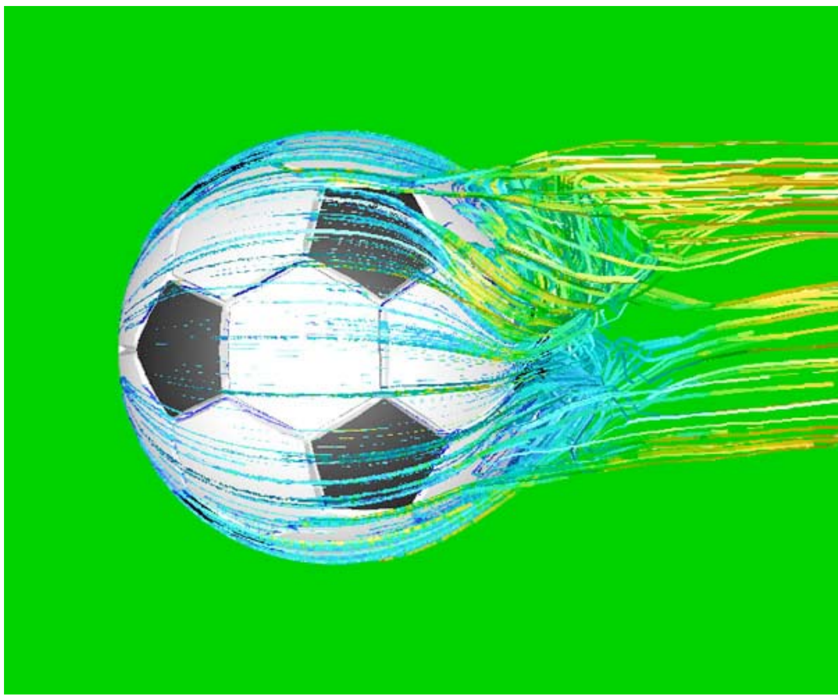
Models of Motion

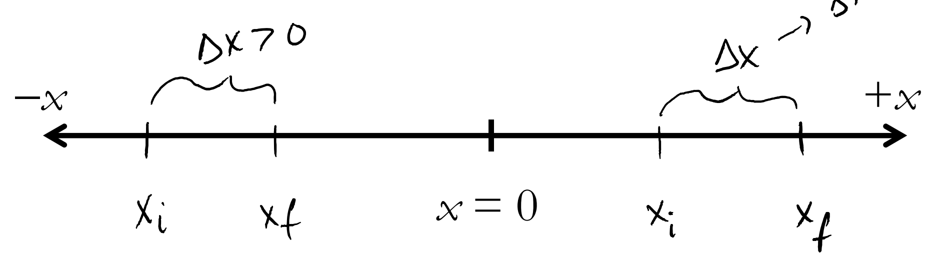
- How do we describe the motion of a soccer ball?




Kinematics: Mathematical Description of Motion

1-D

"Vocabulary"



