Today: sections 2.1–2.3

$\boxed{L4}$

Today: Sections 2.1–2.3

Monday: Sections 2.4–2.6

1d Kinematics

$\boxed{L4}$

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Today: Sections 2.1–2.3

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HW#1: Due Wednesday ← Extended due date

Today: Sections 2.1–2.3

Monday: Sections 2.4–2.6

$\boxed{L4}$

HW#1: Due Wednesday

HW#2: Due Friday 9-4-20

2.1, 2.3, 2.5	§2.1
2.7	§2.2
2.13 a&b, 2.15 a&b	§2.3
2.19, 2.21, 2.31	§2.4
2.33, 2.35 a&b, 2.37, 2.43	§2.5
2.49, 2.51	§2.6

ASU

Kinematics

* Want to describe 3d motion

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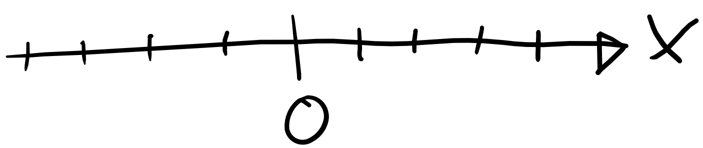

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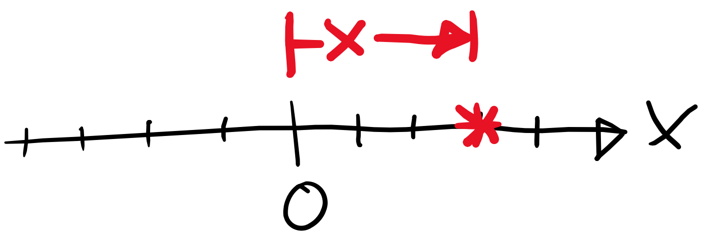

$x = +3$ units

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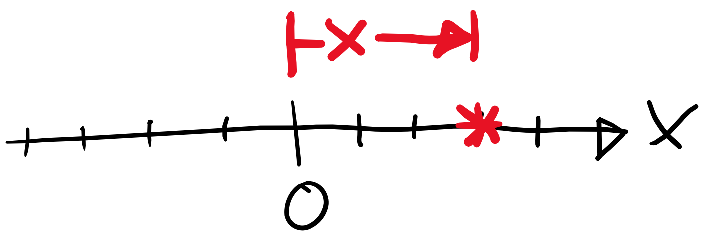

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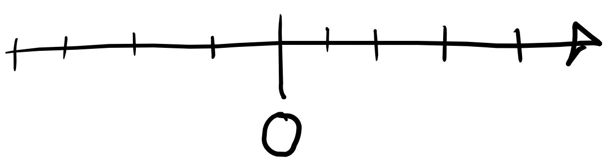

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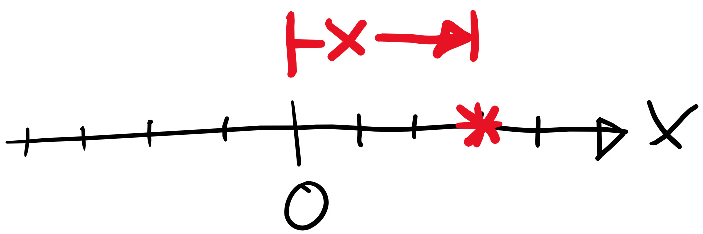

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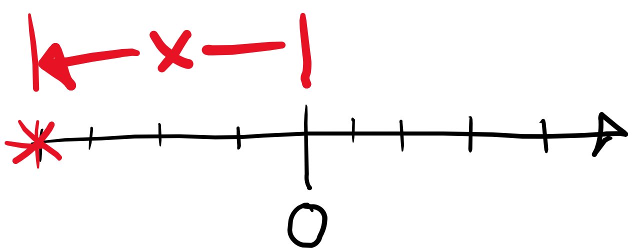

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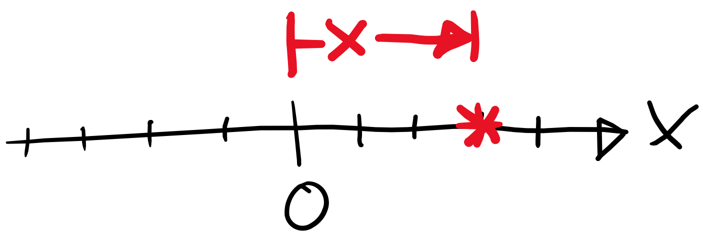

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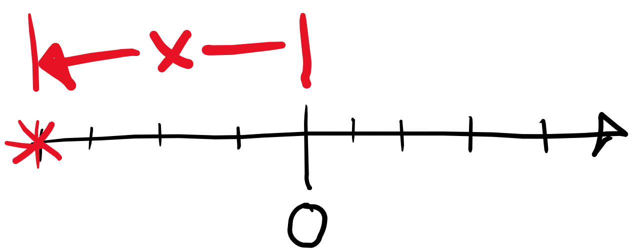

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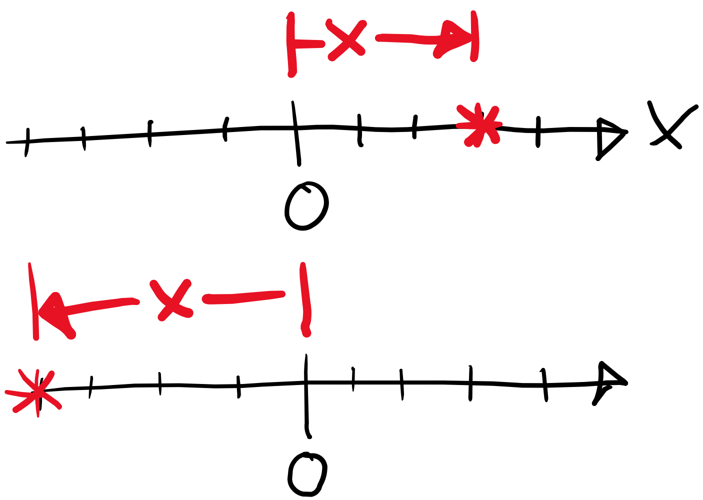

$x = +3$ units

$x = -4$ units

Units could be ft, m, km, Miles, cm, ...

Displacement, time & average velocity

Displacement, time & average velocity

$$\Delta x = x_2 - x_1$$

Displacement, time & average velocity

$$\Delta x = x_2 - x_1$$

Final   Initial

Displacement, time & average velocity

$$\underbrace{\Delta x = x_2 - x_1}_{\text{Displacement}} \quad \& \quad \underbrace{\Delta t = t_2 - t_1}_{\text{Time}}$$

Displacement, time & average velocity

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Average velocity $\equiv v_{AVE}$

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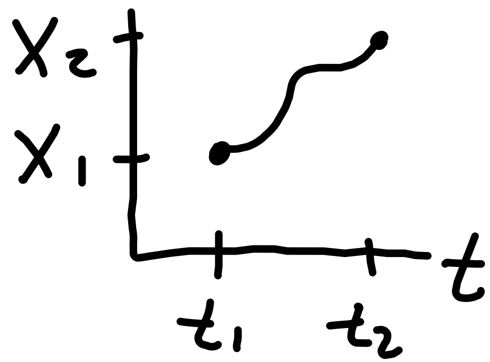
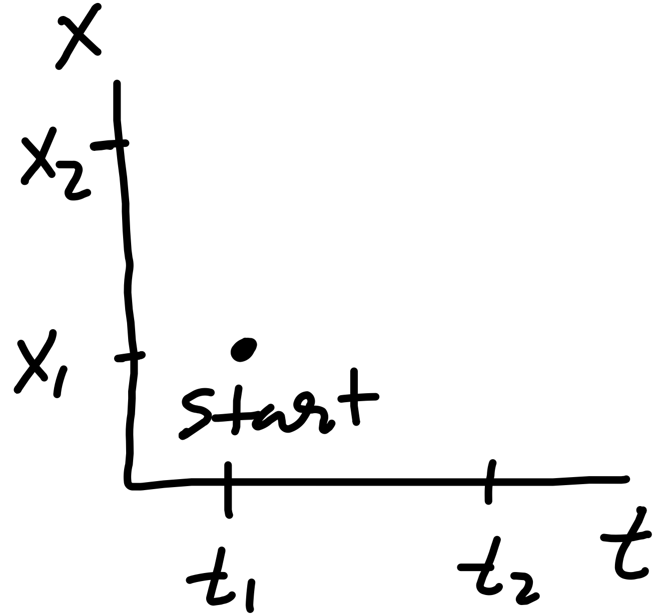
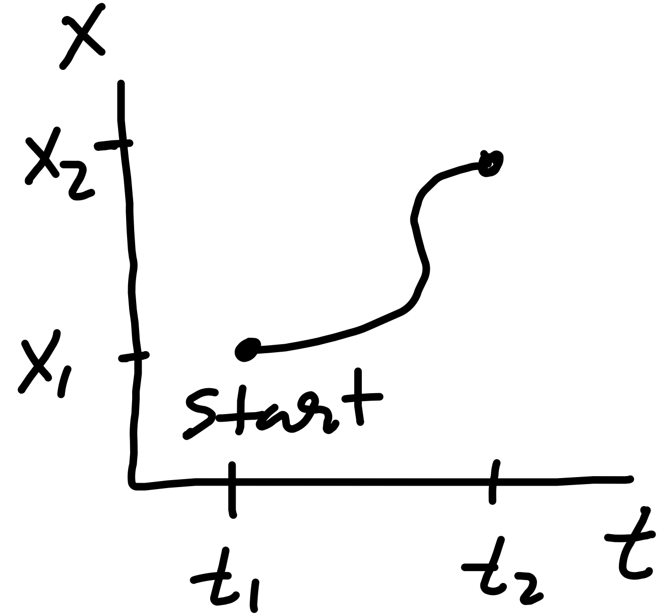



x
x2
x1
start
t1
t2
t


x
x_2
x_1
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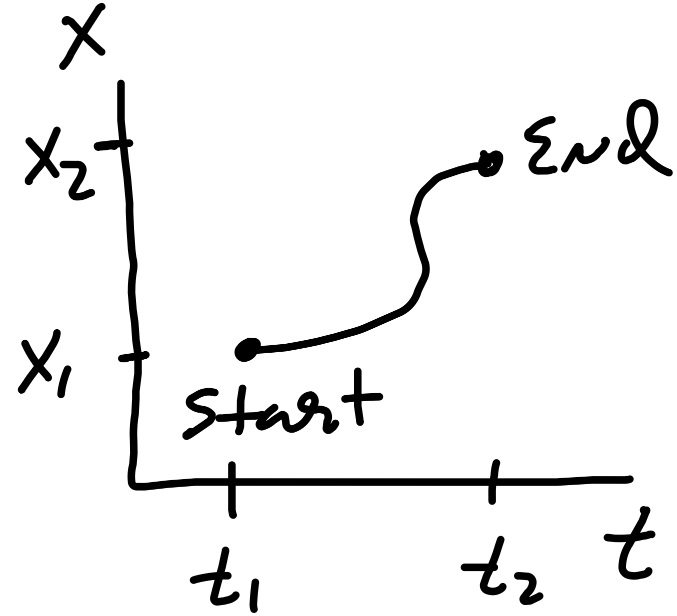
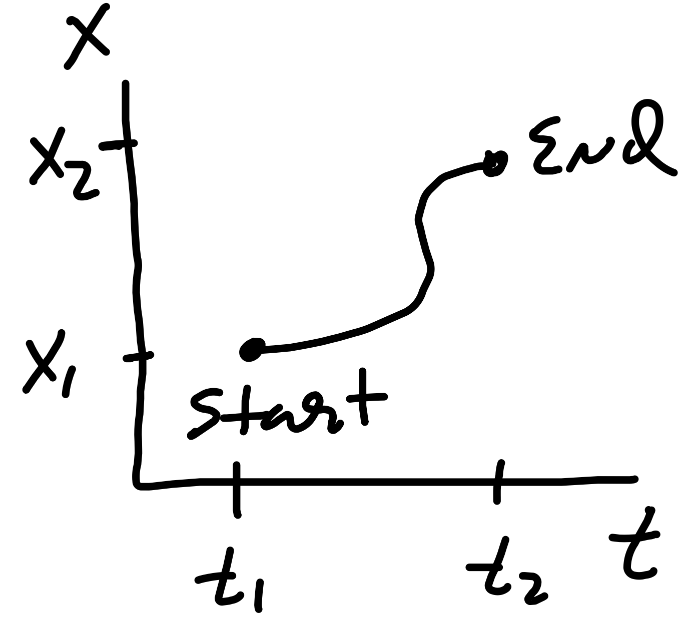
t_2



ASU

$$\Delta x = x_2 - x_1 \quad \&$$

$$\Delta t = t_2 - t_1$$

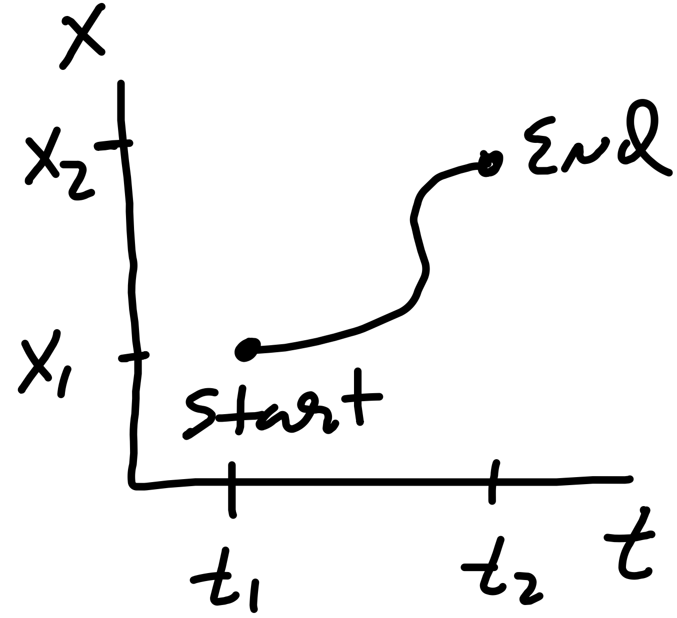


$\Delta x = x_2 - x_1$ &

$\Delta t = t_2 - t_1$

What about a

Different path ?



