negative (-).

Here are a few other designations:

West ⟷ East

Left ⟷ Right

$-$ ⟷ $+$

North ↕ South

Up ↕ Down

$+$ ↕ $-$

Q5: A cat starts at the fire hydrant. It walks 4m [right], then 3m [left] then another 5m [right].

Left ⟵ | | | | | | | | | | | | | | | | | | | | | ⟶ Right

$-10 \quad -9 \quad -8 \quad -7 \quad -6 \quad -5 \quad -4 \quad -3 \quad -2 \quad -1 \quad 0 \quad 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10$

Initial Position: $\vec{d_i} = 0m\ [R]$

Final Position: $\vec{d_f} = 6m\ [R]$

Distance: $d = 12m$

Displacement: $\Delta\vec{d} = 6m\ [R]$

$$\Delta\vec{d}_{TOT} = \Delta\vec{d_1} + \Delta\vec{d_2} + \Delta\vec{d_3}$$
$$= 4m[R] + 3m[L] + 5m[R]$$
$$= 4m[R] - 3m[R] + 5m[R]$$
$$= 6m\ [R]$$

$$d_{TOT} = d_1 + d_2 + d_3$$
$$= 4m + 3m + 5m$$
$$= 12m$$

$$\Delta\vec{d} = \vec{d_f} - \vec{d_i}$$
$$6m[R] = \vec{d_f} - 0m[R]$$
$$\quad +0 \qquad\qquad +0$$
$$6m[R] = \vec{d_f}$$

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Q6: A cat starts 3m [left] of the fire hydrant. It moves 10m [right].

$\vec{d_i}$

Left $\longleftarrow$ | | | | | | | | | | | | | | | | | | | | | $\longrightarrow$ Right
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10
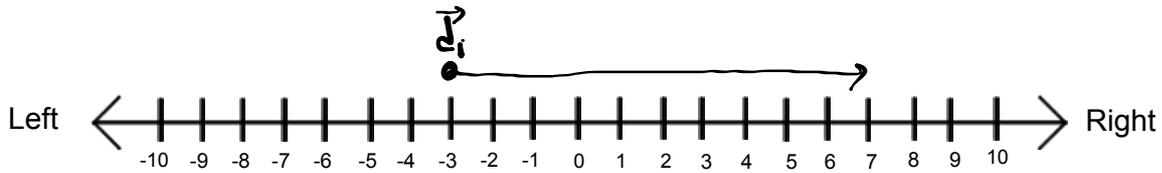
Initial Position: $\vec{d_i} = 3m[L]$ or $-3m[R]$

Final Position:

Distance:

Displacement: $\Delta\vec{d} = 10m[R]$

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

$10m[R] = \vec{d_f} - (-3m[R])$

$\boxed{10 = \vec{d_f} + 3}$ ⤳ Always work this step before reverse BEDMAS

$-3 \qquad -3$

$7 = \vec{d_f}$

$\vec{d_f} = 7m[R]$

Q7: A cat starts 5m [right] of the fire hydrant. It moves 7m [left].

Left $\longleftarrow$ | | | | | | | | | | | | | | | | | | | | | $\longrightarrow$ Right
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10
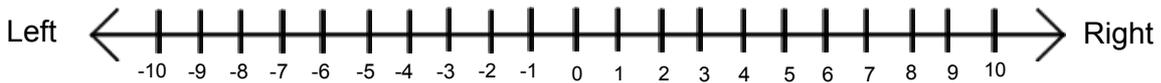
Initial Position: $\vec{d_i} = 5m[R]$

Final Position:

Distance:

Displacement: $\Delta\vec{d} = 7m[L]$ or $-7m[R]$

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

$-7m[R] = \vec{d_f} - (5m[R])$

$-7 = \vec{d_f} - 5$

$+5 \qquad +5$

$-2 = \vec{d_f}$

$\boxed{\vec{d_f} = -2m[R]}$

$\vec{d_f} = 2m[L]$ ← Best answer!

