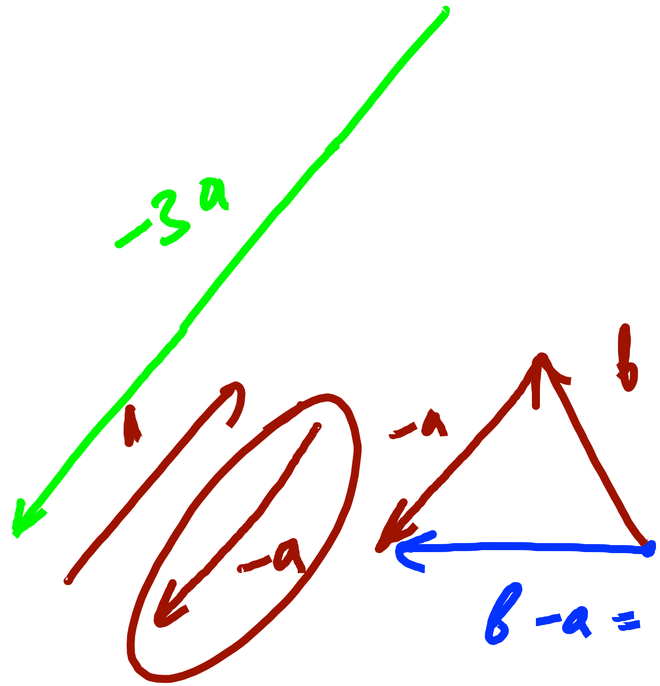
A question about vectors

You have three arrows with magnitudes of 3 m, 4 m, and 6 m (or 8 m). If you ADD all three arrows together as vectors, what is the ***minimum*** (or maximum) possible length of the resultant vector?

1. -1 m
2. 1 m
3. 2 m
4. 0 m
5. 3.6 m
6. 13
7. none of the above



$b - a = b + (-a)$

$c = b - a =$

$= b + \underline{\underline{-a}}$

$d = \underline{\underline{-3a}}$

Average velocity is defined as

1. $\frac{r_1 - r_2}{\Delta t}$

2. $\frac{r_2 - r_1}{\Delta t}$

3. $\lim_{\Delta t \to \infty} \frac{r_2 - r_1}{\Delta t}$

4. $\frac{v_1 - v_2}{\Delta t}$

5. $\frac{v_2 - v_1}{\Delta t}$

6. $\lim_{\Delta t \to \infty} \frac{v_2 - v_1}{\Delta t}$

Instantaneous velocity is defined as

Average velocity is defined as

1. $\dfrac{r_1 - r_2}{\Delta t}$

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5. $\dfrac{v_2 - v_1}{\Delta t}$

6. $\lim\limits_{\Delta t \to \infty} \dfrac{v_2 - v_1}{\Delta t}$

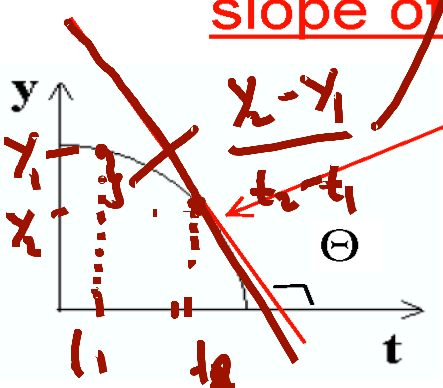
Instantaneous velocity is defined as

Instantaneous velocity

average velocity $= \dfrac{\text{net displacement}}{\text{total time}}$, or, $\bar{v} = \dfrac{\Delta \vec{x}}{\Delta t}$

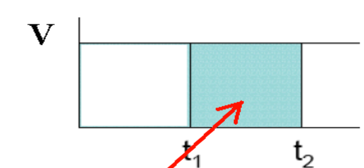
instantaneous velocity = $\vec{v} = \lim_{\Delta t \to 0} \dfrac{\Delta \vec{x}}{\Delta t}$

This is an intimidating definition. It's often easier, and more intuitive, to find instantaneous velocity from the slope of the tangent of a position vs. time graph.



$v = \tan(\Theta)$

$\Delta x = v \cdot \Delta t$



"displacement = area under velocity vs. time graph"

Speed and Velocity

Speed is a scalar representing how fast an object is traveling.

Velocity is a vector combining the speed with the direction of motion. We can also define velocity as the rate of change of position.

Sometimes we want to know the average values (averaged over time) of the speed or velocity.

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

Instantaneous speed = |instantaneous velocity|

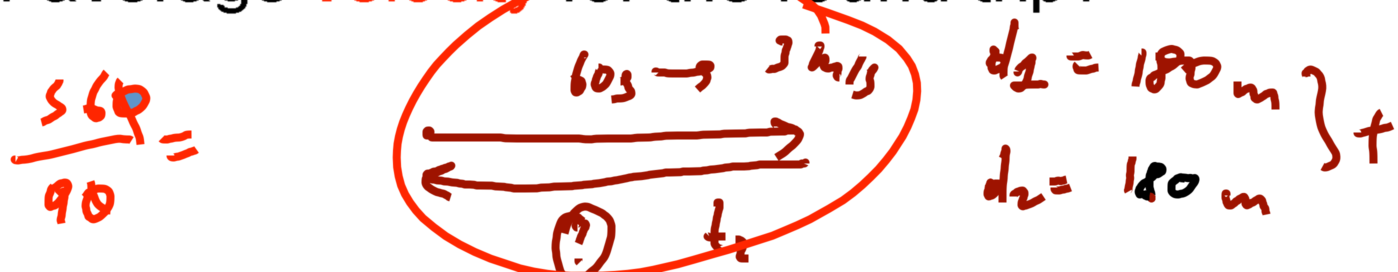
A Question about a round trip

On your way to class one morning, you leave home and walk at 3.0 m/s east towards campus. After exactly one minute, you realize that you've left your physics assignment at home, so you turn around and run, at 6.0 m/s, back to get it.