$x_f \leftarrow x_i$

$\Delta x < 0$

Position: value of coordinate

→ coordinate system → +/− direction, origin

final initial

Displacement: change in position, $\Delta x = x_f - x_i$

→ doesn't depend on origin

→ has a sign → moving towards or away from origin

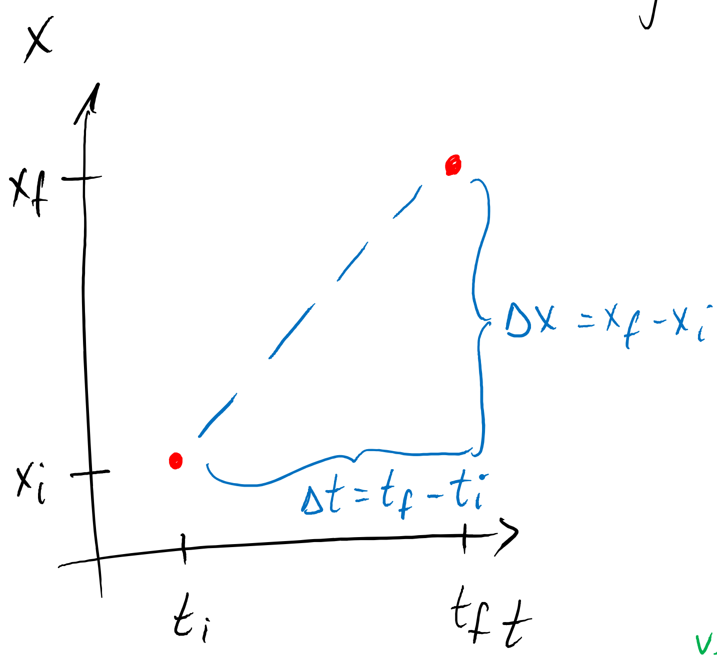
Distance → $|\Delta x|$

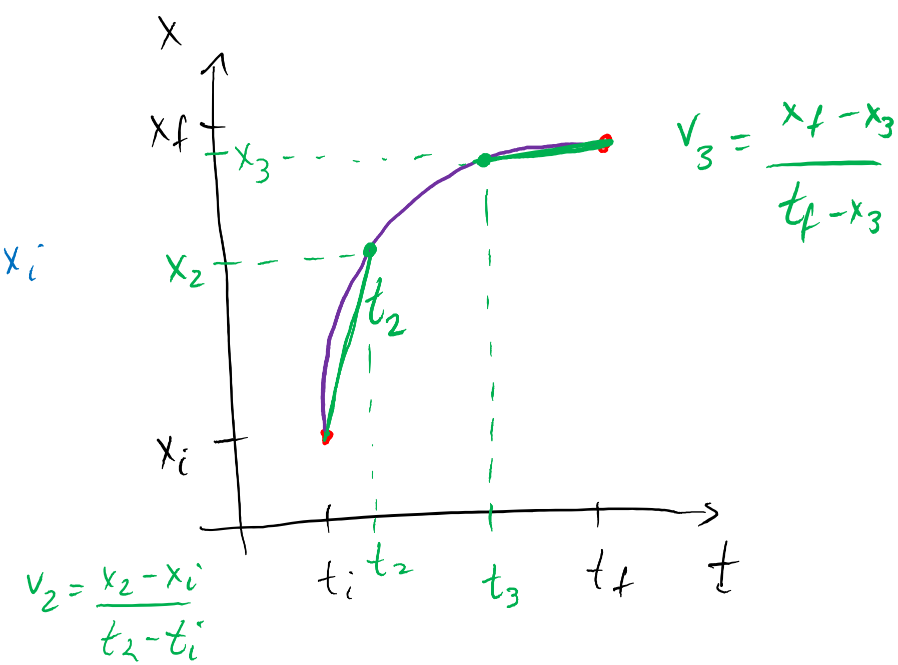
Velocity $\left(= \text{"speed"}\right)$

$$V_{ave} = \frac{\Delta x}{\Delta t} \leftarrow \text{Displacement} = \frac{x_f - x_i}{t_f - t_i}$$

