DESCRIBING MOTION: KINEMATICS IN ONE DIMENSION

AP Physics

Section 2-1 Reference Frames and Displacement

Model the velocity of the ball from the time it leaves my hand till the time it hits the ground?

THINK ABOUT IT

- Is it a 1D or 2 D if it goes straight up and comes back?
- When will you call a ball traveling upwards 2D and WHY?
- If a car moves in a circle on the ground is it 1D or 2 D?

DESCRIBING MOTION: KINEMATICS IN ONE DIMENSION

Mechanics – study of motion, force, energy

Kinematics – how objects move

Dynamics – why objects move

Translational Motion – move without rotation

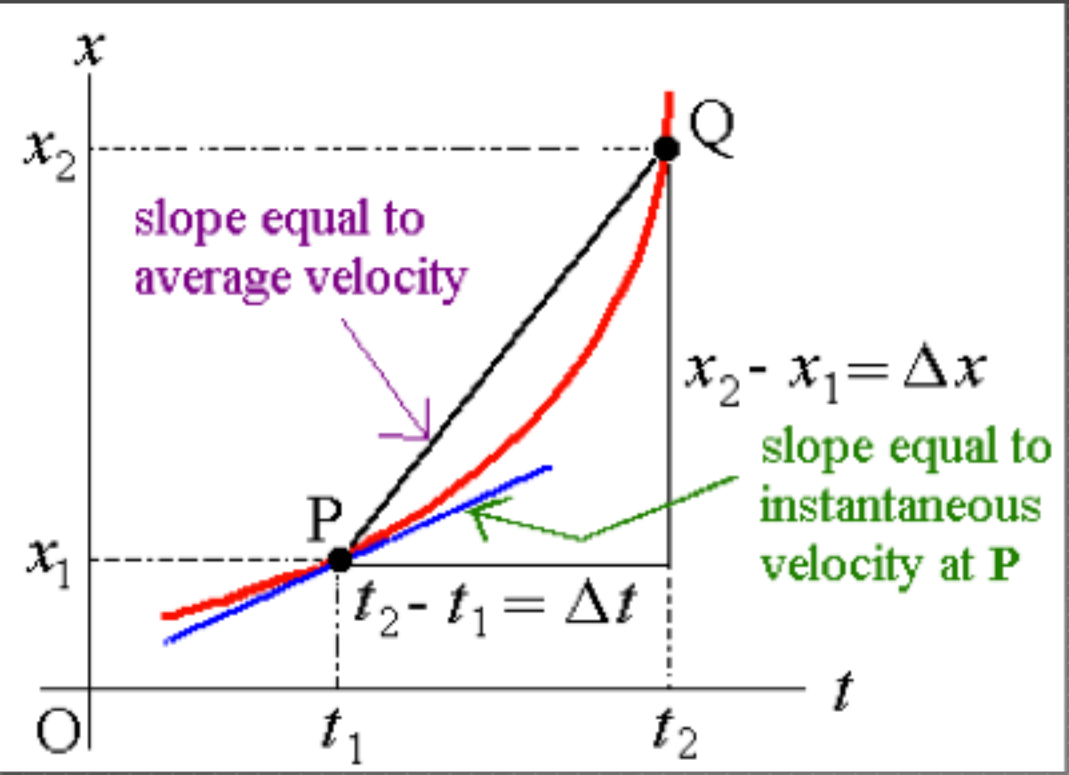
VELOCITY

- Rate of change of position = $\Delta x / \Delta t$

ACCELERATION

- Rate of change of Velocity = $\Delta V / \Delta t$

AVERAGE AND INSTANTANEOUS VELOCITY



$V_{avg} = \Delta x/\Delta t = (X_f - X_i)/(t_f - t_i)$

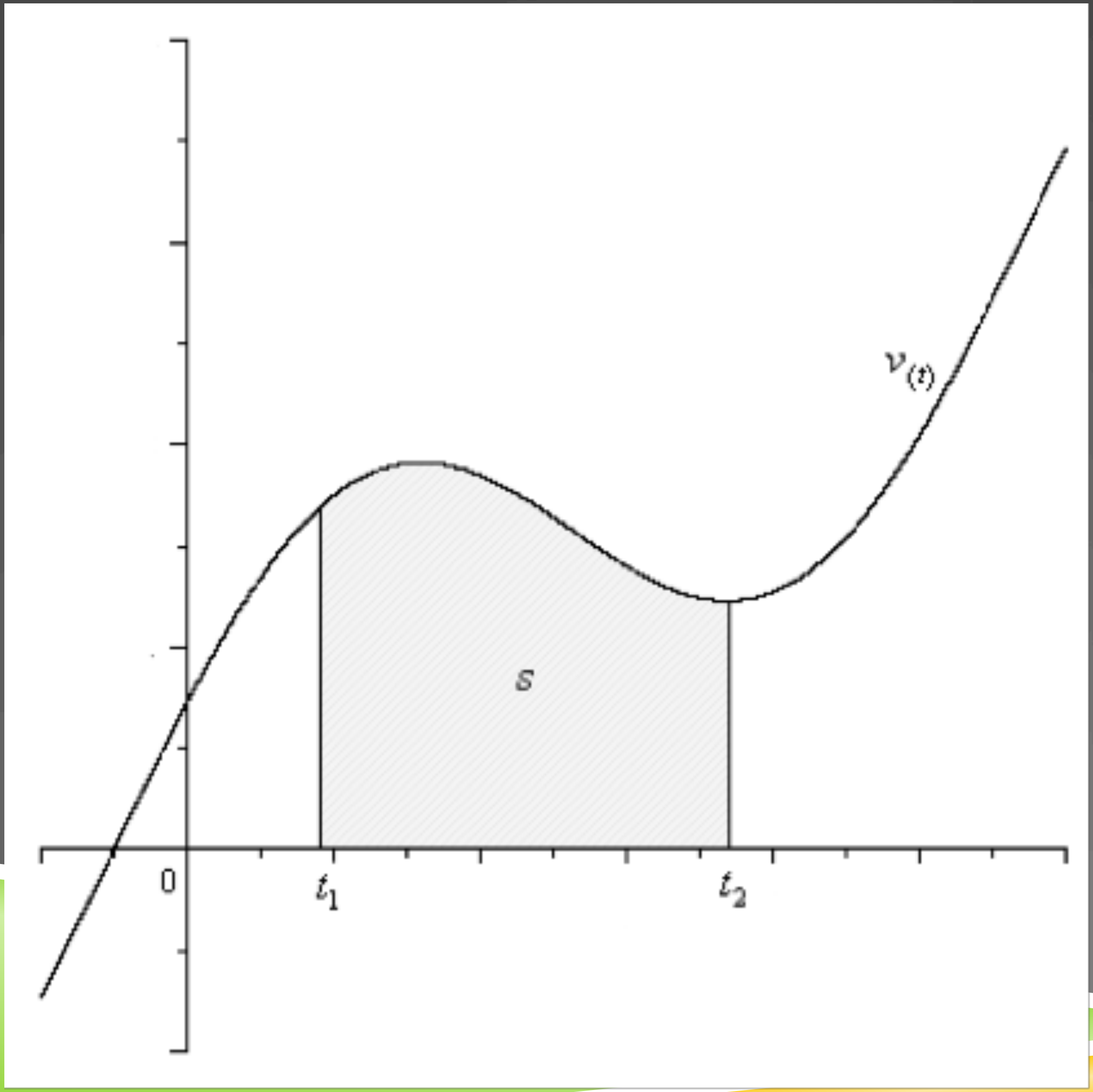
$V_{inst} = \mathrm{Lim}_{\Delta t \to 0} (\Delta x/\Delta t)$