1. **0 m/s**	2. **2.5 m/s**	3. **3 m/s**	4. **3.5 m/s**	5. **4 m/s**
6. **4.5 m/s**	7. **5 m/s**	8. **5.5 m/s**	9. **6 m/s**	0. **6.5 m/s**

What is your average speed for the round trip?

What is your average velocity for the round trip?

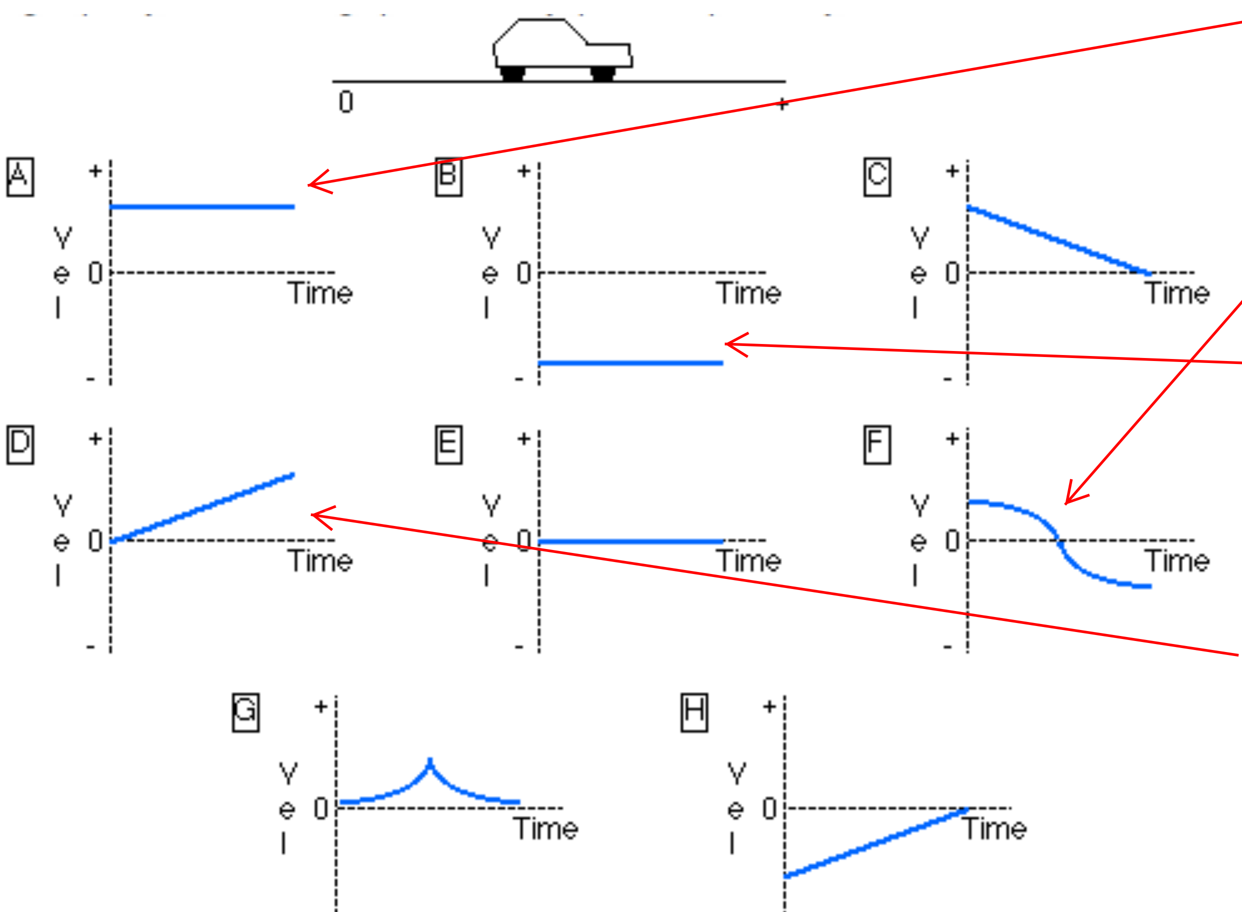


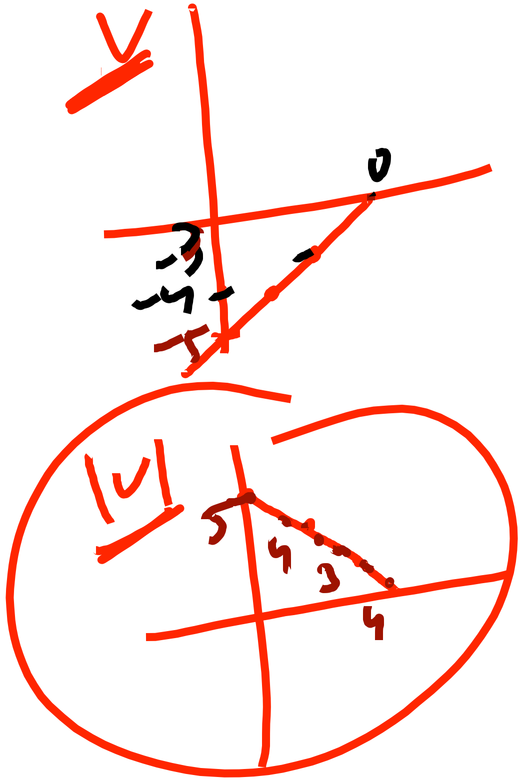
A toy car can move to the right or left along a horizontal line (the positive portion of the distance axis). The positive direction is to the right. Choose the correct velocity-time graph for the car: (a) moving to the right (away from the origin) at a steady (constant) velocity?

(b) reversing direction?