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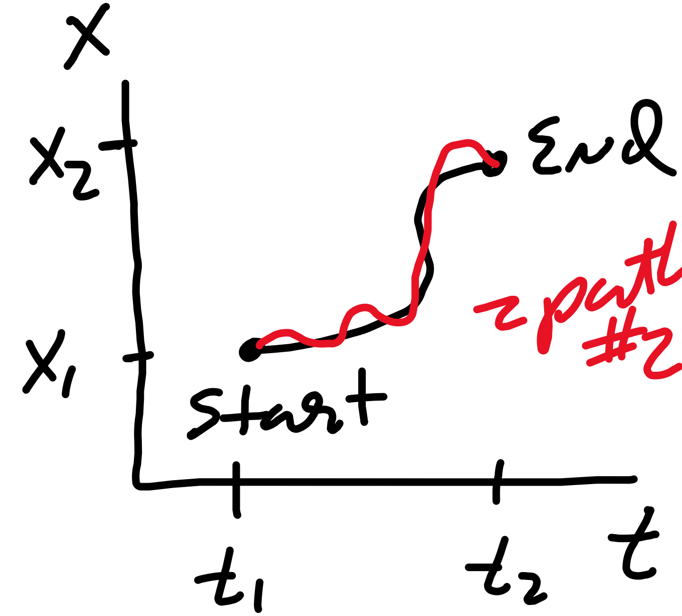

What about a Different path?

We can easily see that the path is not important for Δx.

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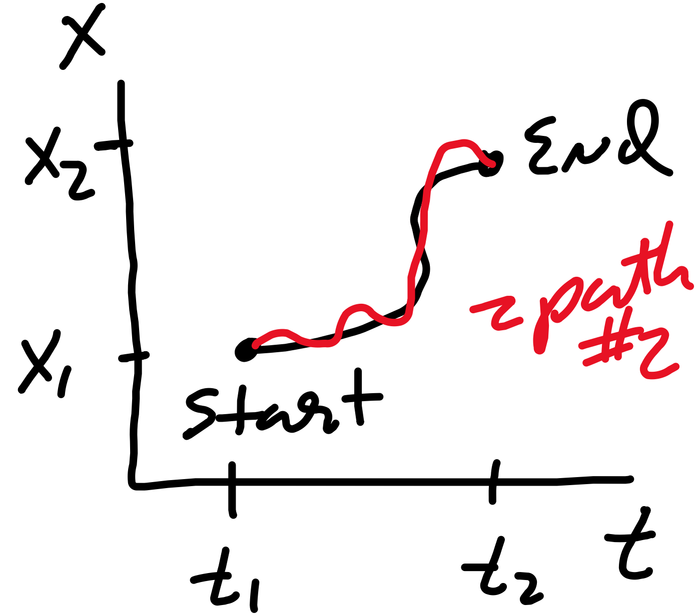

We can easily see that the path is <u>not</u> important for Δx.

This means V_{AVE} is path independent.

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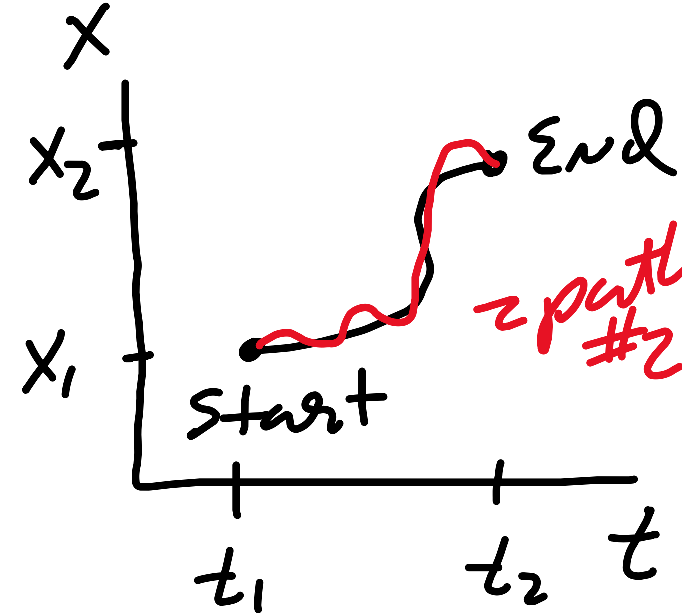
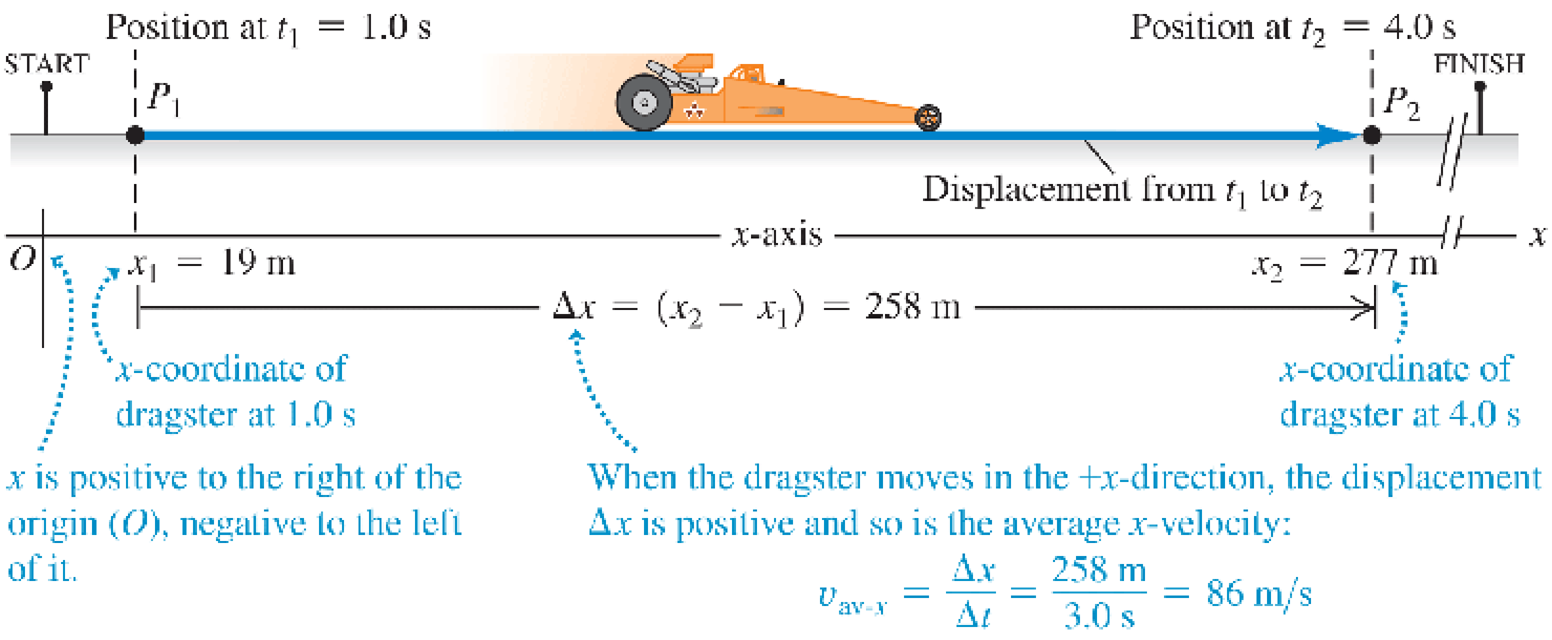


What about a Different path ?

We can easily see that the path is <u>not</u> important for Δx. This means v_{AVE} is path independent. The average speed, however, we will define as

$$\boxed{\text{speed}_{AVE} = \frac{\text{path length}}{\Delta t}}$$

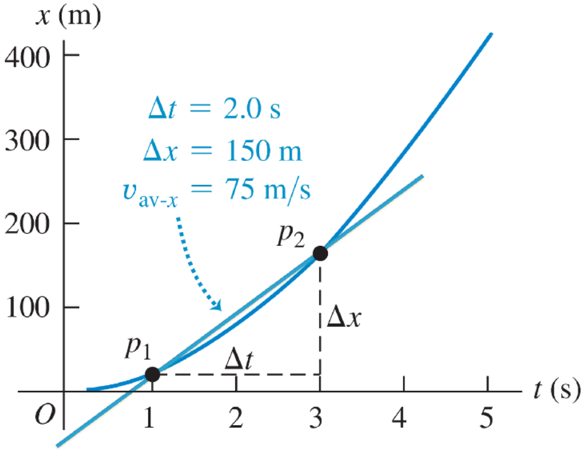
Figure 2.1



Positions of a dragster at two times during its run.

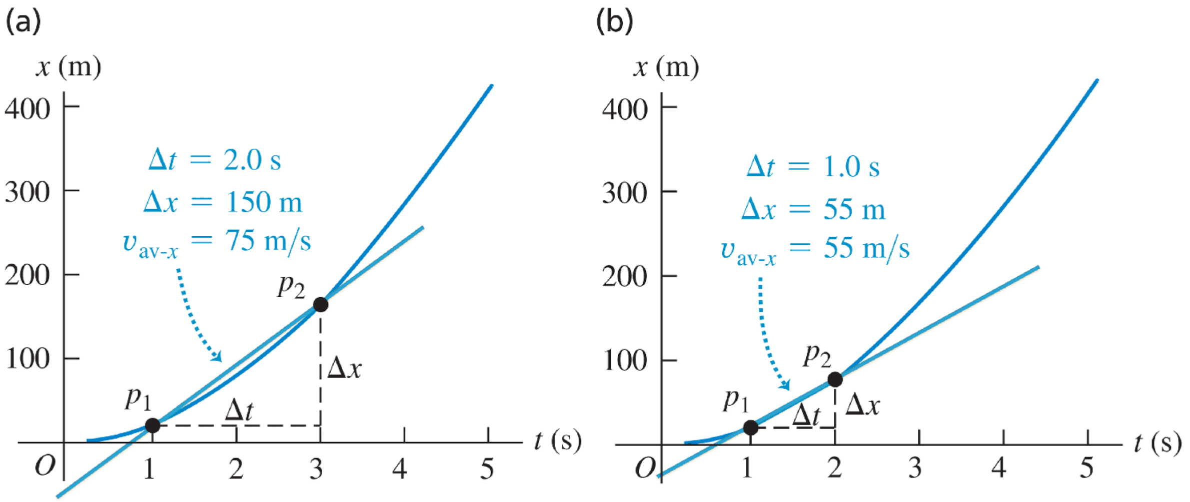
Finding velocity on x-t graph

(a)



As the average x-velocity $v_{av\text{-}x}$ is calculated over shorter and shorter time intervals ...