$= dx/dt$

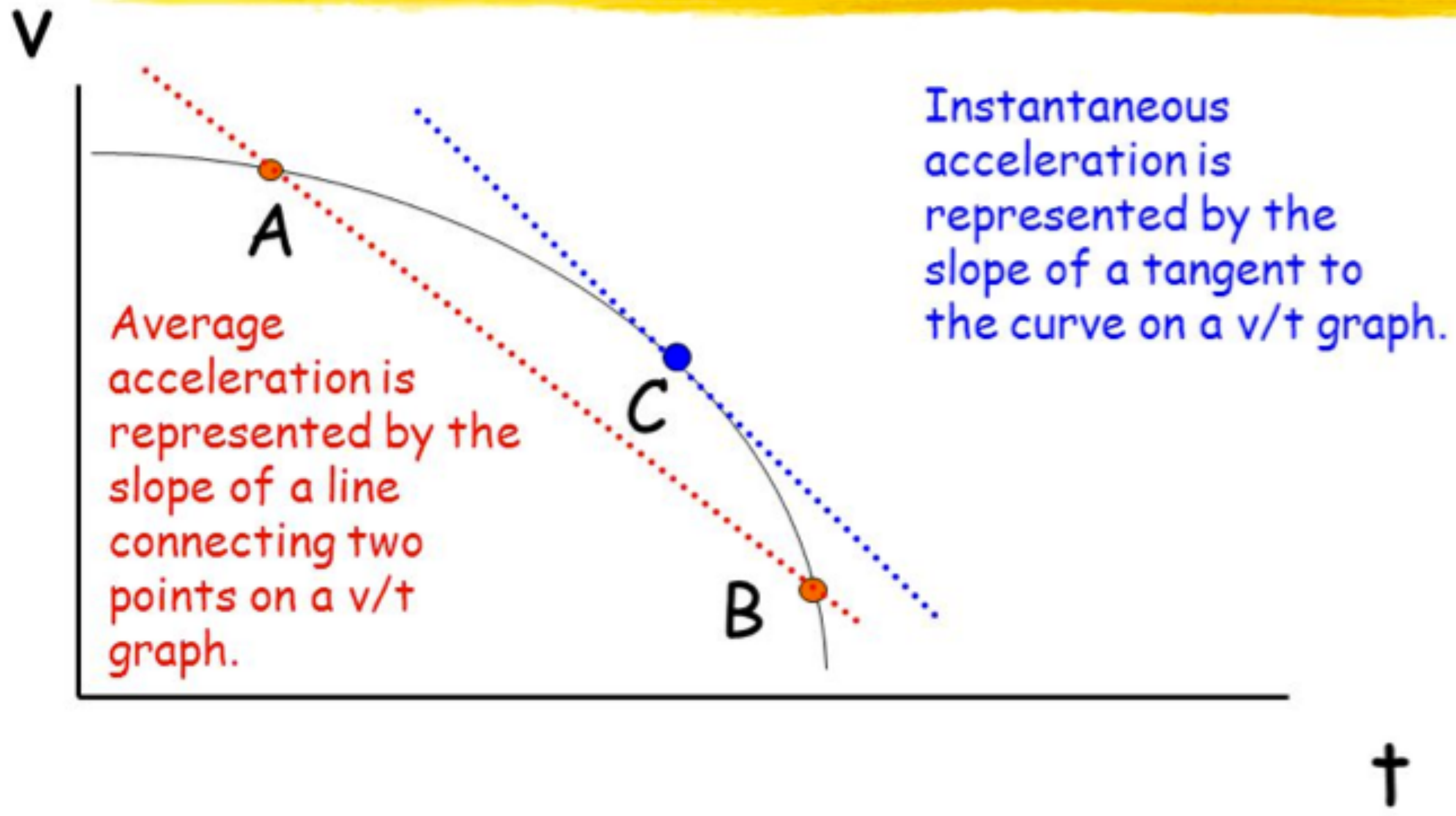
Average velocity, constant acceleration and the "Big Four"