(c) moving toward the left (toward the origin) at a steady (constant) velocity?

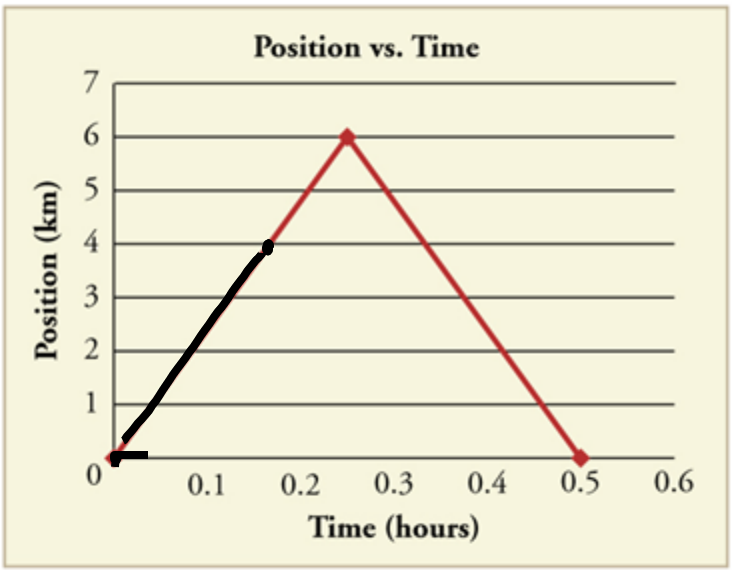
(d) increasing its speed at a steady (constant) rate?




0
-3
-4
-5
5
4
3
4

Motion with a constant velocity *(MCV)*

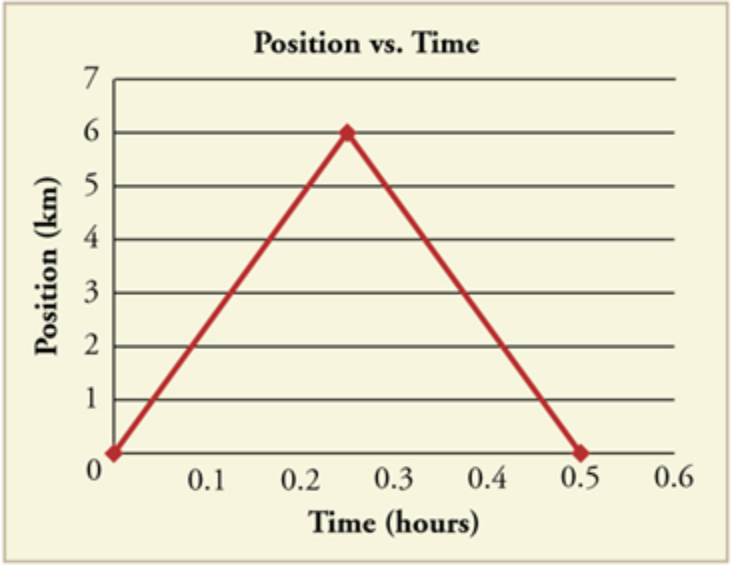
For *MCV* $v_{inst} = v_{ave} = \dfrac{r_2 - r_1}{t_2 - t_1}$ for *any* two t_1 and t_2 (!)



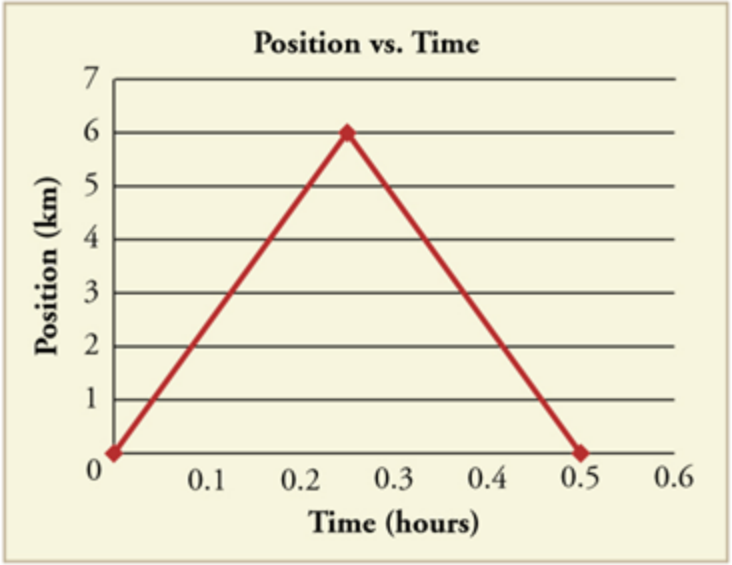
Is the motion for t = (0, 0.2) MCV?