Finding velocity on x-t graph



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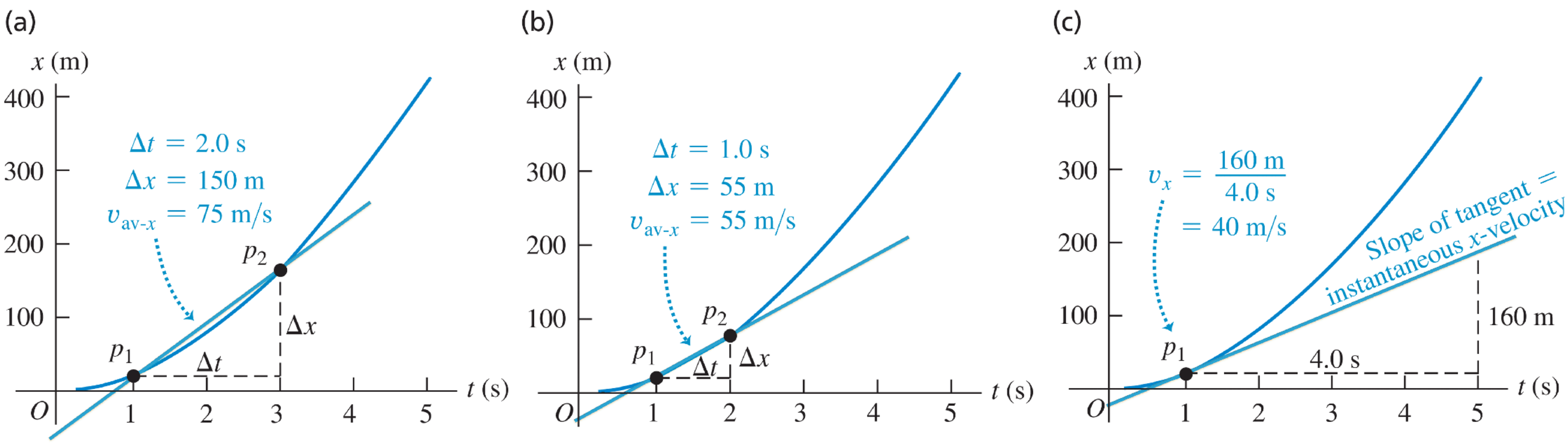
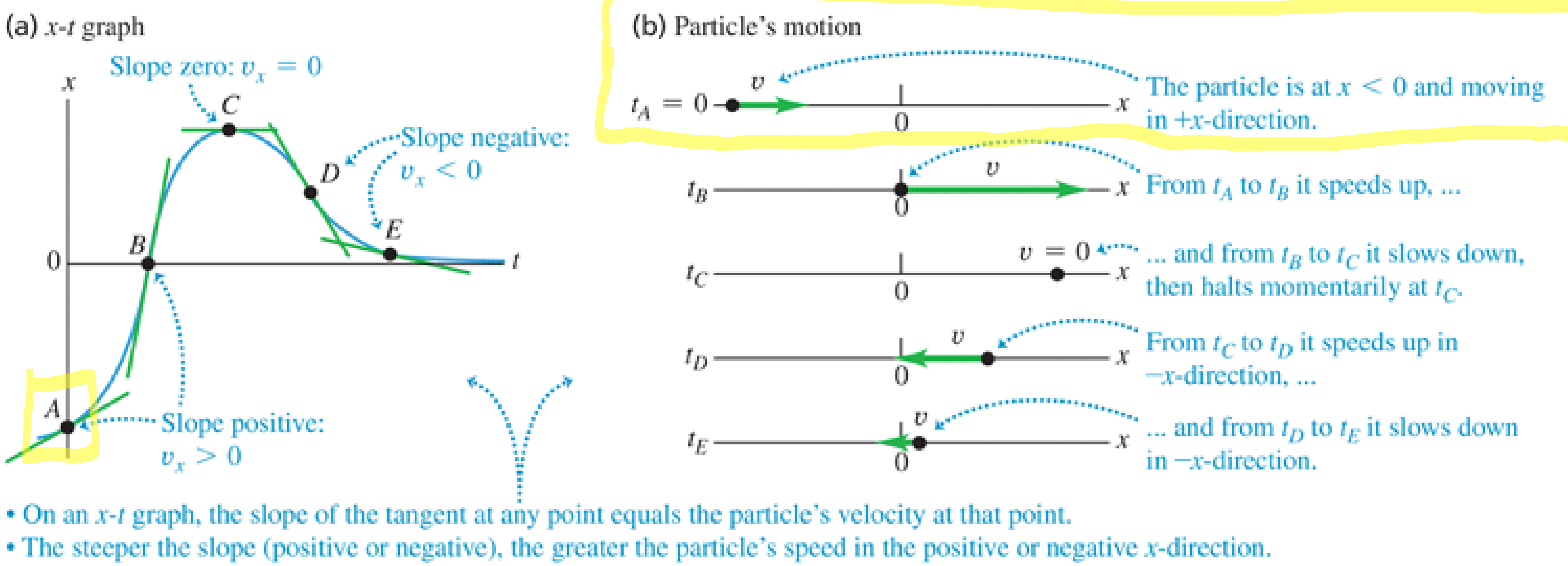


As the average x-velocity $v_{av\text{-}x}$ is calculated over shorter and shorter time intervals ...

... its value $v_{av\text{-}x} = \Delta x / \Delta t$ approaches the instantaneous x-velocity.

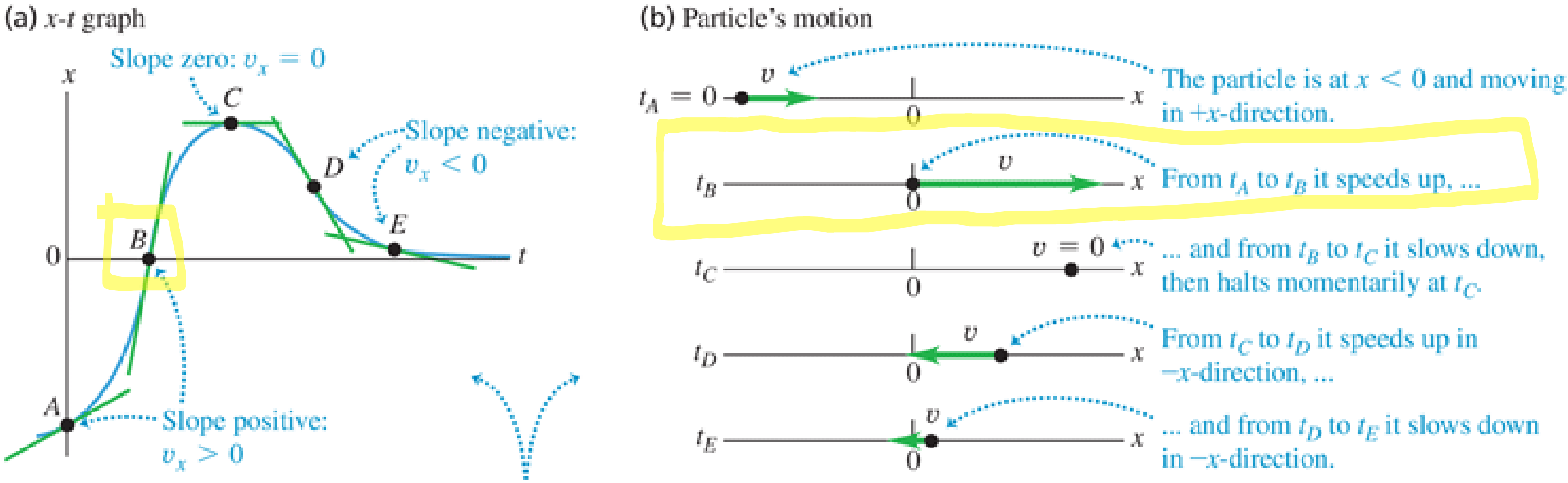
The instantaneous x-velocity v_x at any given point equals the slope of the tangent to the x-t curve at that point.

Finding velocity on x-t graph



(a) The x-t graph of the motion of a particular particle. (b) A motion diagram showing the position and velocity of the particle at each of the times labeled on the x-t graph.

Finding velocity on x-t graph



- On an x-t graph, the slope of the tangent at any point equals the particle's velocity at that point.
- The steeper the slope (positive or negative), the greater the particle's speed in the positive or negative x-direction.

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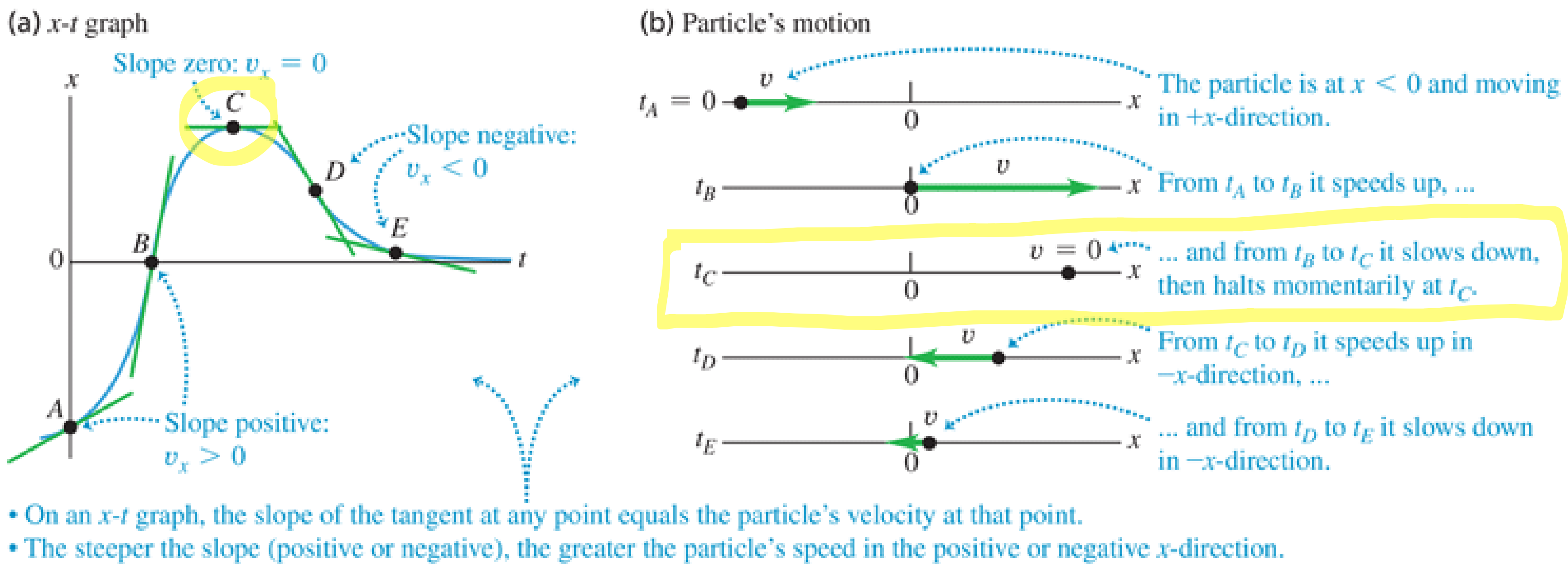
Finding velocity on x-t graph



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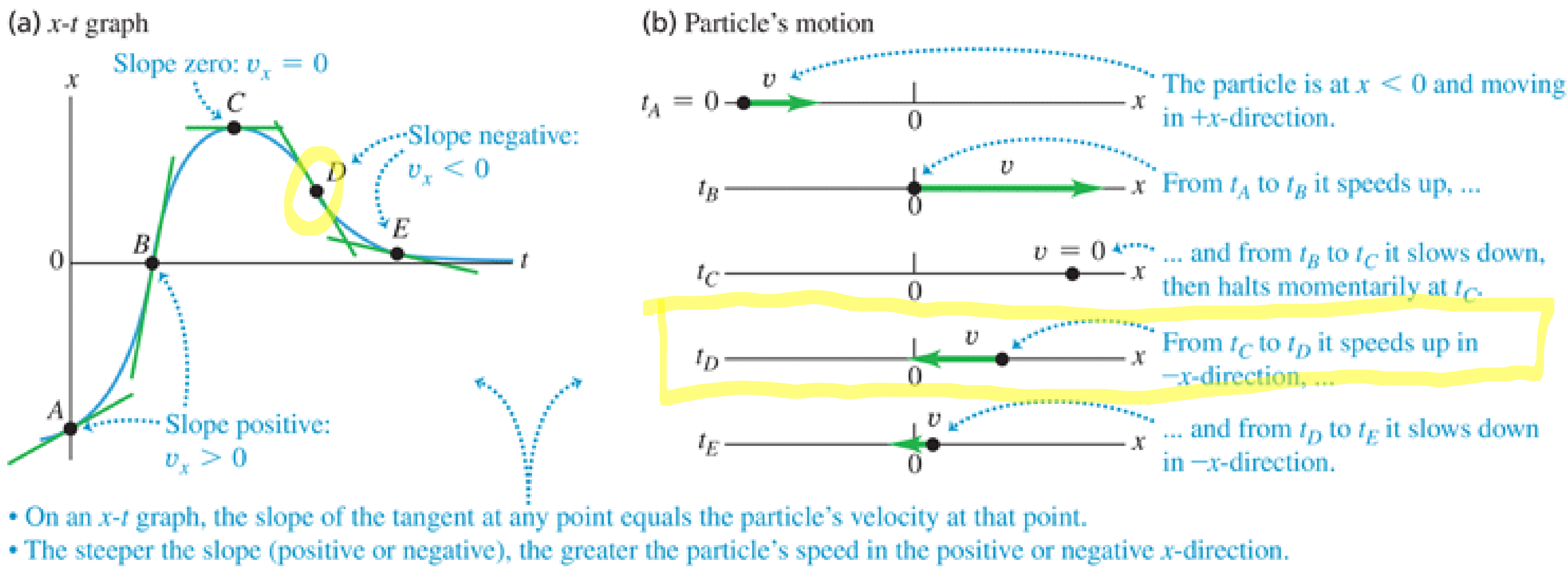