→ doesn't depend on origin

→ sign, moving towards or away from origin

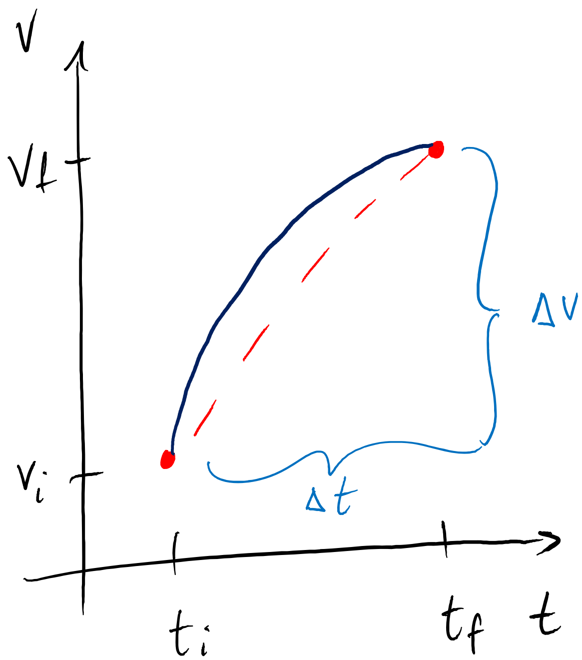




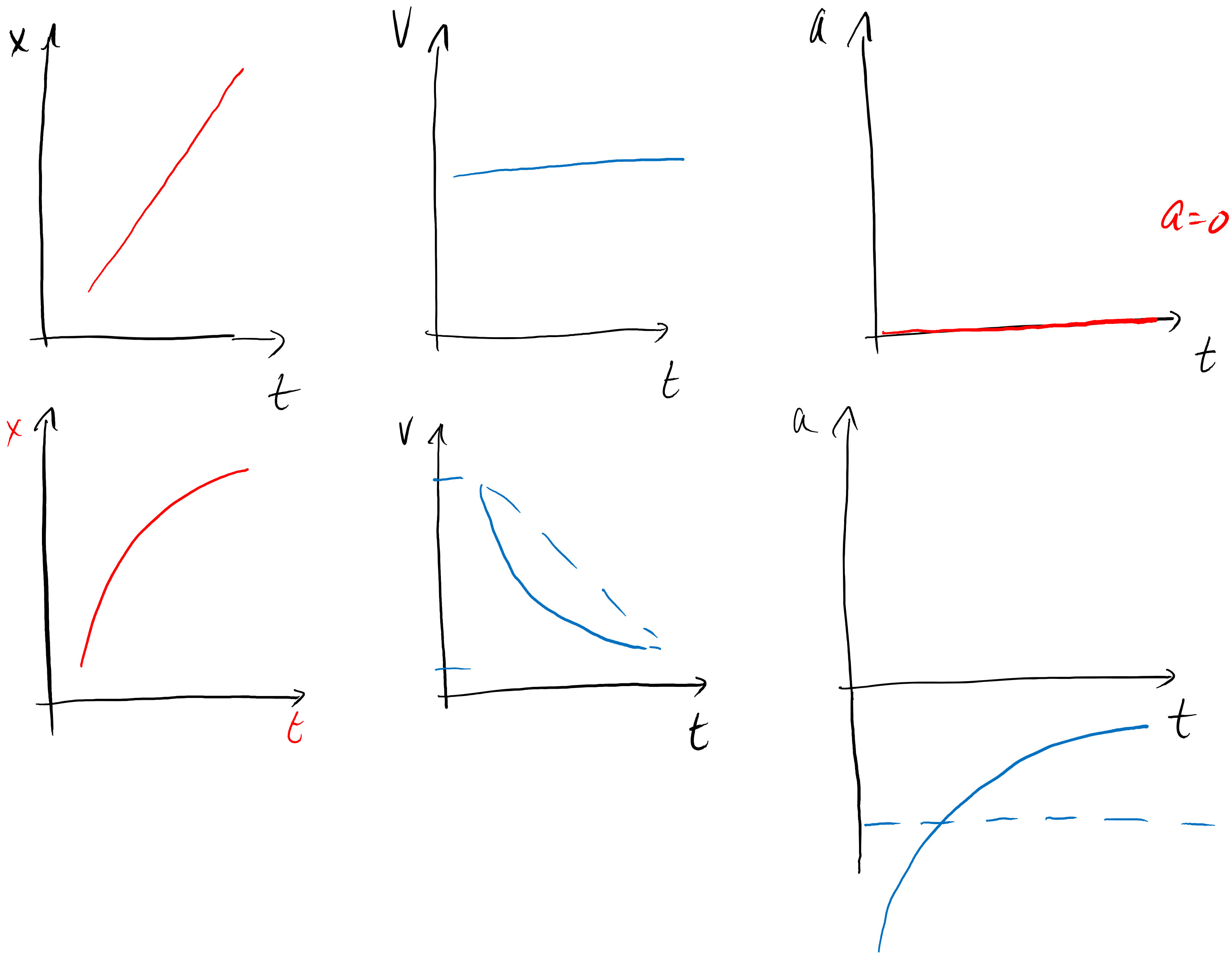
Acceleration

$$a_{ave} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

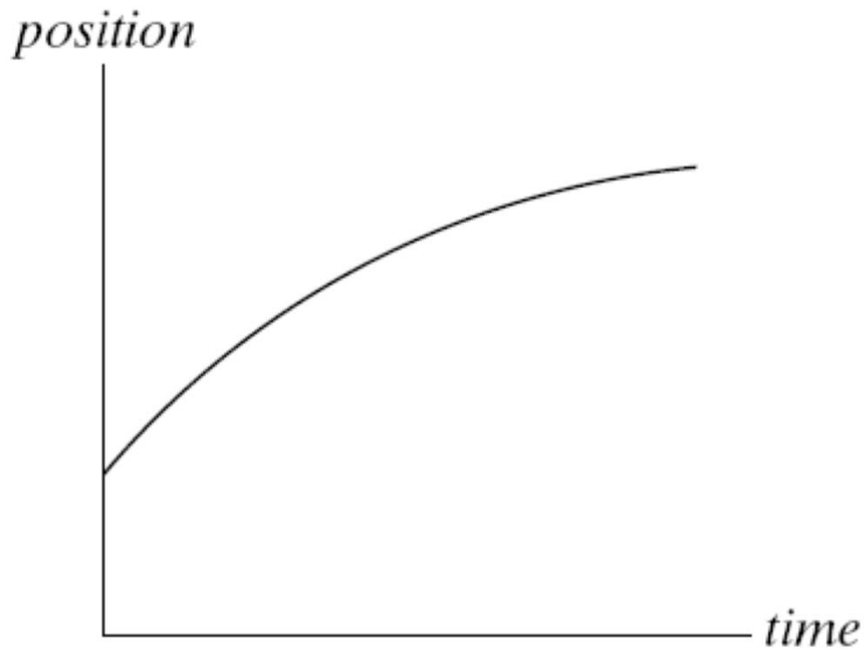
- doesn't depend on origin
- sign +/– origin



