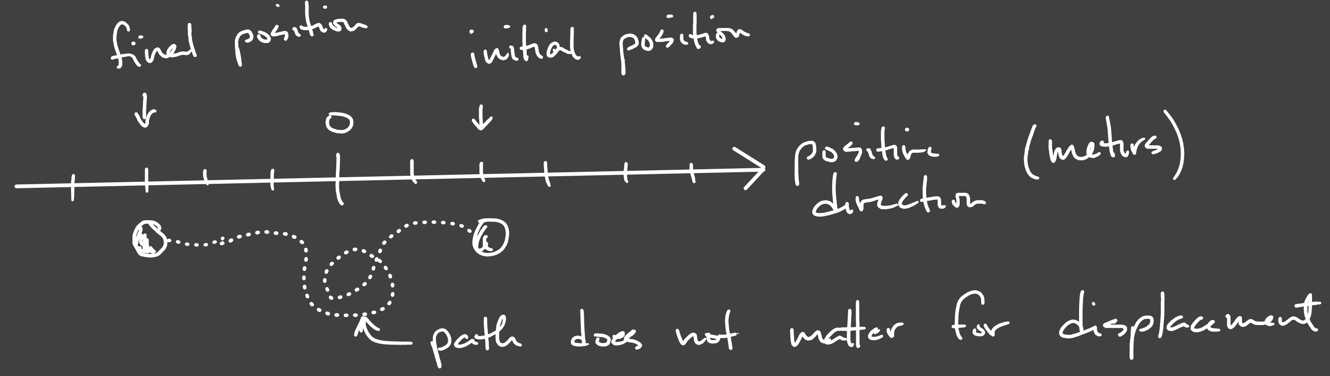
Chapter 2 – Describing Motion

position – where an object is relative to some other place

change in position (this is more important than position)
→ distance travelled
→ displacement → distance + direction
east / west
30° N of West
+ / −



→ d = final position − initial position
$d = -3m - (2m) = -5m$
$d = -5m$ ← neg means to the left

time interval → t → time to get from initial to final position

rate of change of position
ratio of distance/displacement and time
→ speed = $\frac{\text{distance}}{\text{time}}$ units → $\left[\frac{m}{s}\right]$ or $\left[\frac{\text{miles}}{\text{hour}}\right]$
→ velocity → speed and direction

Average speed → $\frac{85 \text{ miles}}{2 \text{ hours}} = 42.5 \text{ miles/hour}$ } trip to Montgomery

↳ ratio between long distances and long times

$\frac{150 \text{ miles}}{2.25 \text{ hour}} = 67 \text{ miles/hour}$ } trip to Atlanta

seeing the ratio of distance + time helps me to compare how the trips went

Instantaneous speed → speedometer speed

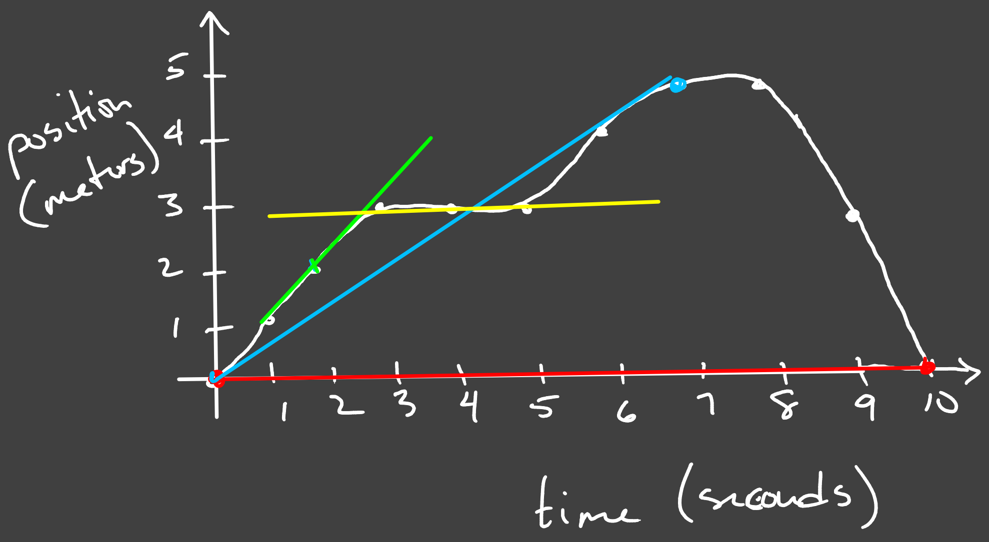
↳ ratio of the smallest distance and time interval possible