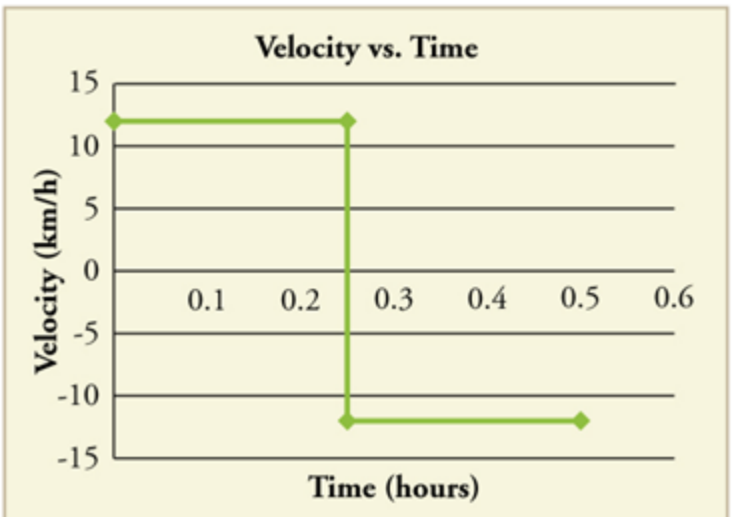
1. Yes 2. No 3. ??? ☹

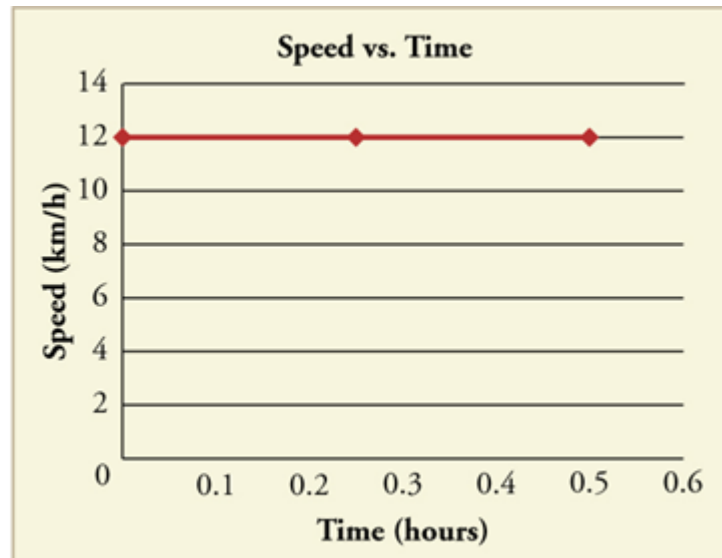
What about t = (0.2, 0.4) ?



For the given Position vs. Time graph, plot the graph Velocity vs. Time, and Speed vs. Time

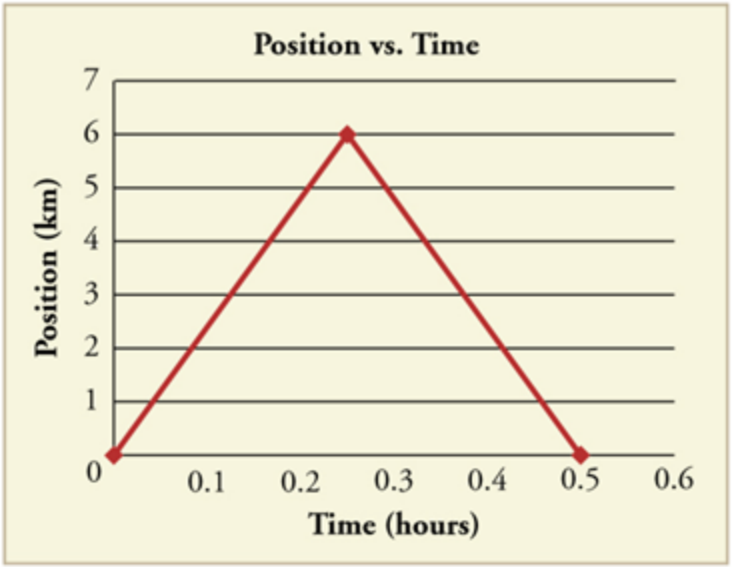

Position vs. Time
Position (km)
7
6
5
4
3
2
1
0
0.1
0.2
0.3
0.4
0.5
0.6
Time (hours)


Velocity vs. Time
Velocity (km/h)
15
10
5
0
-5
-10
-15
0.1
0.2
0.3
0.4
0.5
0.6
Time (hours)

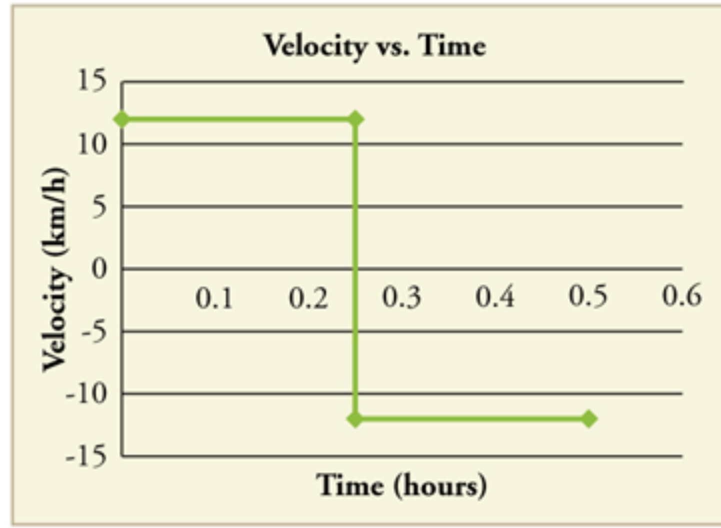

Speed vs. Time
Speed (km/h)
14
12
10
8
6
4
2
0
0.1
0.2
0.3
0.4
0.5
0.6
Time (hours)

The meaning of…

The slope



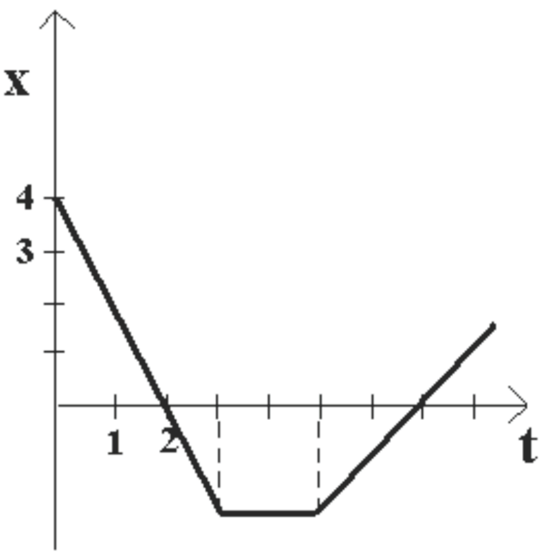
The area



Example

An object undergoes a 1-dimentional motion along the x-axis.