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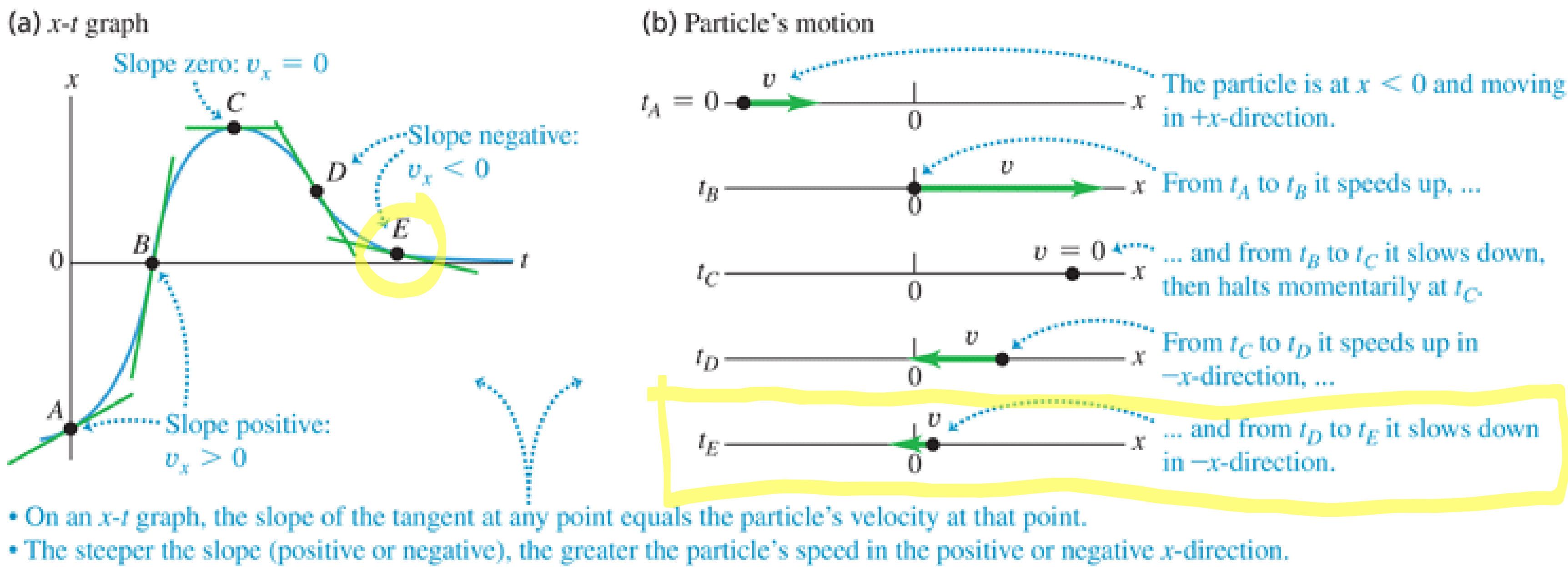

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Imagine the motion of a flashing object constrained to move in the vertical direction

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Average velocity $= \frac{\Delta y}{\Delta t}$

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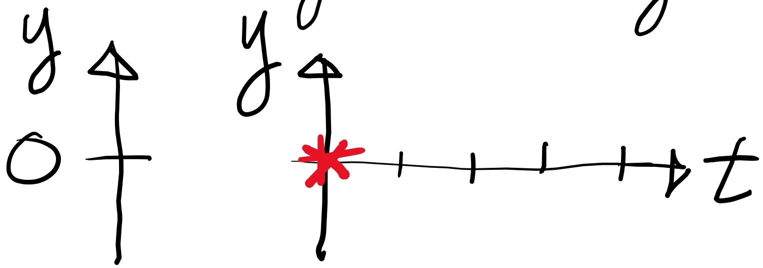

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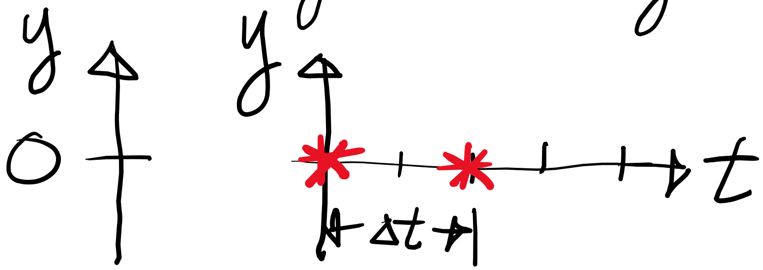

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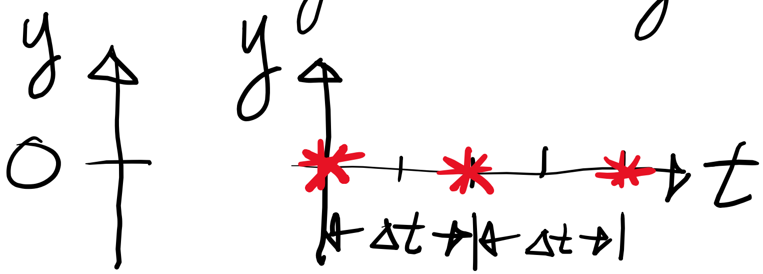

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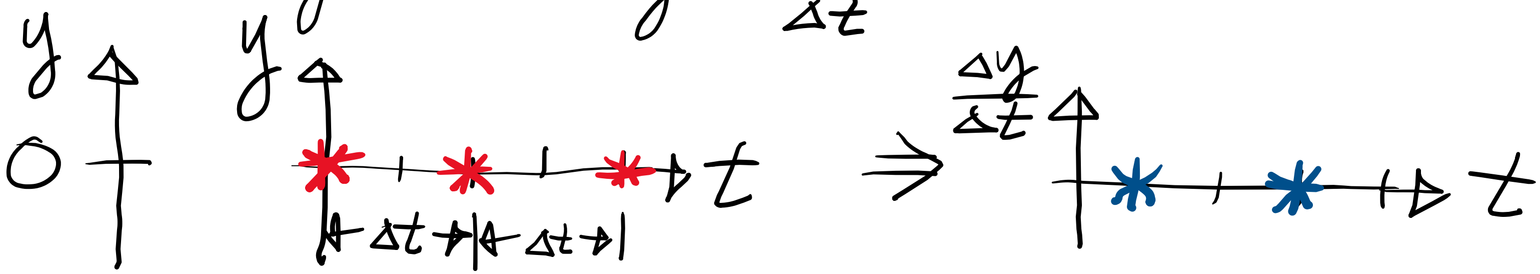

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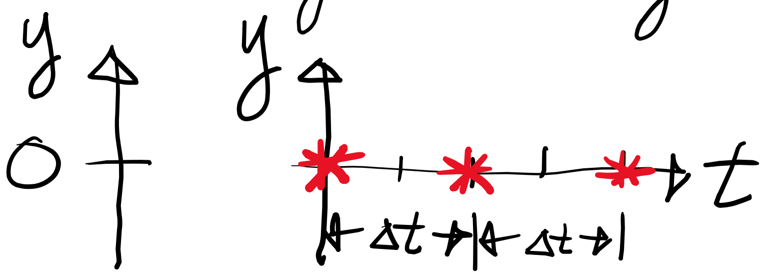

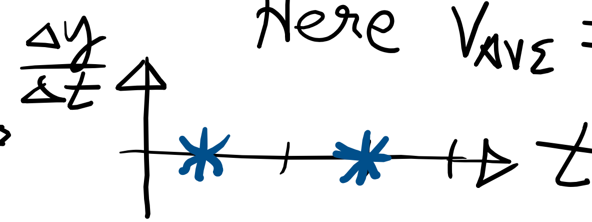

Here $V_{AVE} = 0$

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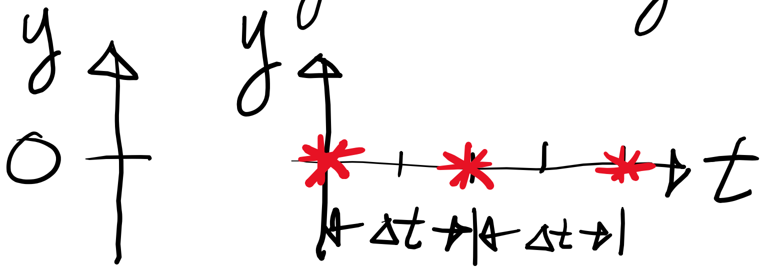
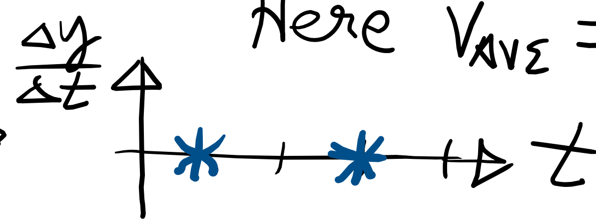


$\Rightarrow$



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Now double the rate

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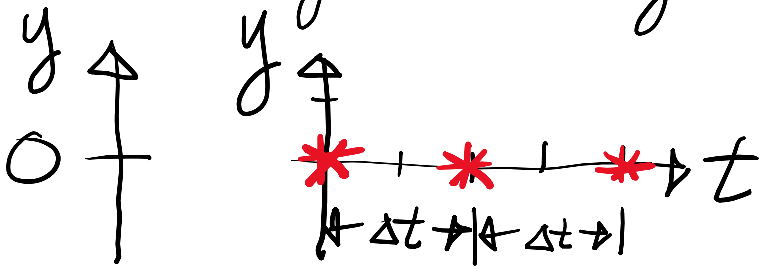

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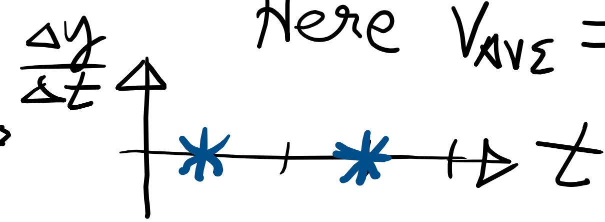

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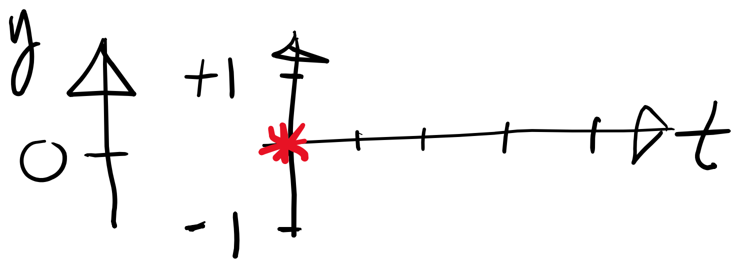

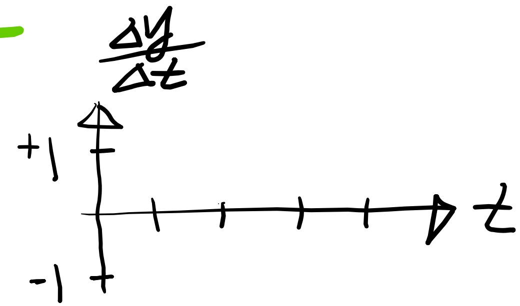

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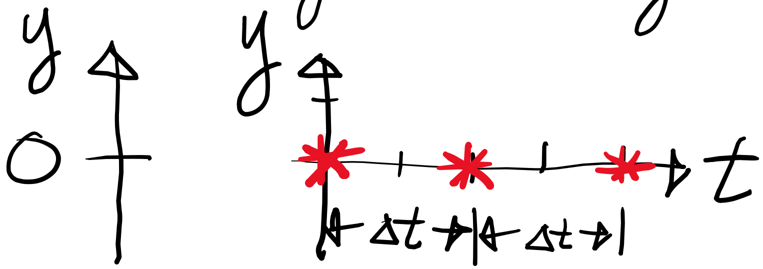

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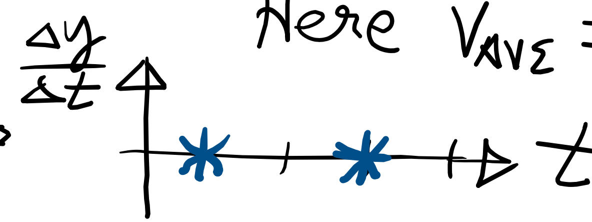

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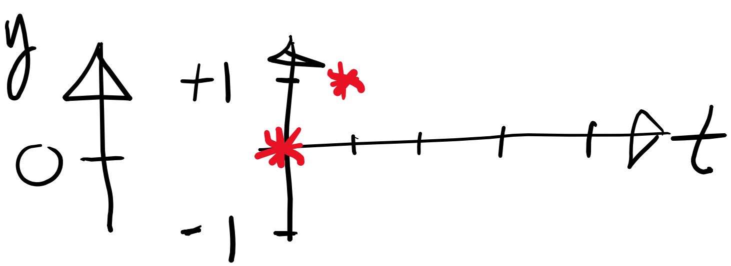