$\rightarrow a_{ave} = \frac{\Delta v}{\Delta t} \rightarrow$ slope


x
t
V
t
a
a=0
t
x
t
v
t
a
t

A train car moves along a long straight track. The graph shows the position as a function of time for this train. The graph shows that the train:



1.speeds up all the time. → a>0

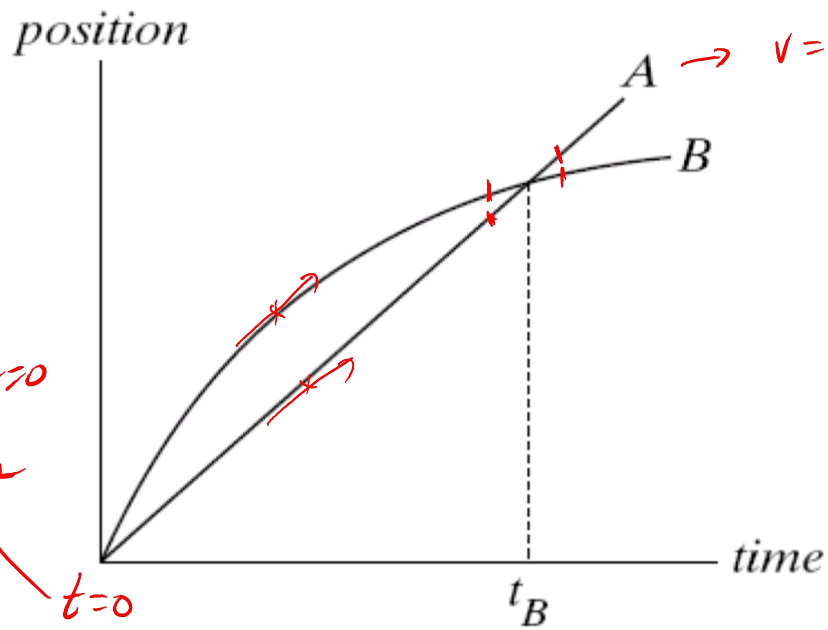
2.slows down all the time. → a<0

a>0 → a<0

3.speeds up part of the time and slows down part of the time.

4.moves at a constant velocity.

The graph shows position as a function of time for two trains running on parallel tracks. Which is true:



→ v = const → const slope

$a_A = 0$

starting at $t=0$

V_{ave} = same

$t=0$

1. At time t_B, both trains have the same velocity. → slopes are different
2. Both trains speed up all the time. $a_A = 0$
3. Both trains have the same velocity at some time before t_B.
4. Somewhere on the graph, both trains have the same acceleration.

Kinematic Equations

- Descriptions of Motion (words → sentences)

$x(t)$, $v(t)$, $a = \text{const.}$

instantaneous $v = \dfrac{\Delta x}{\Delta t}$ $\quad v \rightarrow \Delta t \rightarrow 0$

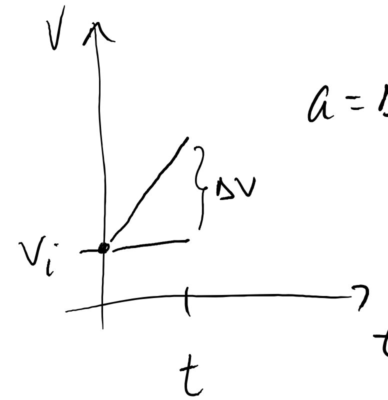
$\left(\lim_{\Delta t \to 0} \dfrac{\Delta x}{\Delta t} \right)$

→ tangent to Δx vs Δt curve

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t - 0} = \frac{v - v_i}{t}$$

← initial time

$$at = v - v_i, \quad v = v_i + at$$



$a = \Delta v / \Delta t$