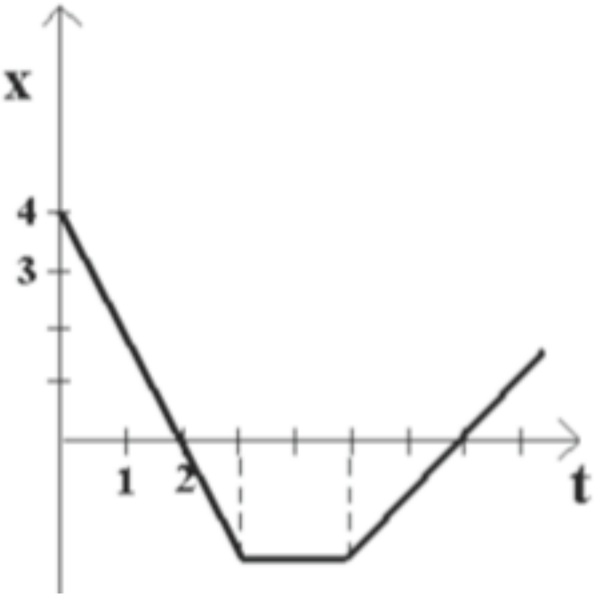
The graph below represents location vs. time function.



Find: x(1) x(4)

Average speed and average velocity for the following time intervals:

t = (1, 3) t = (5, 7) t = (1, 7)

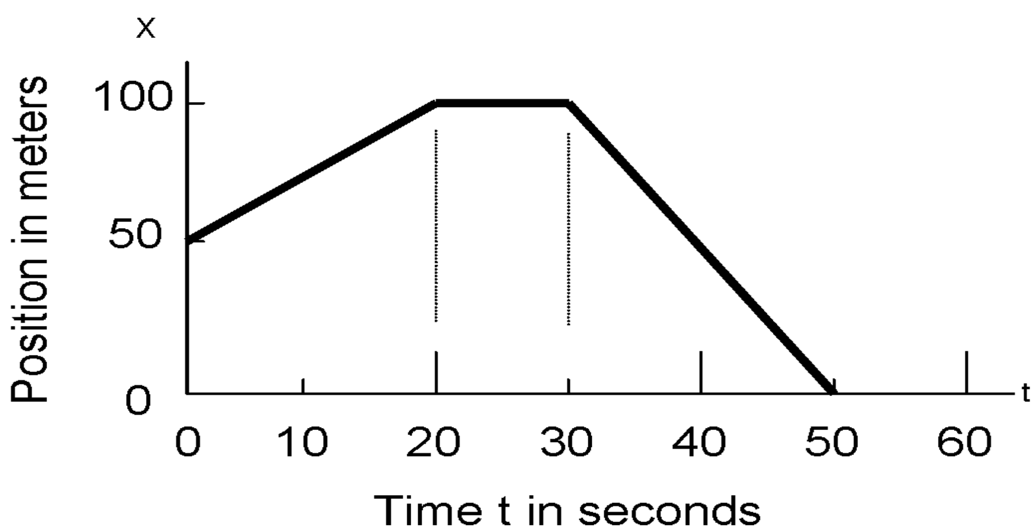


Find: x(1) x(4)

Average speed and average velocity for the following time intervals:

t = (1, 3) t = (5, 7) t = (1, 7)

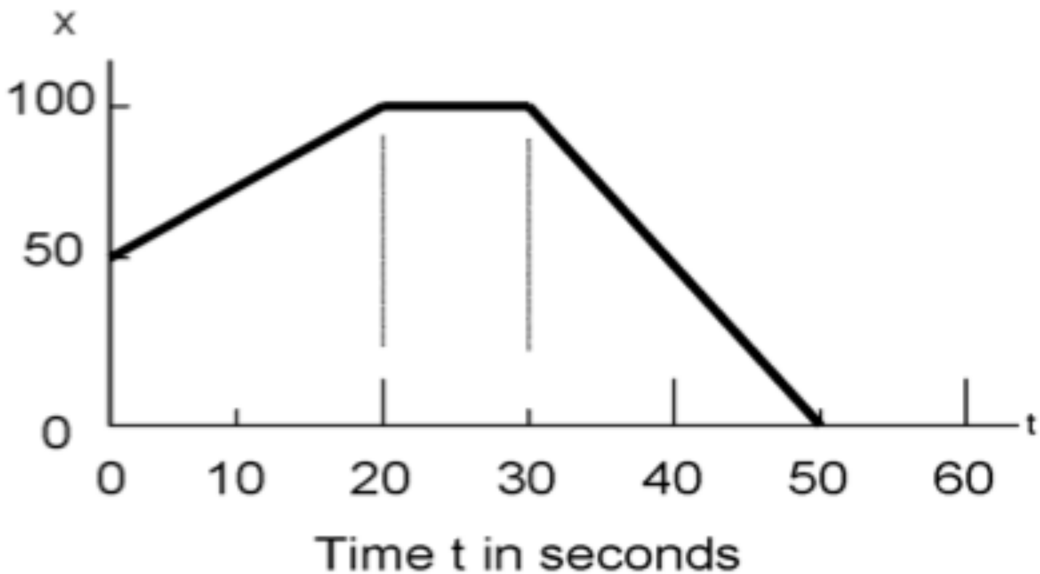
Answer the questions about this graph:



1) Instantaneous velocity at 10 s.
2) Instantaneous velocity at 25 s.
3) The displacement during the interval 20 to 30 s.
4) The average velocity for the interval 0 to 50 s.
5) The average speed during the interval 0 to 50 s.