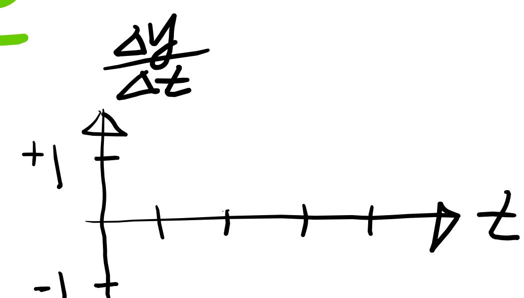

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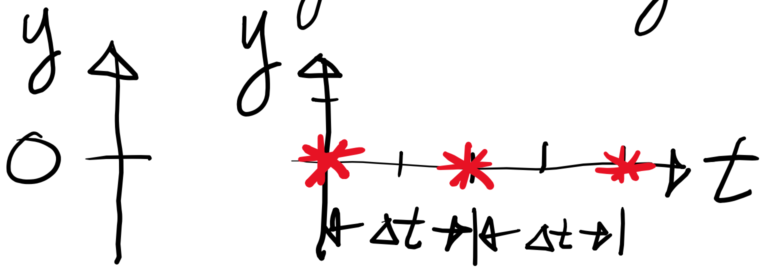

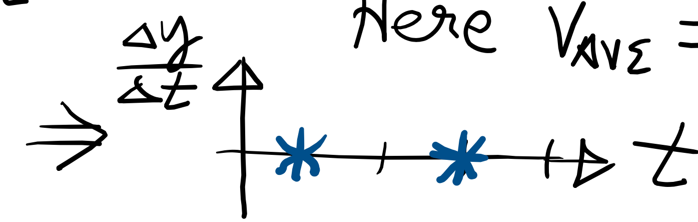

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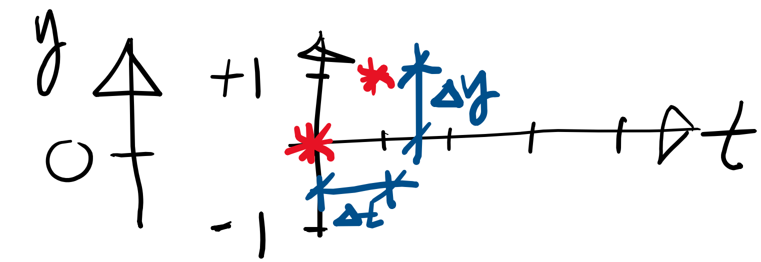

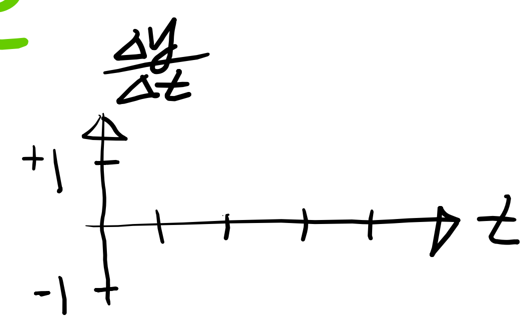

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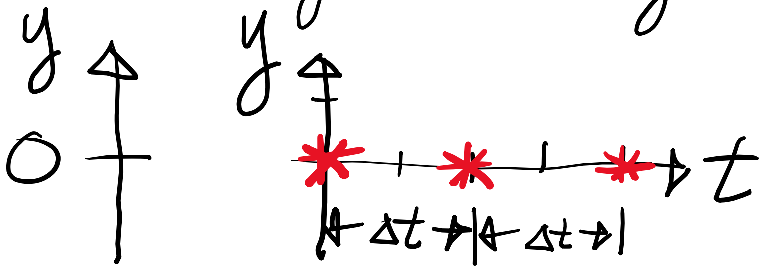

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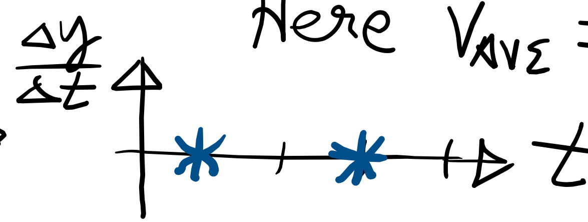

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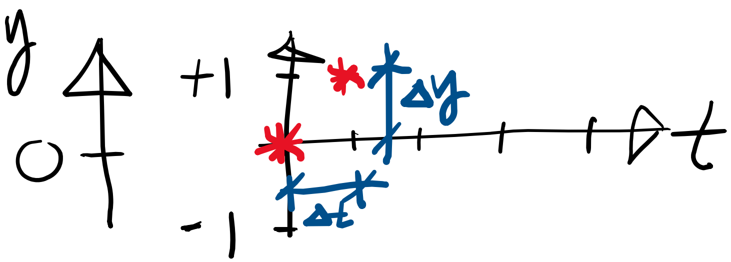

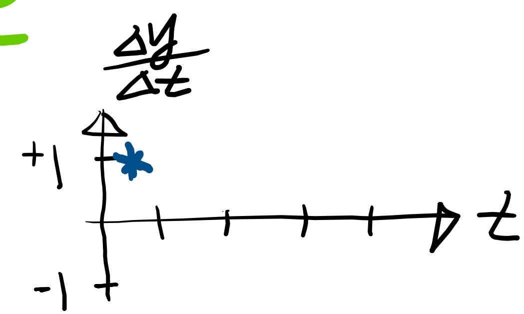

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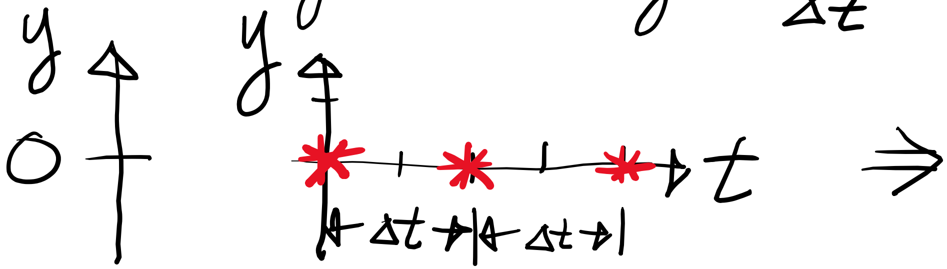

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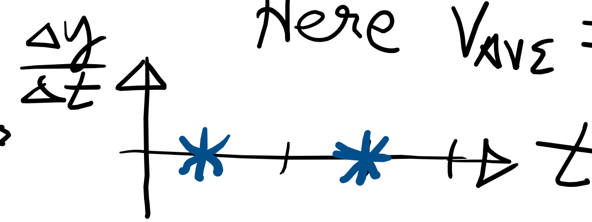

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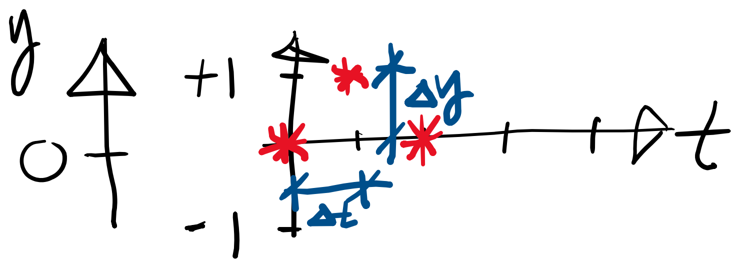

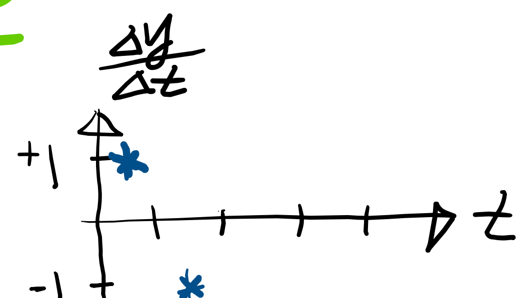

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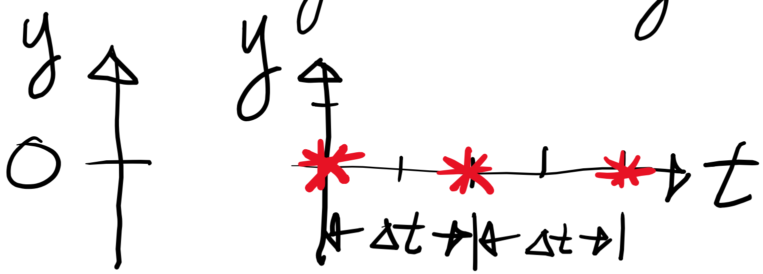
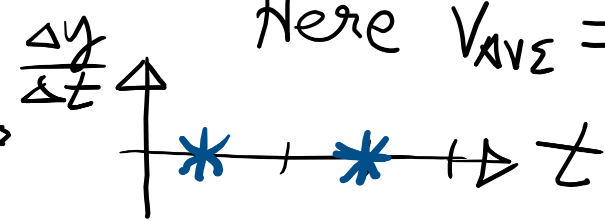
Average velocity $= \frac{\Delta y}{\Delta t}$

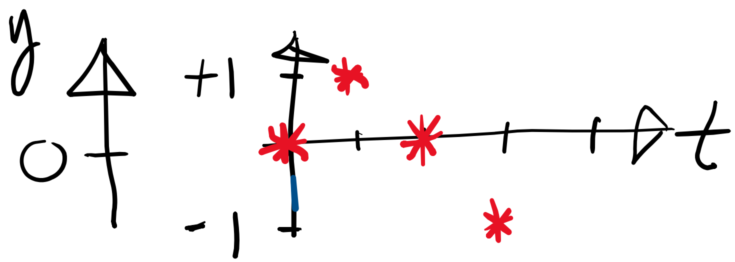


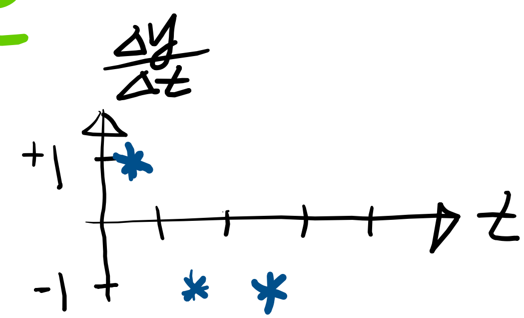
$\Rightarrow$

Here $V_{AVE} = 0$



Now double the rate





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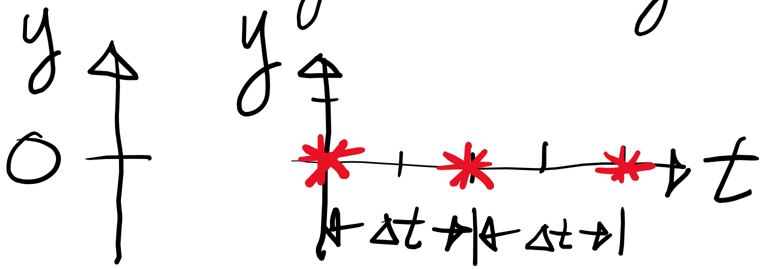

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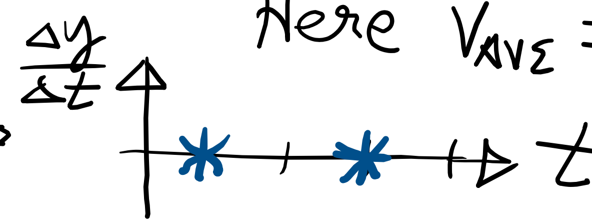

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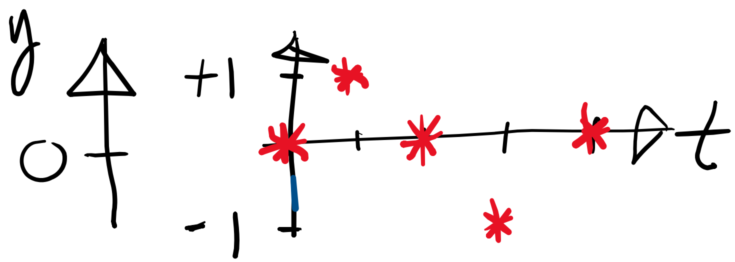

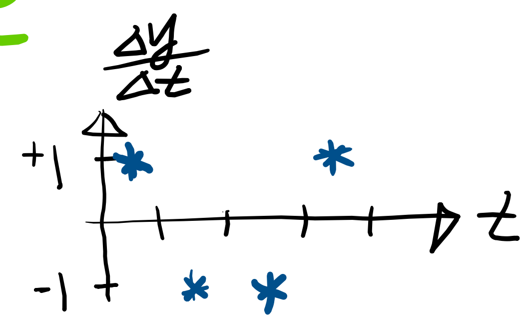

Imagine the motion of a flashing object constrained to move in the vertical direction

