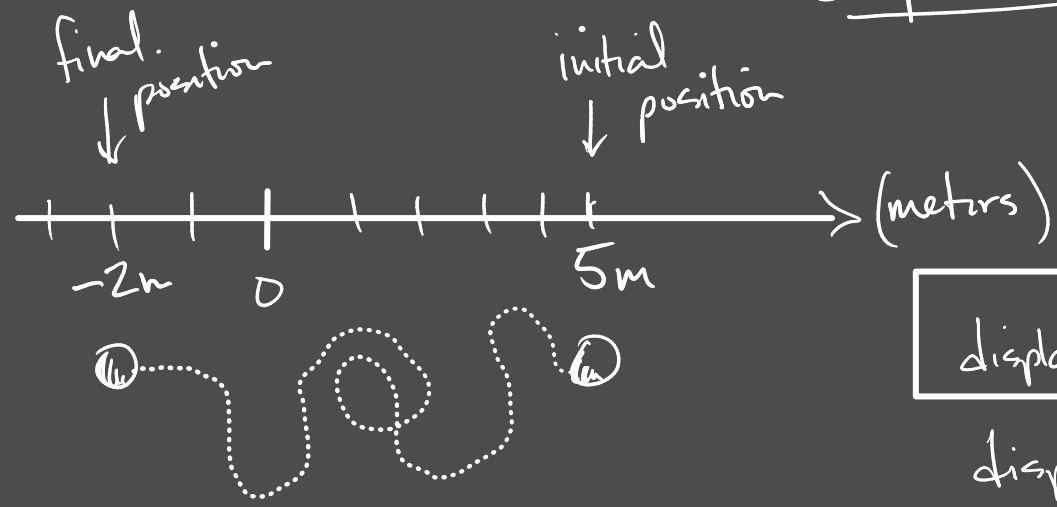


Chapter 2 - Describing Motion

position - where an object is relative to some other place.

change in position → distance travelled
→ displacement → distance + direction
east / west
30° north of west
+ / -



$$\text{displacement} = \text{final position} - \text{initial position}$$

$$\text{displacement} = -2\text{m} - (+5\text{m}) = -7\text{m}$$

time interval - $t \rightarrow$ time to get from initial position to final position

rate of change of position
ratio of distance/displacement and time

→ $\text{speed} = \frac{\text{distance}}{\text{time}}$ units → $\left[\frac{\text{miles}}{\text{hour}} \right]$
↓ $\left[\frac{\text{meters}}{\text{second}} \right]$