1. **- 2**   2. **- 1**   3. **0**   4. **2**   5. **2.5**

6. **3**   7. **3.5**   8. **4**   **(with appropriate SI units)**



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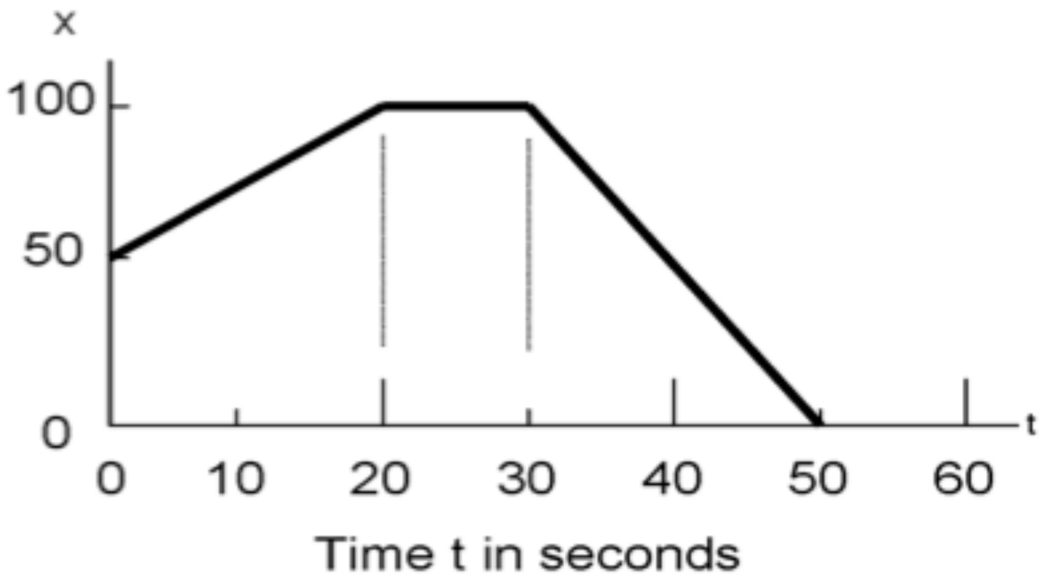

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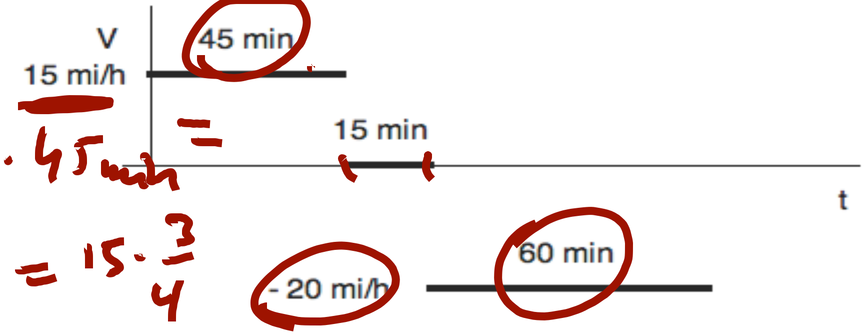
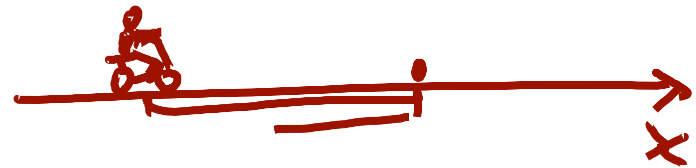
Example

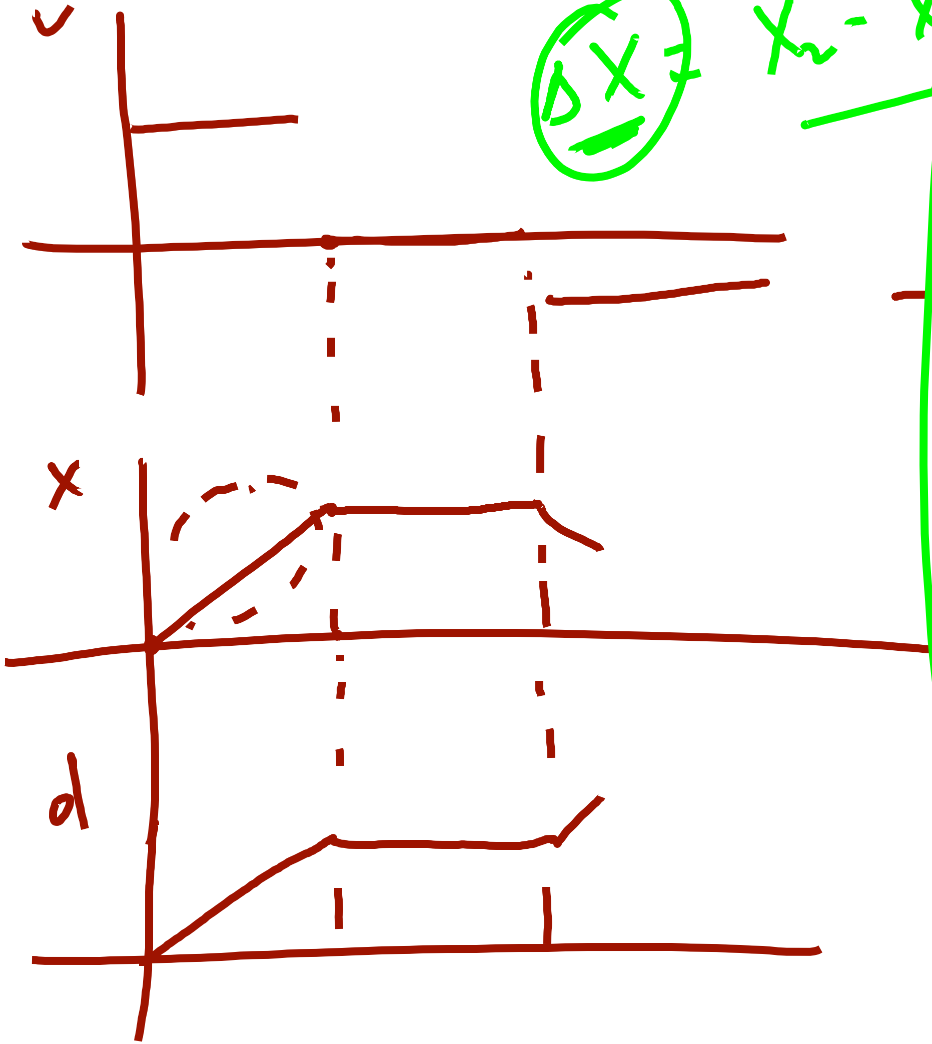
$d = v \cdot t = 15 \frac{mi}{h} \cdot 45 min = 15 \cdot \frac{3}{4}$