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

distance — smallest interval

time ↳ smallest possible interval of time

On a graph, these differences can be seen as the difference between the slope from one end to the other, vs the slope of the graph at a particular point in the curve.



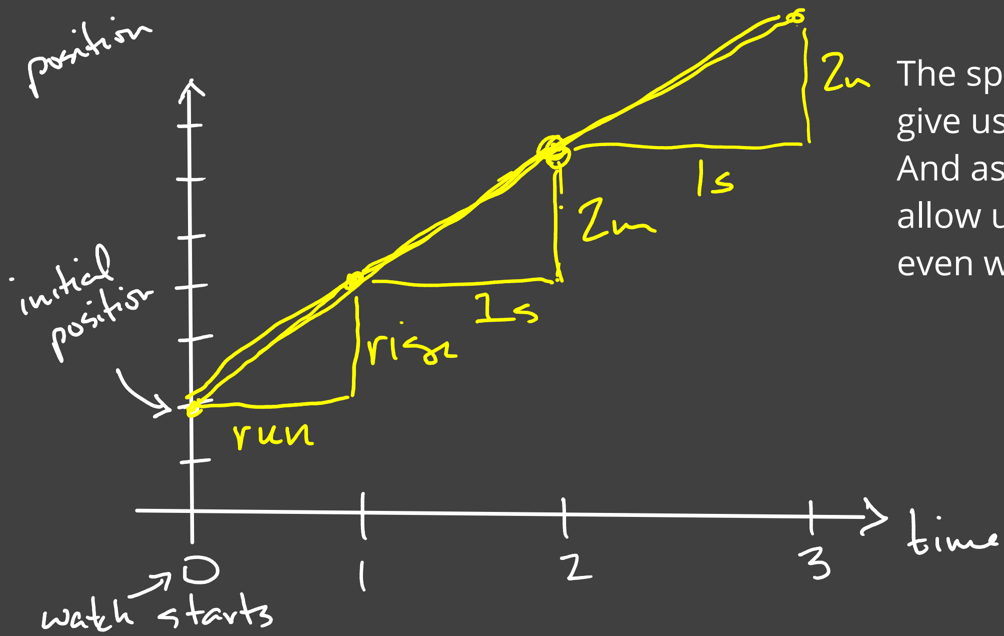
— average velocity of the entire trip

— average velocity from 0s to 7s.

— instantaneous velocity at 2 seconds

— instantaneous velocity at 4 seconds

$$v = \frac{x_f - x_i}{t} = \frac{5m - 0m}{7s} = \frac{5}{7}\ m/s$$



The speed formula can be used backwards to give us the position of an object some time later. And as long as the time intervals are short, it can allow us to update the position of an object even when the velocity is not constant.