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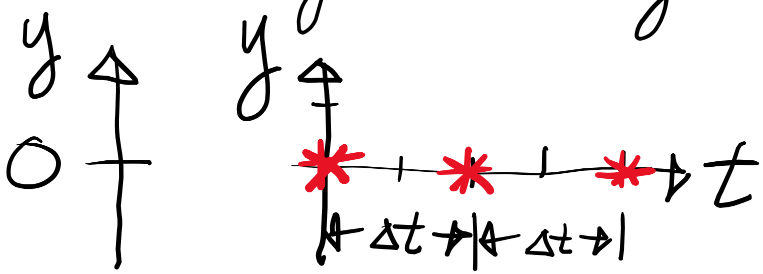
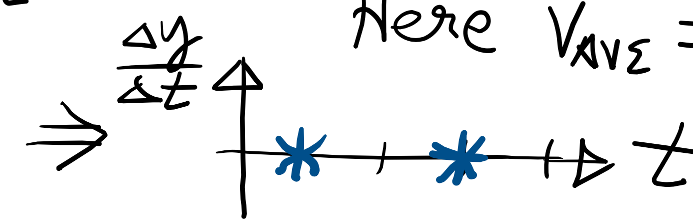
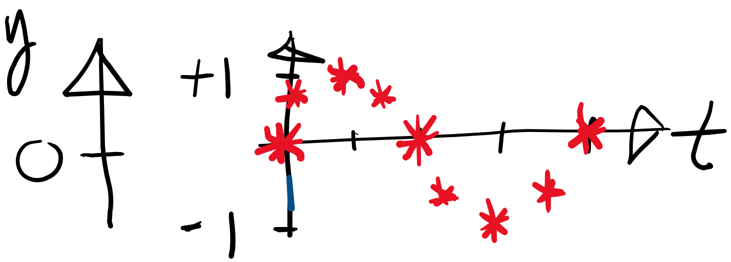
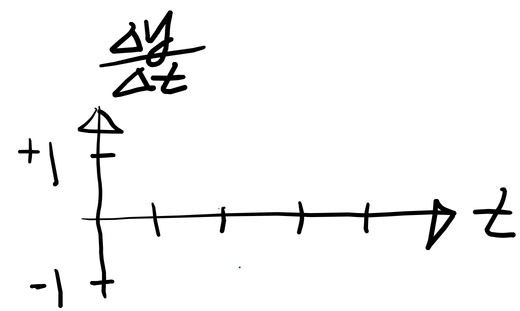




Here $V_{AVE} = 0$

QUAD RATE





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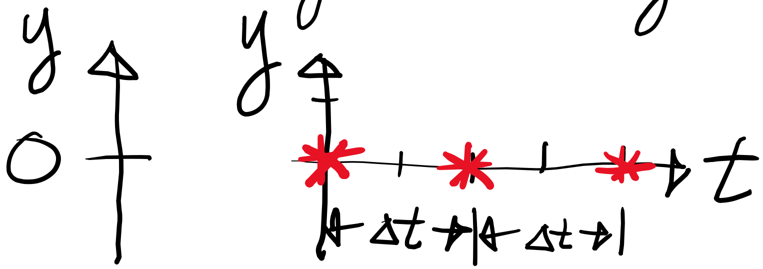

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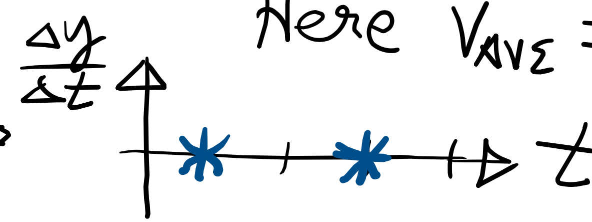
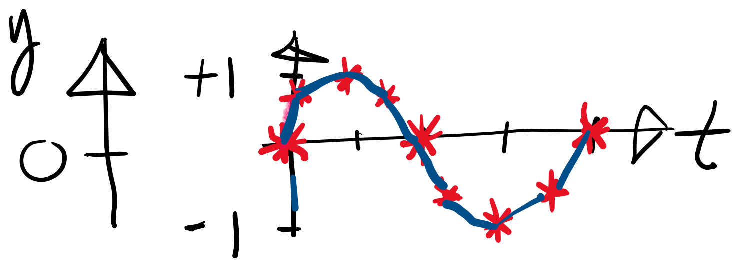
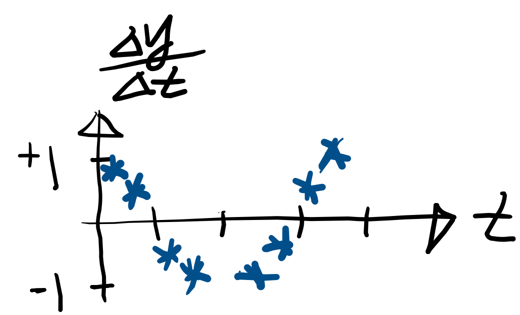


Here $V_{AVE} = \emptyset$

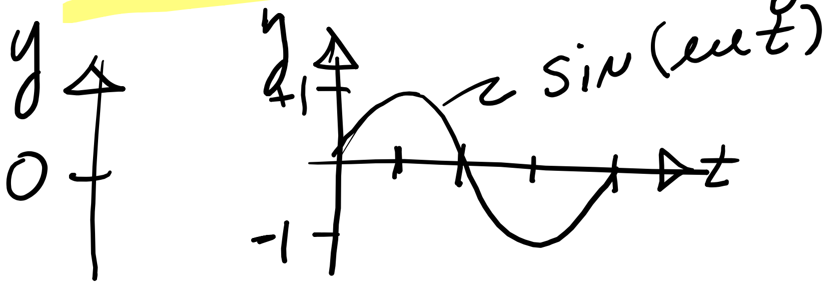
QUAD RATE



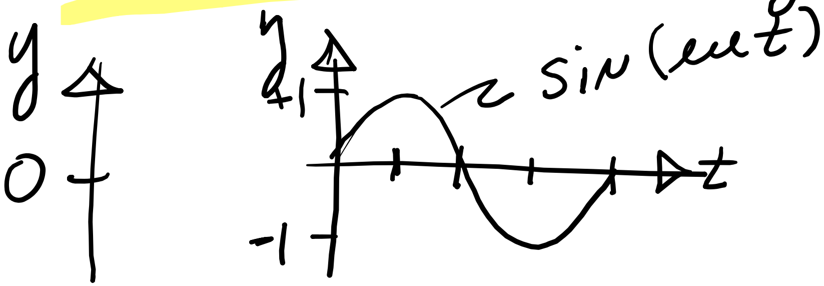


Continuous light

Continuous light

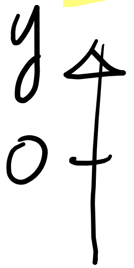


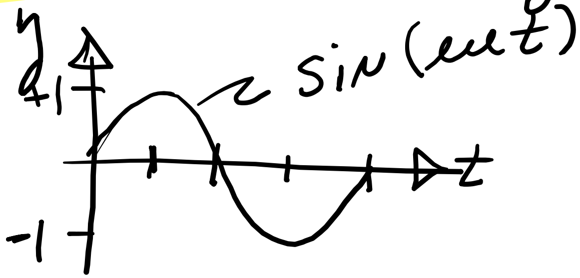
Continuous light



Now there is no nice Δt between flashes of light

Continuous light



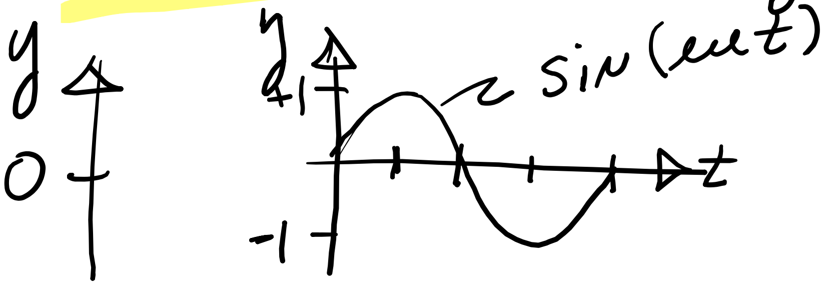


Now there is no nice Δt between flashes of light

Solution: Take limit as $\Delta t \to 0$:

$$v = \lim_{\Delta t \to 0} \frac{\Delta y}{\Delta t} \equiv \frac{dy}{dt}$$

Continuous light



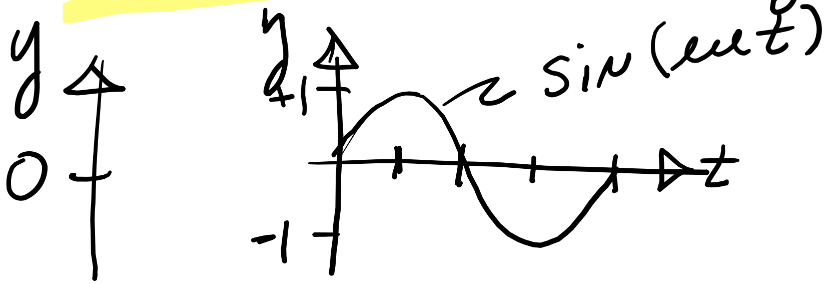
Now there is no nice Δt between flashes of light

Solution: Take limit as $\Delta t \to 0$:

$$v = \lim_{\Delta t \to 0} \frac{\Delta y}{\Delta t} \equiv \frac{dy}{dt}$$

$$v = \frac{d}{dt}\sin(\omega t) = \omega \cos(\omega t)$$

Continuous light



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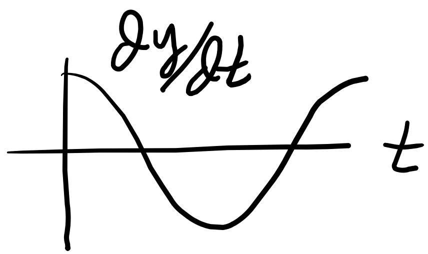
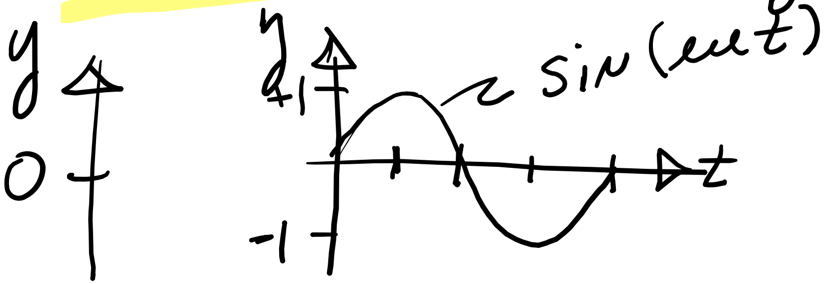


Continuous light



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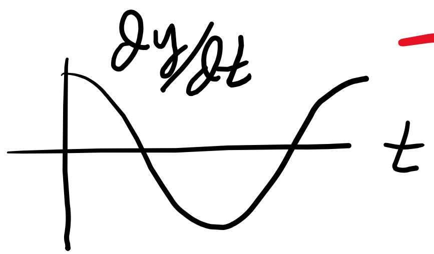
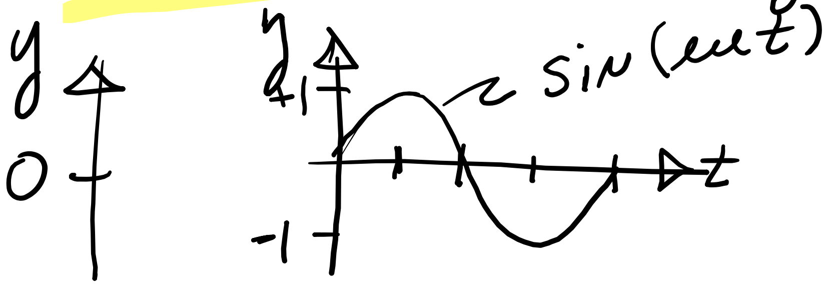


We can see that the velocity is never constant (in this example)

Continuous light



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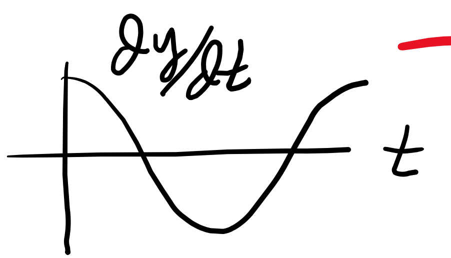

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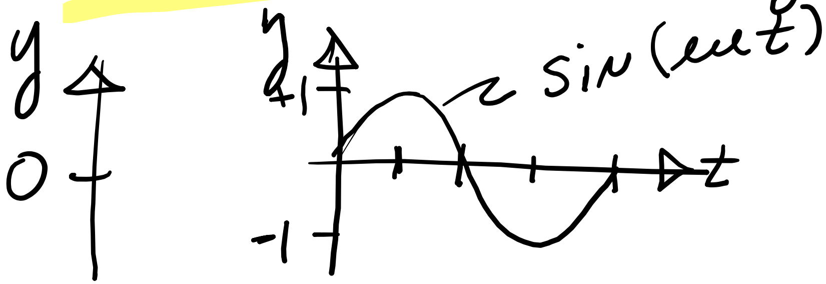

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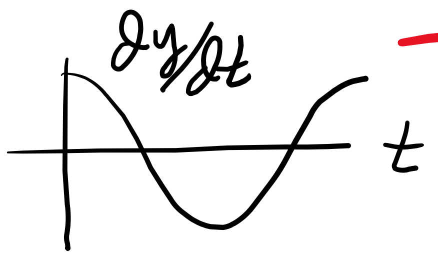