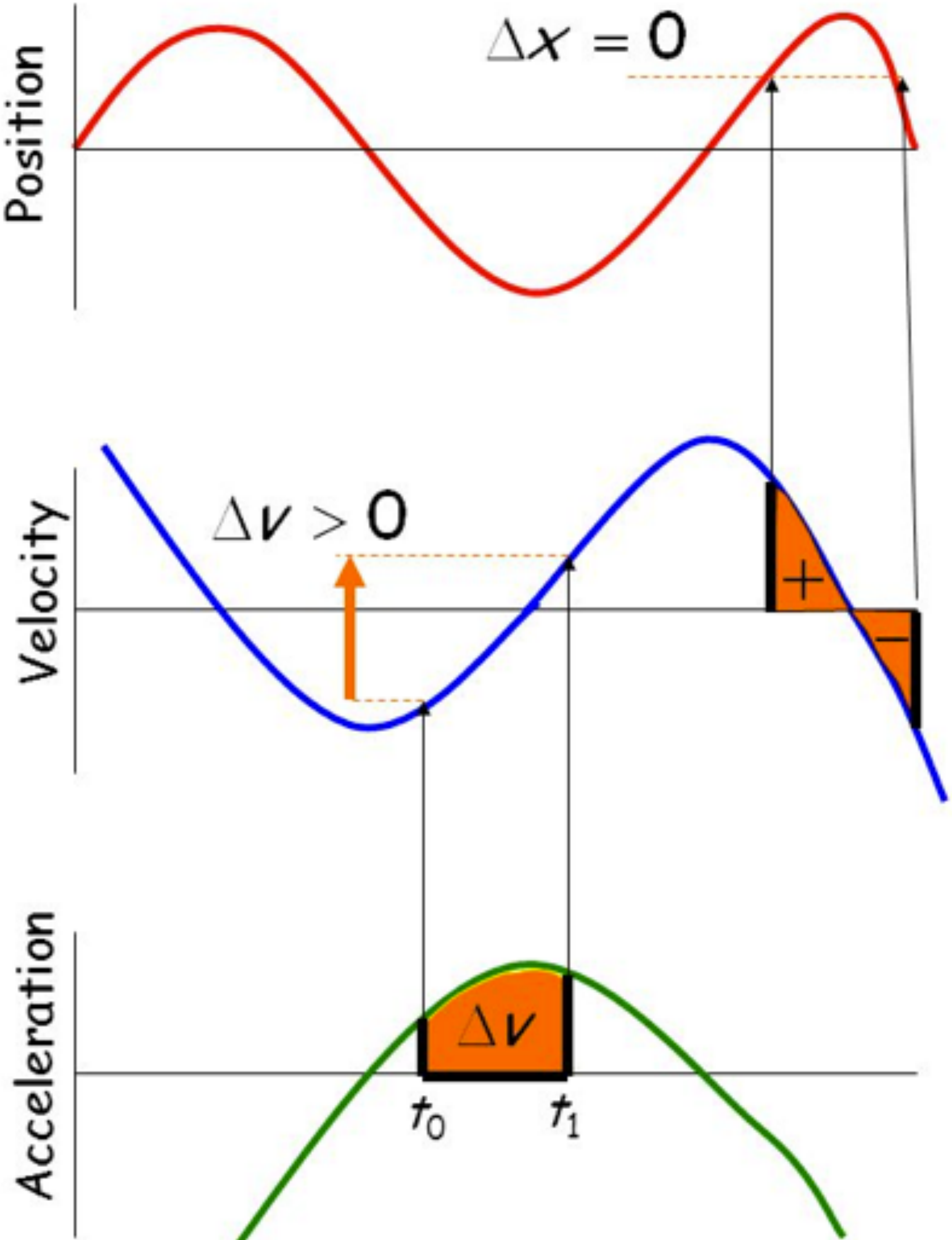
- $v_{av} = \frac{x}{t}$
- $a = \frac{v - v_o}{t}$
- $x = \frac{1}{2}(v_o + v)t$
- $x = v_o t + \frac{1}{2}at^2$
- $v = v_o + at$
- $v^2 = v^2 + 2ax$