velocity → speed and direction

→ $\frac{\text{displacement}}{\text{time}}$

Average speed

→ ratio between
long distances
long times

$$\frac{85 \text{ miles}}{2 \text{ hours}} = 42.5 \text{ miles/hour}$$

} trip to Montgomery

$$\frac{150 \text{ miles}}{2.25 \text{ hours}} = 67 \text{ miles/hour}$$

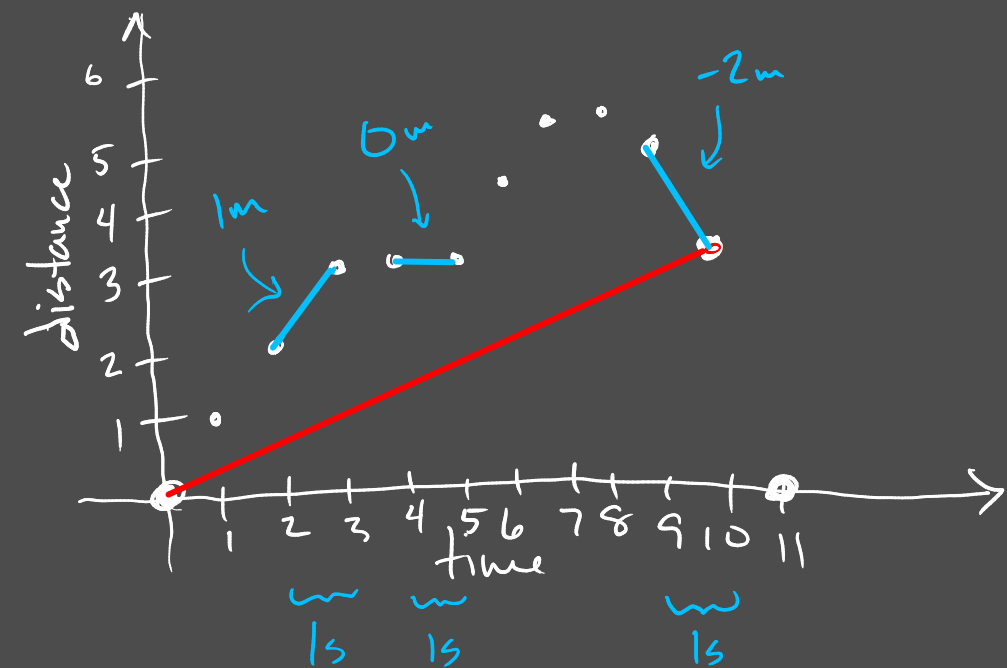
} trip to Atlanta

Instantaneous speed

→ speedometer speed

→ ratio of the
distance and
the smallest time
interval possible

← having ratios
makes comparing
the trips
easy



$$\text{velocity} = \frac{\text{displacement}}{\text{time}}$$

$$V_1 = \frac{1\text{m}}{1\text{s}} = 1\text{m/s}$$

$$V_2 = \frac{0\text{m}}{1\text{s}} = 0\text{m/s}$$

$$V_3 = \frac{-2\text{m}}{1\text{s}} = -2\text{m/s}$$

negative sign
means going backwards

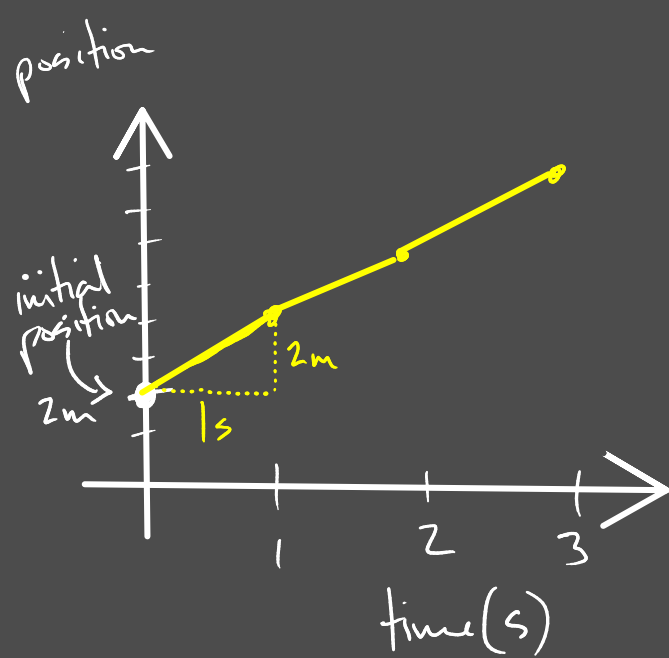
final position = 3m
initial position = 0m
time interval = 10s

$$\text{velocity} = \frac{\text{displacement}}{\text{time}}$$

$$= \frac{\text{final position} - \text{initial position}}{\text{time}}$$

$$= \frac{3\text{m} - 0\text{m}}{10\text{s}} = \frac{3\text{m}}{10\text{s}}$$

$$= 0.3\text{m/s}$$



time	velocity	position	displacement
0-1s	2 m/s	4m	2m
1-2s	2 m/s	6m	2m
2-3s	2 m/s	8m	2m

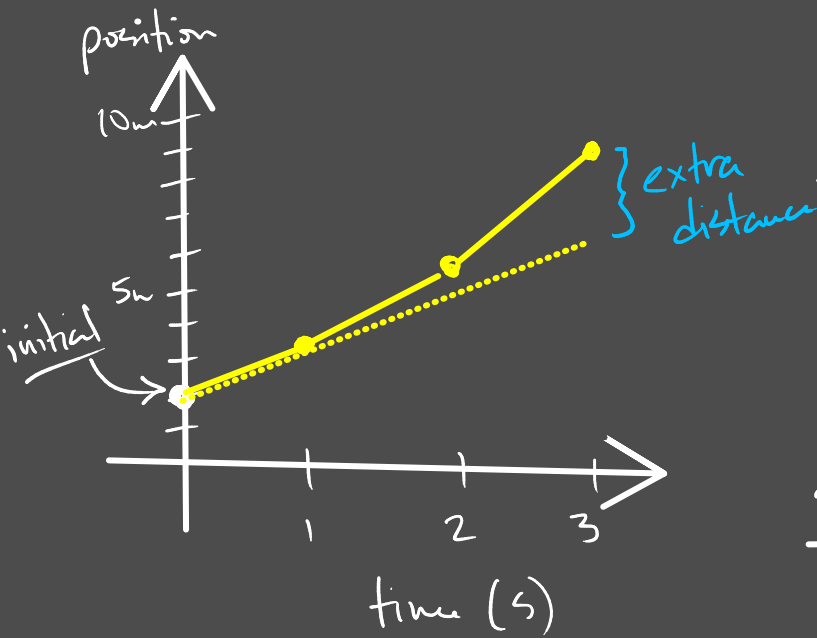
How long does it take to go 120 meters?

$$60s = \frac{120m}{2 \frac{m}{s}} \quad \left| \quad \frac{120m}{2} \cdot \frac{s}{m} \right.$$

$$\text{Velocity} = \frac{\text{displacement}}{\text{time}}$$

$$\text{displacement} = \text{velocity} \times \text{time}$$

$$\text{time} = \frac{\text{displacement}}{\text{velocity}}$$



time	velocity	position	displacement	change in velocity
0-1s	1 m/s	3m	1m	1 m/s
1-2s	2 m/s	5m	2m	1 m/s
2-3s	3 m/s	8m	3m	1 m/s

Notice how the speed in the above problem was changing over time.

How much? How quickly?

Acceleration - rate of change of velocity

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time interval}}$$

What is the acceleration?

change $\rightarrow \Delta \text{Velocity} = \frac{1 \text{ m/s}}{1 \text{ s}}$

$$a = \frac{\Delta \text{Velocity}}{\Delta \text{time}} = \frac{1 \text{ m/s}}{1 \text{ s}}$$

$$a = 1 \text{ m/s}^2 = 1 \text{ m/s}^2$$

what if acc changes over time?

jerk = $\frac{\text{change in acc}}{\text{time}}$ rate of change of change snap $\xrightarrow{\text{rate of change}}$ crackle $\xrightarrow{\text{rate of change}}$ pop.

So the rate of change of position is the speed (or velocity), and the rate of change of velocity is acceleration.

$$v = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{\Delta t}$$

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t}$$

$\Rightarrow x_f = x_i + \underbrace{v \cdot \Delta t}_{\text{displacement}}$

$\Rightarrow v_f = v_i + \underbrace{a \cdot \Delta t}_{\substack{\text{change in} \\ \text{velocity}}}$

LIMITS

- constant velocity
- or
- short time interval

- constant acceleration
- or
- short time interval