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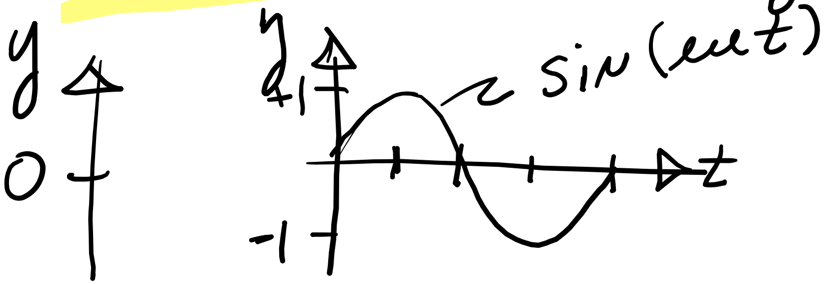
Define acceleration: $a_{AVE} \equiv \frac{\Delta v}{\Delta t}$ & $a = \frac{dv}{dt}$

Continuous light



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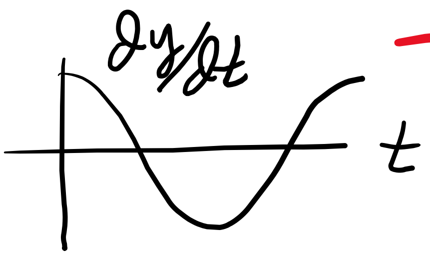
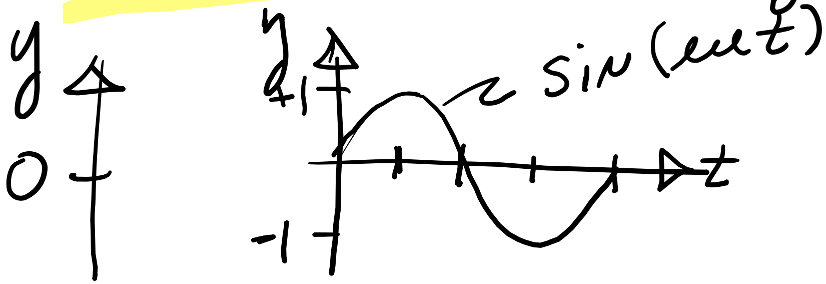


We can see that the velocity is never constant (in this example)

Define acceleration: $a_{AVE} \equiv \frac{\Delta V}{\Delta t}$ & $a = \frac{dV}{dt}$

But $v = \frac{dy}{dt}$

Continuous light



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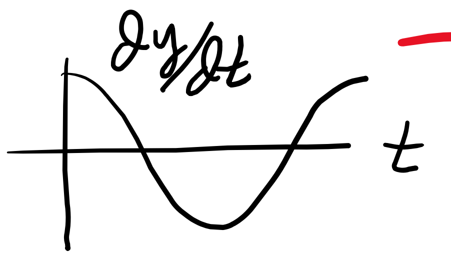

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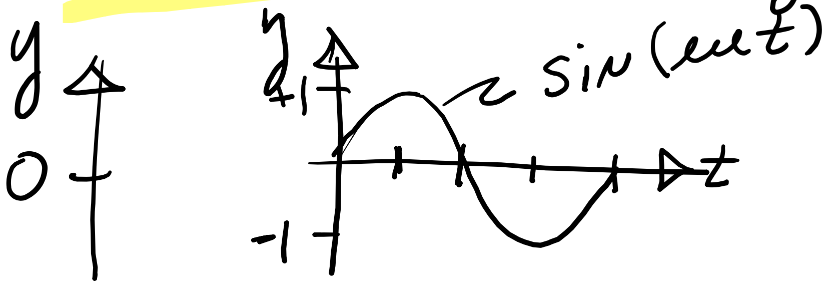
Define acceleration: $a_{AVE} \equiv \frac{\Delta V}{\Delta t}$ & $a = \frac{dV}{dt}$

But $v = \frac{dy}{dt}$ so $a = \frac{d}{dt}\left(\frac{dy}{dt}\right)$

ASU

Continuous light



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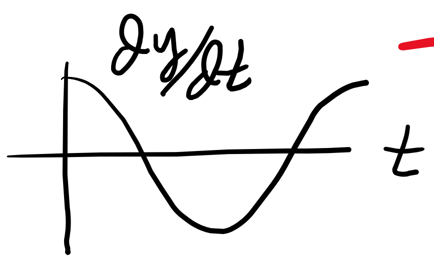

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Define acceleration: $a_{AVE} \equiv \frac{\Delta V}{\Delta t}$ & $a = \frac{dV}{dt}$

But $v = \frac{dy}{dt}$ so $a = \frac{d}{dt}\left(\frac{dy}{dt}\right) = \frac{d^2y}{dt^2}$ 2nd derivitive

Acceleration

Average *x*-acceleration of a particle in **straight-line motion** during time interval from t_1 to t_2

Change in x-component of the particle's velocity

$$a_{\text{av-}x} = \frac{\Delta v_x}{\Delta t} = \frac{v_{2x} - v_{1x}}{t_2 - t_1}$$

Final x-velocity minus initial x-velocity

Time interval

Final time minus initial time

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Average *x*-acceleration of a particle in **straight-line motion** during time interval from t_1 to t_2

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Final *x*-velocity minus initial *x*-velocity

Time interval

Final time minus initial time

The **instantaneous *x*-acceleration** of a particle in **straight-line motion** ...

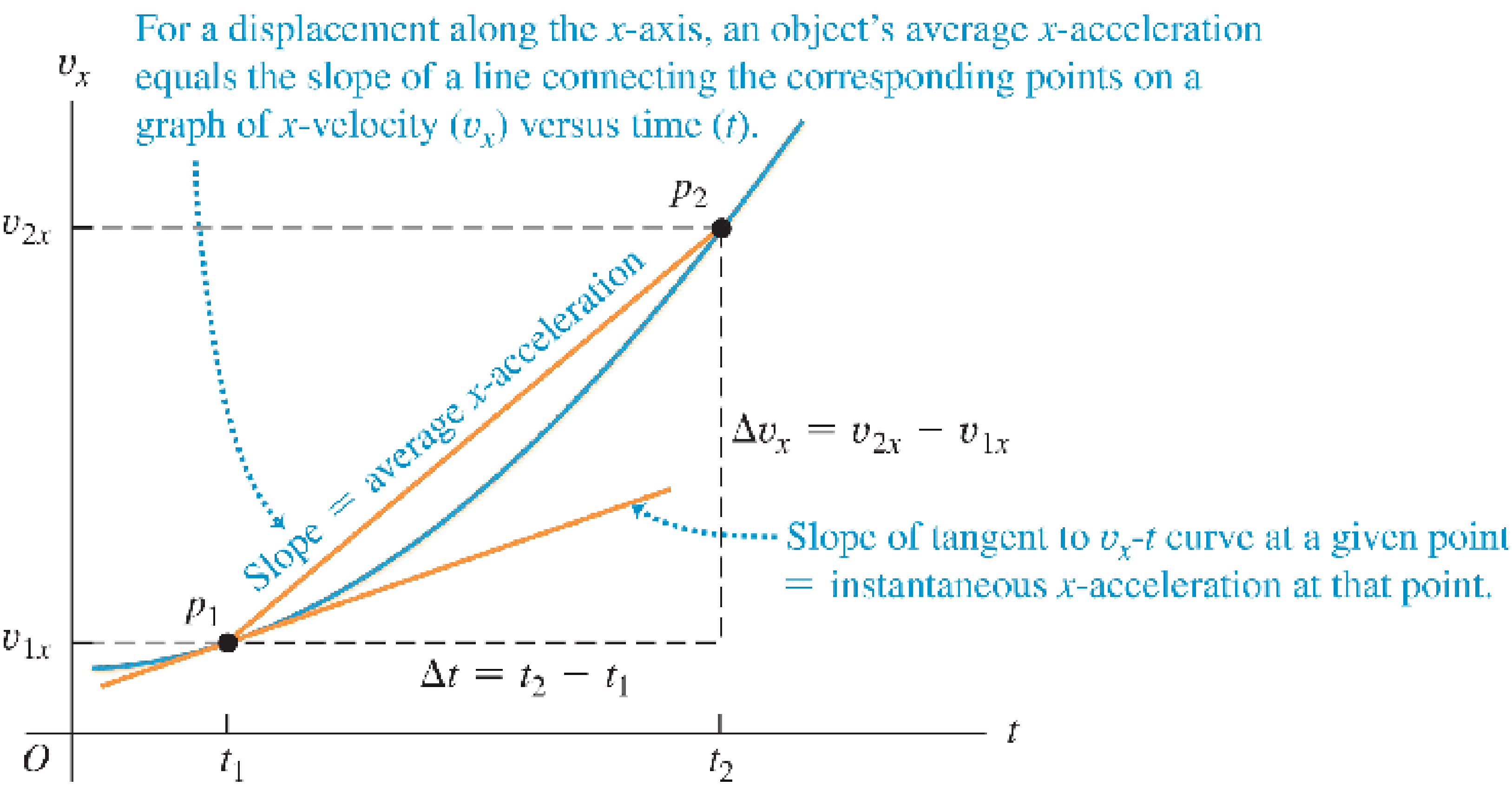
$$a_x = \lim_{\Delta t \to 0} \frac{\Delta v_x}{\Delta t} = \frac{dv_x}{dt}$$

... equals the limit of the particle's average *x*-acceleration as the time interval approaches zero ...

... and equals the instantaneous rate of change of the particle's *x*-velocity.

ASU

Acceleration



Acceleration

Rules for the Sign of x-Acceleration

If x-velocity is:	... x-acceleration is:
Positive & increasing (getting more positive)	Positive: Particle is moving in $+x$-direction & speeding up

Acceleration

Rules for the Sign of x-Acceleration

If x-velocity is:	... x-acceleration is:
Positive & increasing (getting more positive)	Positive: Particle is moving in $+x$-direction & speeding up
Positive & decreasing (getting less positive)	Negative: Particle is moving in $+x$-direction & slowing down

Acceleration

Rules for the Sign of x-Acceleration

If x-velocity is:	... x-acceleration is:
Positive & increasing (getting more positive)	Positive: Particle is moving in $+x$-direction & speeding up
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Negative & increasing (getting less negative)	Positive: Particle is moving in $-x$-direction & slowing down

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Rules for the Sign of x-Acceleration