Area under the curve – Total displacement



AVERAGE AND INSTANTANEOUS ACCELERATION





Displacement = area under $v(t)$ curve

$$\Delta x = \int_{t_0}^{t_1} v\,dt$$

Change in velocity = area under $a(t)$ curve

$$\Delta v = \int_{t_0}^{t_1} a\,dt$$

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Positive – up and right

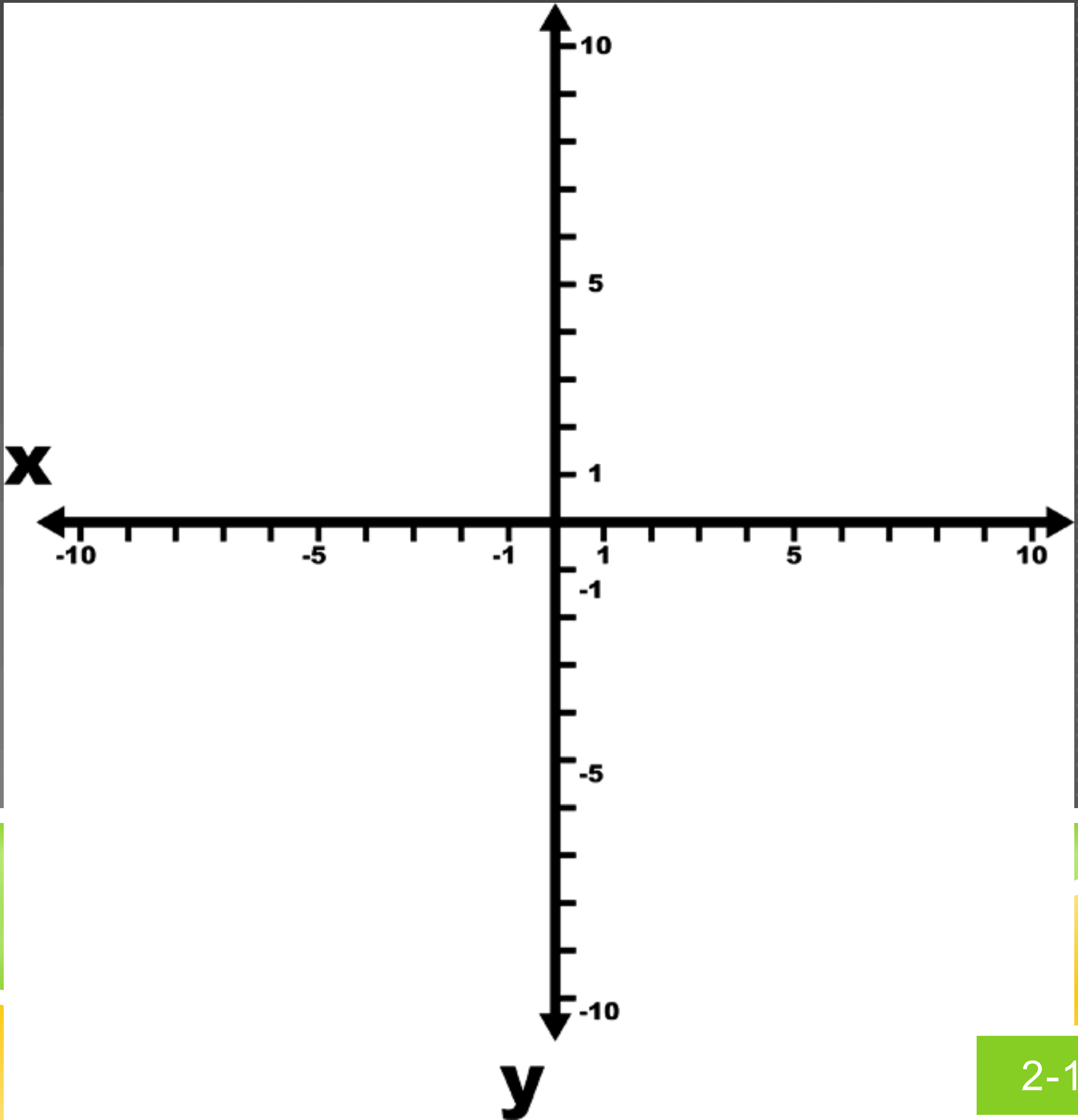
Negative – down and left

Graph in distant-time graph :

1. Constant position

2. Constant Velocity

3. Constant Acceleration



RECAP the Average Velocity / Average Speed

- In the qualifying round of the 50-yd freestyle in the sectional swimming championship, Dugan got an early lead by finishing the first 25.00 yd in 10.01 seconds. Dugan finished the return leg (25.00 yd distance) in 10.22 seconds.

a. Determine Dugan's average speed for the entire race.
b. Determine Dugan's average speed for the first 25.00 yd leg of the race.
c. Determine Dugan's average velocity for the entire race.

a. 2.472 yd/s
b. 2.498 yd/s
c. 0 yd/s

During the annual shuffleboard competition, Renee gives her puck an initial speed of 9.32 m/s. Once leaving her stick, the puck slows down at a rate of -4.06 m/s/s.

a. Determine the time it takes the puck to slow to a stop.

b. Use your initial speed and the calculated time to determine the average speed and the distance which the puck travels before stopping.

a. 2.30 s
b. 10.7 m

- You drive a beat-up pickup truck along a straight road for 8.4 km at 70 km/hr., at which point the truck runs out of gasoline and stops. Over next 30 minutes, you walk another 2.0 km farther along the road to a gas station.