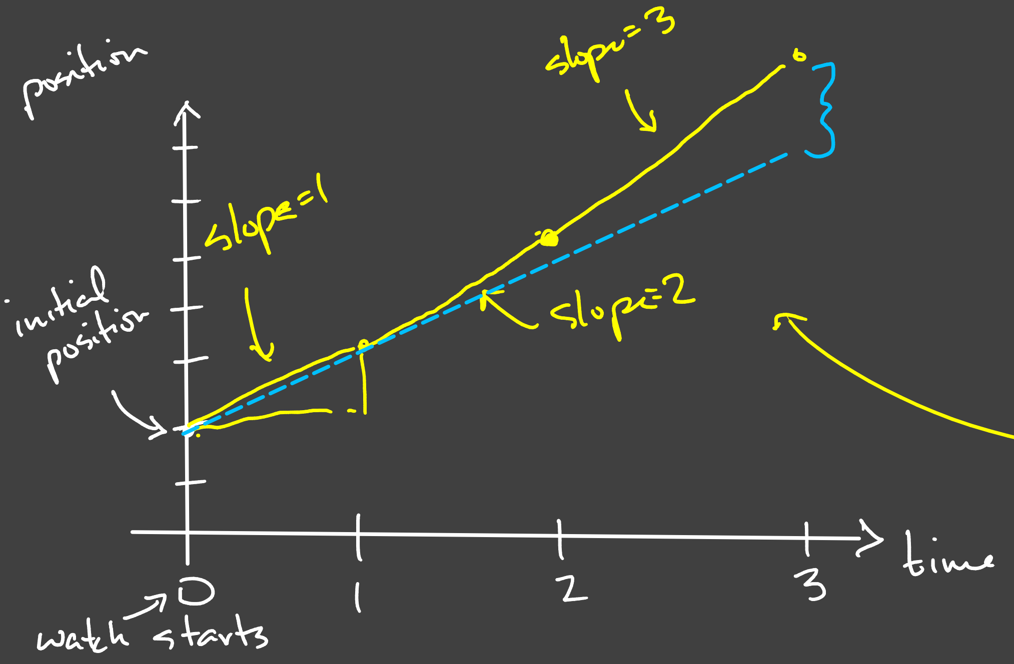
$$V = \frac{\text{displacement}}{\text{time interval}}$$

$$\underline{d = V \times t}$$

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

How long to go 120 meters?

$$120m = 2\,m/s \cdot t \Rightarrow t = 60s$$



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

parabola

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

$\boxed{\text{How much?}}$ and how quickly?

Acceleration – rate of change of velocity

$$a = \frac{\text{change in velocity}}{\text{time}}$$

units: $\dfrac{\frac{m}{s}}{s}$

$$\frac{m}{s} \cdot \frac{1}{s} = \frac{m}{s \cdot s} = \frac{m}{s^2}$$

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

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

$$x_f = \underbrace{x_i + v \cdot \Delta t}$$

LIMITS
- constant velocity

or
- short time interval

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

$$v_f = \underbrace{v_i + a \cdot \Delta t}$$

- constant acc.

or
- short time interval

$\Delta x \rightarrow$ change in x position

$\Delta x = x_f - x_i$

$\Delta t \rightarrow$ change in time

$\Delta t = t_f - t_i$

$\Delta v \rightarrow$ change in velocity

$\Delta v = v_f - v_i$

$\Delta \rightarrow$ delta means "change in" and that is always final − initial

But what about changes in acceleration?

rate of change in acceleration $\rightarrow$ jerk $\xrightarrow[\text{of change}]{\text{rate}}$ snap $\xrightarrow[\text{of change}]{\text{rate}}$ crackle $\xrightarrow[\text{of change}]{\text{rate}}$ pop

We will stick to cases of constant acceleration for now

This is easy to handle mathematically and convenient since things fall at constant acceleration.

special acceleration $9.8\ m/s^2 = g$

$$\boxed{x_f = x_i + v_i \cdot t + \frac{1}{2} \cdot a \cdot t^2 \Rightarrow \Delta x = v_i \cdot t + \frac{1}{2} a t^2}$$

$$\boxed{v_f = v_i + a t}$$

Ex: How long does it take to speed up to 100 meters/second if you start at 0 m/s and you accelerate at 15 m/s^2?

$$100\ m/s = 0\ m/s + (15\ m/s^2)(t)$$

$$\frac{100\ m/s}{15\ m/s^2} = 6.7s = t$$

Ex: What is your acceleration if you go from 10m/s to 40 m/s in 2.5 seconds?

$$a = \frac{\Delta v}{\Delta t} = \frac{40\ m/s - 10\ m/s}{2.5\ s} = \frac{30\ m/s}{2.5\ s} = 12\ m/s^2$$

Ex: How far to you go in the first second of accelerating from rest at 10 m/s^2? How far do you go in the second second? Third second?

What's next:
* Falling objects and throwing objects
* Projectiles
* Cause of acceleration -> forces
* special kind of acceleration -> centripetal
* gravity and planetary orbits