The graph on the right shows the average velocity of a bicyclist riding a bicycle on a straight road.

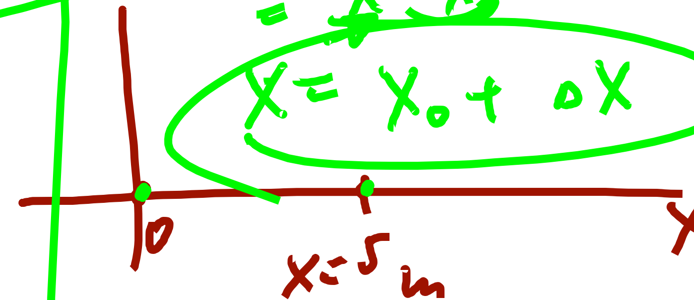


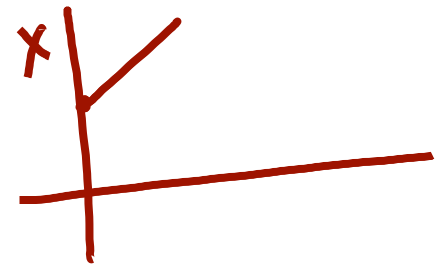
1. Explain the motion of the bicyclist.
2. Find his displacement over first 45 minutes.
3. Find the total displacement over the whole trip.
4. Find the total distance over the whole trip.
5. Calculate the average velocity over the trip.
6. Calculate the average speed over the trip.
7. Plot the graph for his position as a function of time.



$$\Delta x = x_2 - x_1 = x_f - x_i = x - x_0$$

$$x = x_0 + \Delta x$$

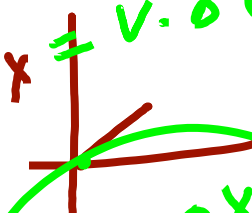




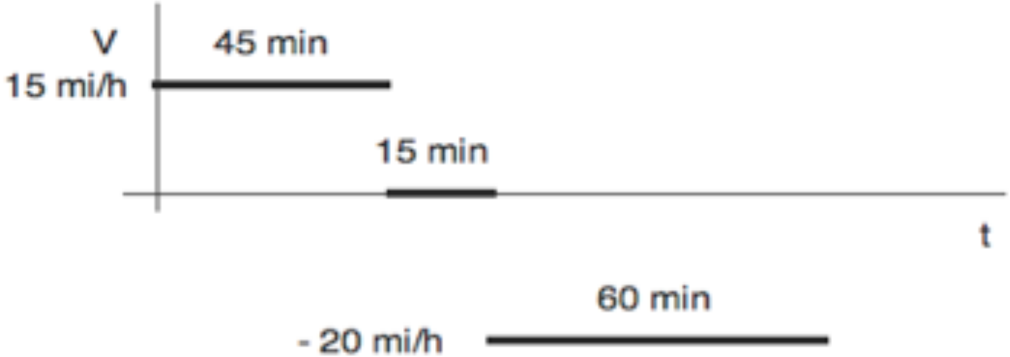
v

v

$$\Delta x = v \cdot \Delta t$$



$$v = \frac{\Delta x}{\Delta t}$$



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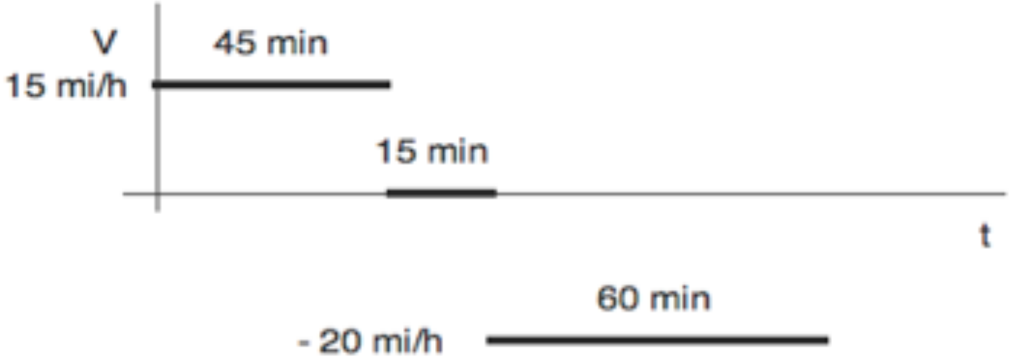

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The list of concepts, definitions, laws and relations to memorize when taking PY 105 course

For each physical quantity a students must be able to answer the following questions:

1. what is its name;

2. what is a usual symbol for the quantity;

3. what is its unit;

4. how to measure the quantity;

5. to what other physical quantities is this quantity related;

6. how is this physical quantity algebraically related to other physical quantities?

Acceleration

Acceleration, average acceleration, instantaneous acceleration, motion with constant acceleration (MCA), properties of MCA.