(a) What is your over all displacement?

(b) What is the time difference Δt from the beginning of your drive to your arrival at the station?

(c) What is your average velocity from the beginning of your drive to your arrival at the station? Find both numerically and graphically.

The following equations give the position $x(t)$ of a particle in four situations (in each equation, x is in meters, t is in seconds, and $t > 0$):

(1) $x = 3t - 2$;

(2) $x = -4t^2 - 2$;

(3) $x = 2/t^2$;

(4) $x = -2$.

(a) In which situation is the velocity v of the particle constant?

(a) In which situation is the velocity v in the negative x direction?

CLASSWORK 1

- Work in groups to solve.

CONSTANT ACCELERATION- A SPECIAL CASE.

Velocity increases or decreases at a constant rate..

(Draw the v-t graph)

- What do you know about Constant Acceleration and Average velocity?

For Constant Acceleration
Avg Velocity is $(V_0 + V_f)/2$

"Because velocity function is linear"

For constant acceleration why is Vavg =1/2(V_0+V_f)

Assume $v = at$.

$$
\begin{aligned}
v_{avg} &\equiv \frac{\int_{t_1}^{t_2} v\,dt}{\int_{t_1}^{t_2}\,dt} = \frac{\Delta x}{\Delta t} \\
&= \frac{\int_{t_1}^{t_2} (at)\,dt}{\int_{t_1}^{t_2}\,dt} \\
&= \frac{a\frac{1}{2}(t_2^2 - t_1^2)}{t_2 - t_1} \\
&= \frac{1}{2}a(t_2 + t_1) \\
&= \frac{1}{2}(v_2 + v_1)
\end{aligned}
$$

AVERAGE QUESTION

A car slows down **uniformly** from a speed of 21.0 m/s to rest in 6.00s. How far did it travel in this time?

$$x = \tfrac{1}{2}(v + v_0)t$$

$$x = \tfrac{1}{2}(21m/s)(6s) = 63m$$

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Average Acceleration – change in velocity per unit time (vector) (meters/second^2)

v is final velocity

v_0 is initial velocity (or at time 0)

Sign of a indicates direction of vector

Deceleration is just negative acceleration

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v - v_0}{t - t_0}$$

THINK ABOUT IT!

From the equation

$V_f^2 - V_0^2 = 2a(X - X_0)$

Find out the Sign of Acceleration when

1. The object is travelling in + direction and speeding up
2. The object is travelling in + direction and slowing down
3. The object is travelling in - direction and speeding up
4. The object is travelling in - direction and slowing down

VELOCITY & ACCELERATION SIGN CHART

		VELOCITY	
ACCELERATION		+	-
	+	Moving forward; Speeding up	Moving backward; Slowing down
	-	Moving forward; Slowing down	Moving backward; Speeding up

AREA UNDER THE CURVE

- Velocity from t_0 to t_1 is area under the curve of Acceleration graph from t_0 to t_1
- Displacement from t_0 to t_1 is area under the curve of Velocity graph from t_0 to t_1

CHALLENGE PROBLEM

A car is behind a truck going 25m/s on the highway. The car's driver looks for an opportunity to pass, guessing that his car can accelerate at 1.0m/s^2. He gauges that he has to cover the 20 m length of the truck, plus 10 m clear room at the rear of the truck and 10 m more at the front of it. In the oncoming lane, he sees a car approaching, probably also traveling at 25 m/s. He estimates that the car is about 400 m away. Should he attempt to pass?

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Two common problems

1. Acceleration and velocity are always in the same direction
   a. No, as an object is thrown upward, velocity is +y, acceleration is –y
2. Acceleration is zero at the highest point.
   a. No, at the highest point, the velocity is zero, but acceleration is always $-9.80 m/s^2$
   b. The object changes velocity, it must have an acceleration