If x-velocity is:	... x-acceleration is:
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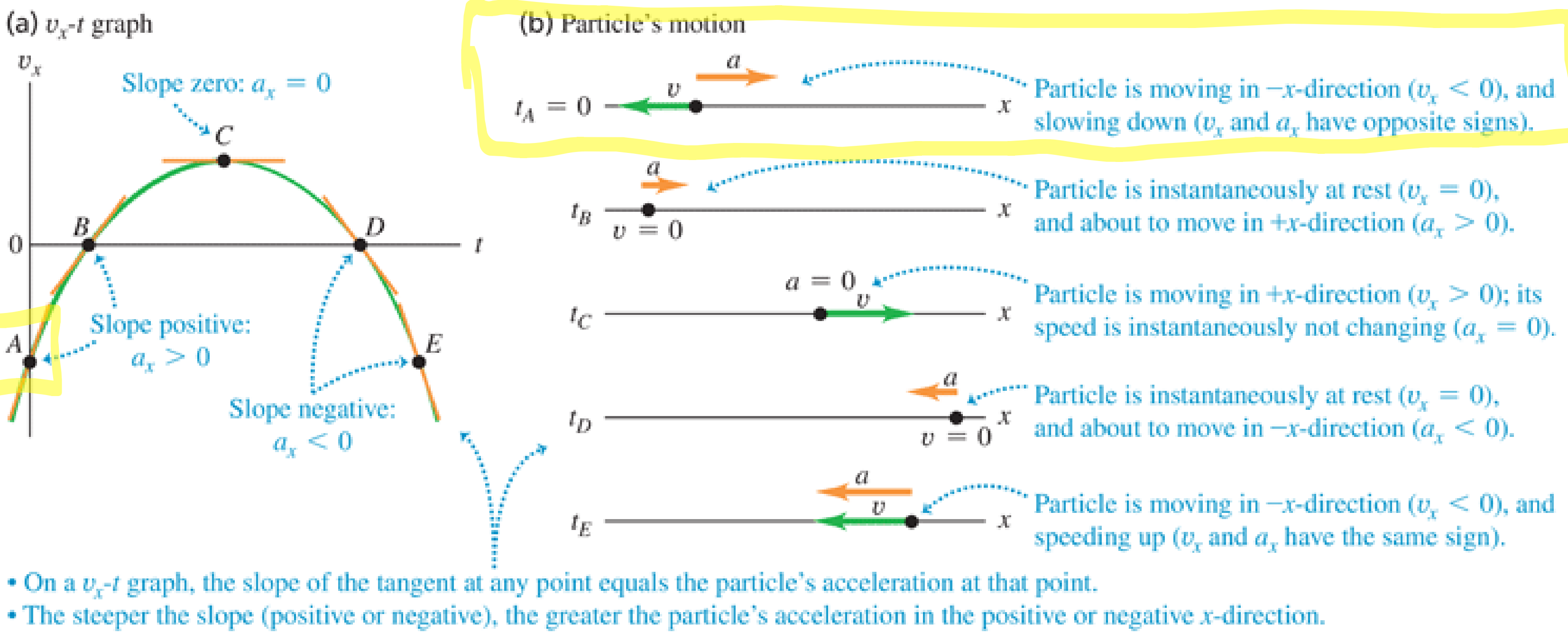
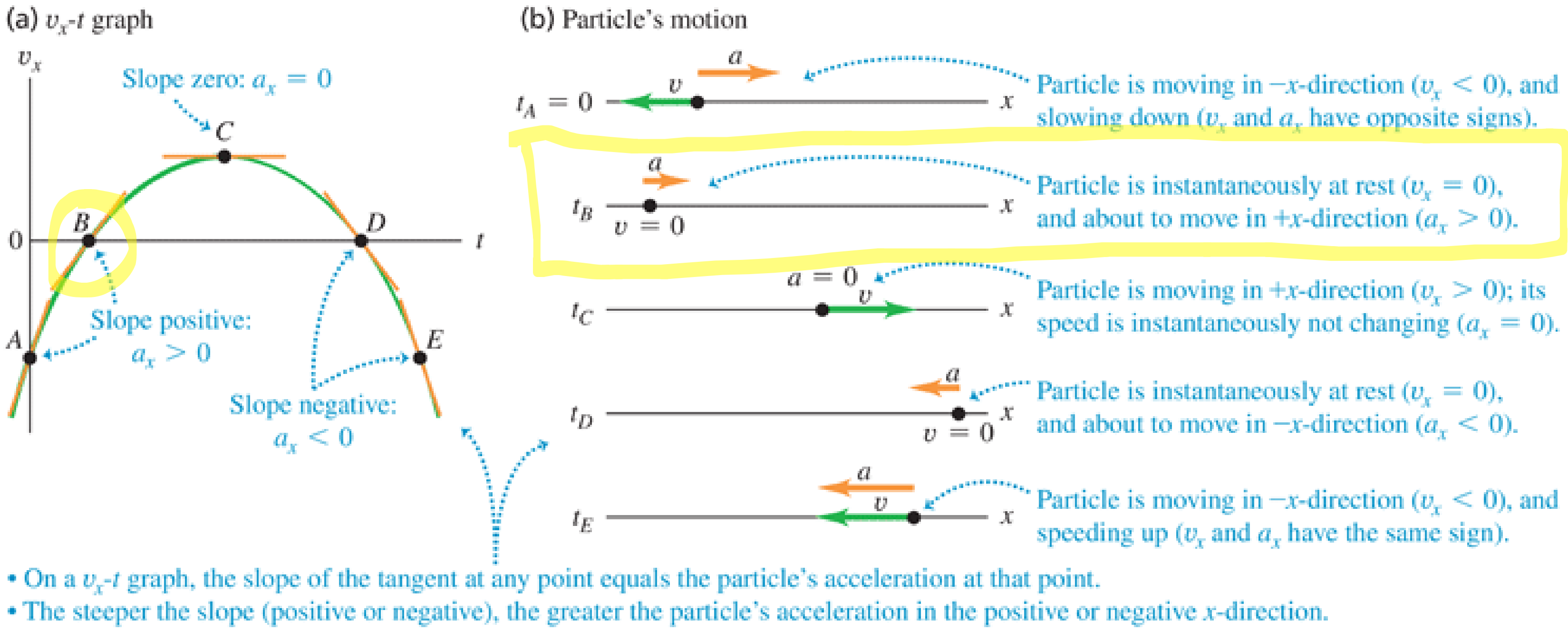
ASU

Acceleration



(a) The v_x-t graph of the motion of a different particle from that shown in Fig. 2.8. (b) A motion diagram showing the position, velocity, and acceleration of the particle at each of the times labeled on the v_x-t graph.

Acceleration



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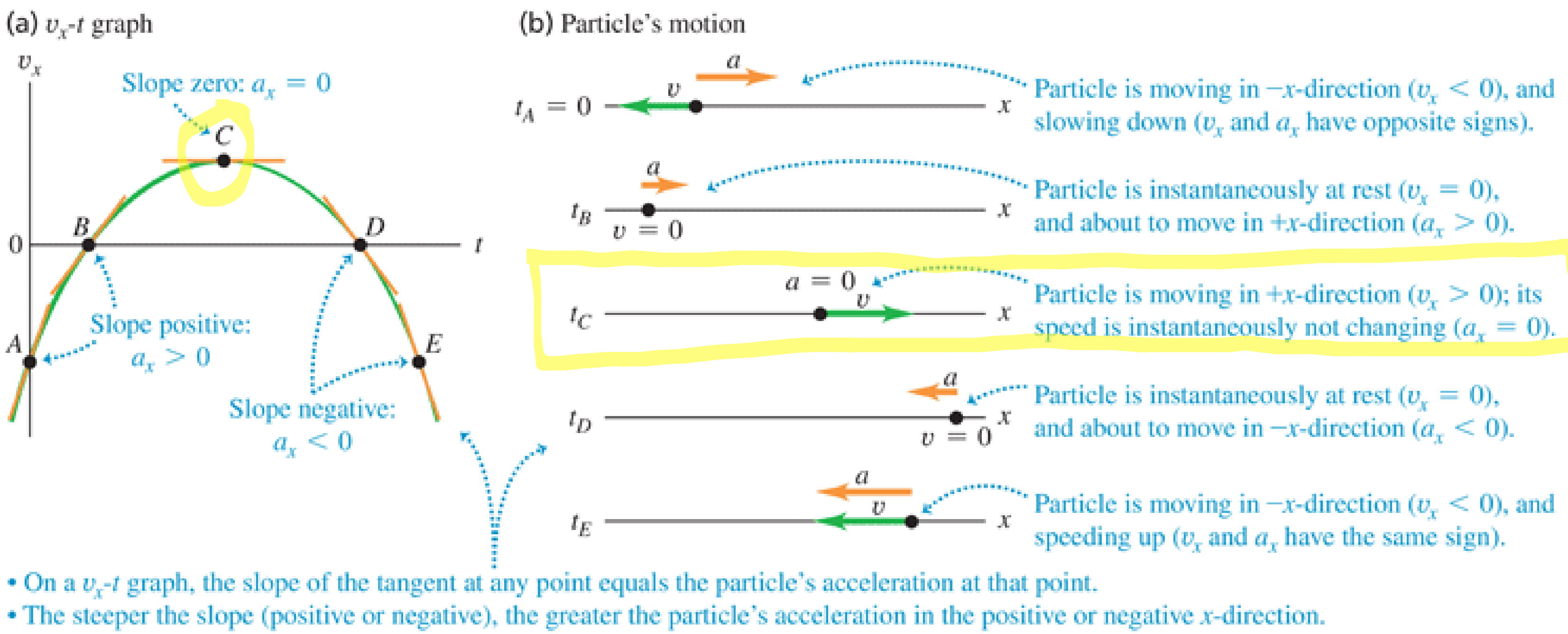

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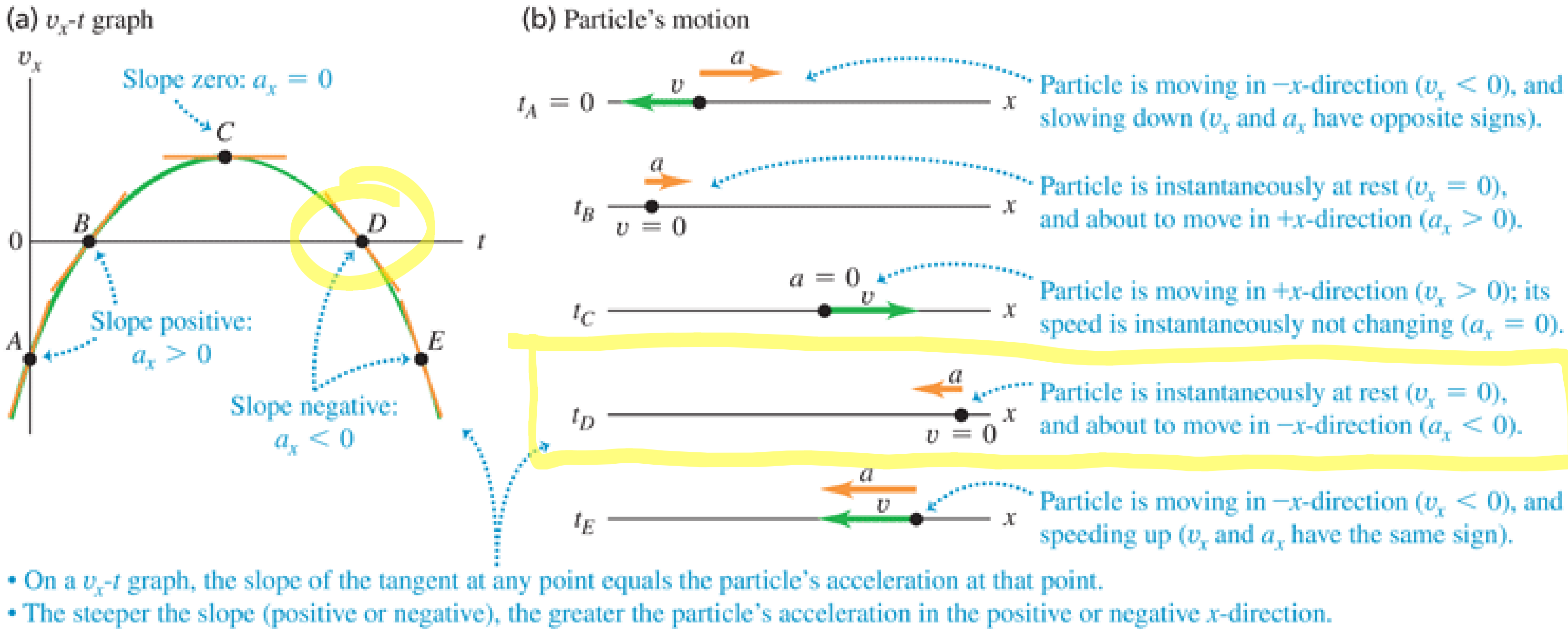

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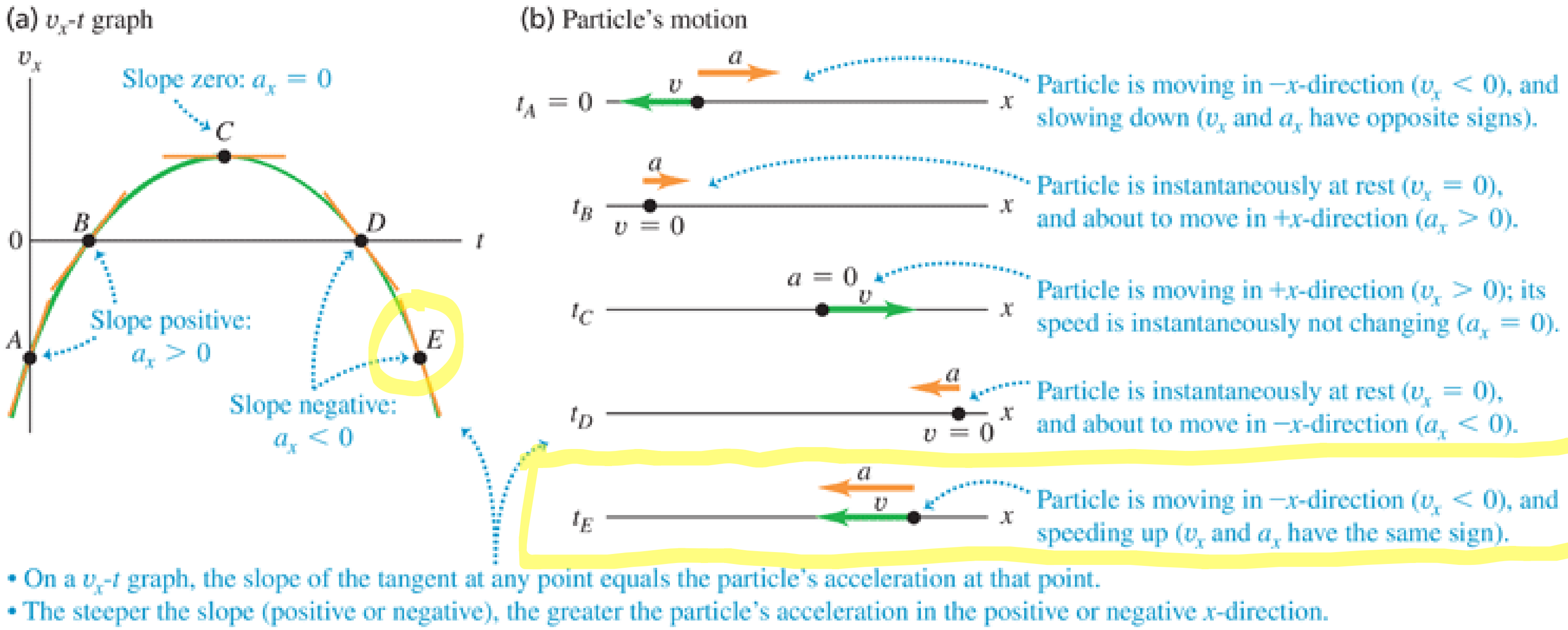

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