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Speed and Velocity

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

$$\overrightarrow{\Delta d_{tot}} = \overrightarrow{\Delta d_1} + \overrightarrow{\Delta d_2} + \ \dots$$

$$\vec{v} = \frac{\overrightarrow{\Delta d}}{\Delta t}$$

Q8: A cat starts at the fire hydrant. It walks 4m [right], then 3m [left] then another 5m [right]. It completes its movement within 10 seconds.

Left ⟵————————————————————⟶ Right
        -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10

Initial Position:

Final Position:

$$\overrightarrow{\Delta d_{TOT}} = 4m[R] + 3m[L] + 5m[R]$$
$$= 4m[R] - 3m[R] + 5m[R]$$
$$= 6m[R]$$

Distance:

Speed:

$$d_{TOT} = d_1 + d_2 + d_3$$
$$= 4m + 3m + 5m$$
$$= 12m$$

Displacement:

Velocity:

Speed

$$v = \frac{d}{t} = \frac{12m}{10s} = 1.2 \text{ m/s}$$

Velocity

$$\vec{v} = \frac{\overrightarrow{\Delta d}}{\Delta t} = \frac{6m[R]}{10s} = 0.6 \text{ m/s}[R]$$

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Q9: A cat starts at the fire hydrant. It walks 4m [right], then 8m [left] then another 2m [left]. It completes its movement within 20 seconds.

Left ⟨————————————————————⟩ Right
  -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10
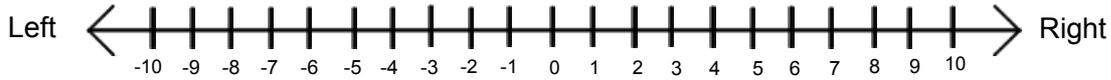
Initial Position:

Final Position:

Distance:

Speed:

Displacement:

Velocity:

$$\Delta \vec{d}_{TOT} = 4m[R] + 8m[L] + 2m[L]$$
$$= 4m[R] - 8m[R] - 2m[R]$$
$$= -6m[R]$$
$$= 6m[L]$$

$$d_{TOT} = d_1 + d_2 + d_3$$
$$= 4m + 8m + 2m$$
$$= 14m$$

Speed
$$V = \frac{d}{t} = \frac{14m}{20s} = 0.7 m/s$$

Velocity
$$\vec{v} = \frac{\Delta \vec{d}}{\Delta t} = \frac{6m[L]}{20s} = 0.\overline{3} m/s [L]$$

Q10: A cat starts off 5m [left] of the fire hydrant. It movs 6m [right] in 3 seconds.

Left ⟨————————————————————⟩ Right
  -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10

Initial Position: $\vec{d}_i = 5m[L]$ or $-5m[R]$

Final Position: $\vec{d}_f = 1m[R]$

Distance: $d = 6m$

Speed: $v = 2 m/s$

Displacement: $\Delta \vec{d} = 6m[R]$

Velocity: $\vec{v} = 2 m/s [R]$

$$\Delta \vec{d} = \vec{d}_f - \vec{d}_i$$
$$6m[R] = \vec{d}_f - (-5m[R])$$
$$6 = \vec{d}_f + 5$$
$$-5 \qquad -5$$
$$1 = \vec{d}_f$$
$$\vec{d}_f = 1m[R]$$

Speed
$$V = \frac{d}{t} = \frac{6m}{3s} = 2 m/s$$

Velocity
$$\vec{v} = \frac{\Delta \vec{d}}{t} = \frac{6m[R]}{3s} = 2 m/s [R]$$

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d — symbol | m — unit

Distance — How far

v — symbol | m/s — unit

Speed — How fast

Δt — symbol | s — unit

time interval

Scalar
magnitude only

MOTION

magnitude and direction

Vector

change in position — **Displacement**

rate of change in position — **average velocity**

rate of change in velocity — **Acceleration** — g gravity — $9.81 m/s^2$

symbol: $\Delta \vec{d}$ | unit: m

symbol: $\vec{v}$ | unit: m/s

symbol: $\vec{a}$ | unit: m/s^2

equation: $\vec{v} = \Delta \vec{d} \div \Delta t$

equation: $\vec{a} = \Delta \vec{v} \div \Delta t$