Average acceleration is defined as

1. $\dfrac{r_1 - r_2}{\Delta t}$

2. $\dfrac{r_2 - r_1}{\Delta t}$

3. $\lim\limits_{\Delta t \to \infty} \dfrac{r_2 - r_1}{\Delta t}$

$\Delta v = v_2 - v_1$

4. $\dfrac{v_1 - v_2}{\Delta t}$

5. $\dfrac{v_2 - v_1}{\Delta t}$

6. $\lim\limits_{\Delta t \to \infty} \dfrac{v_2 - v_1}{\Delta t}$

Instantaneous acceleration is defined as

Acceleration

Acceleration is a **vector** representing the rate and direction of the change of velocity.

Average acceleration $\mathbf{a}_{avg} \equiv (\mathbf{v}_2 - \mathbf{v}_1)/(t_2 - t_1)$

In the limit that the time interval approaches zero, the average acceleration equation gives the instantaneous acceleration.

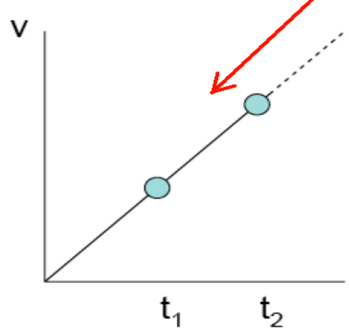
Note that acceleration has the same relation to velocity as velocity has to position.

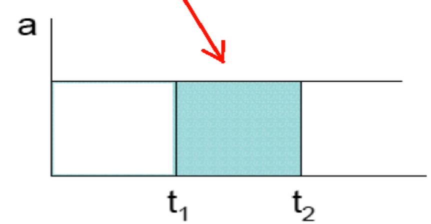
For *MCA* $a_{inst} = a_{ave} = \dfrac{v_2 - v_1}{t_2 - t_1}$ for *any* two t_1 and t_2 (!)

Making use of the motion graphs

The instantaneous acceleration is the slope at a particular instant on a velocity-versus-time graph.

The change in velocity is the area under the curve for a particular time interval on an acceleration-versus time graph.





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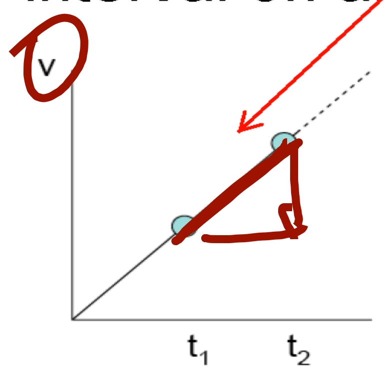
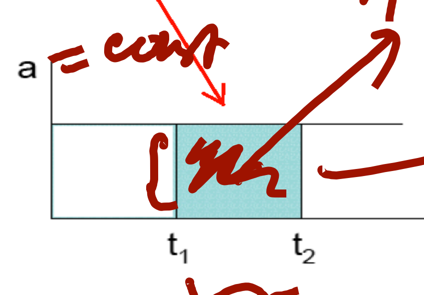
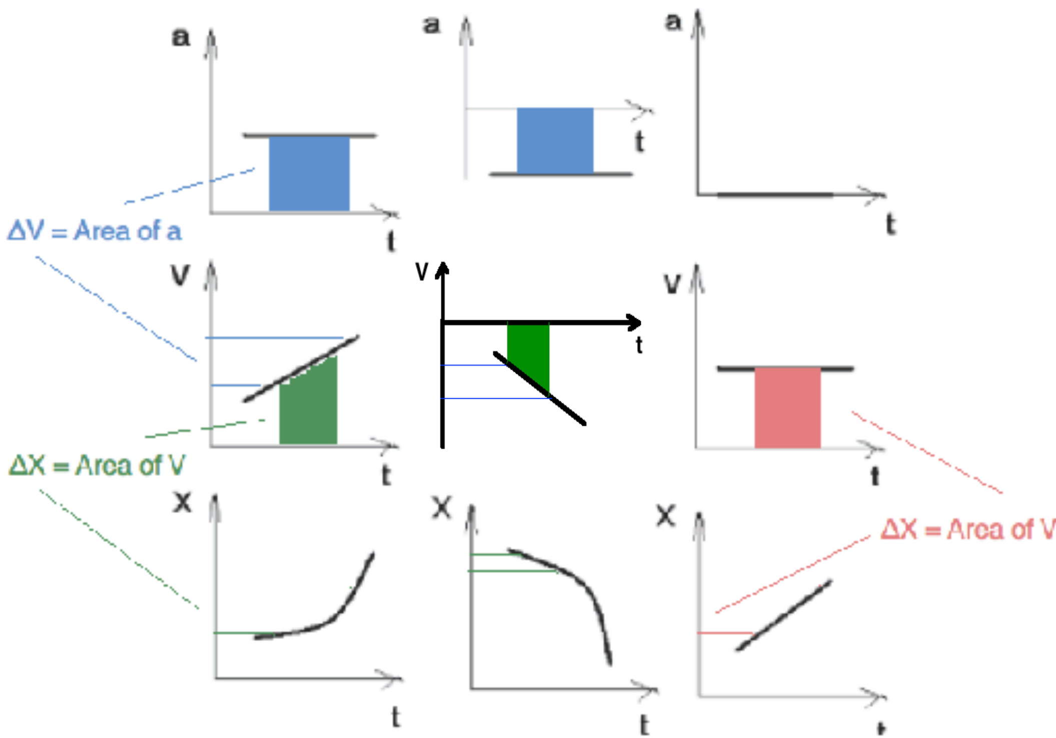




Graphs

A graph is basically a picture of an equation. Graphs of an object's position, velocity, and acceleration as a function of time can tell you a great deal:

- The velocity is the slope of the position graph
- The displacement is the area under the curve of the velocity graph
- The acceleration is the slope of the velocity graph
- The change in velocity is the area under the curve of the acceleration graph



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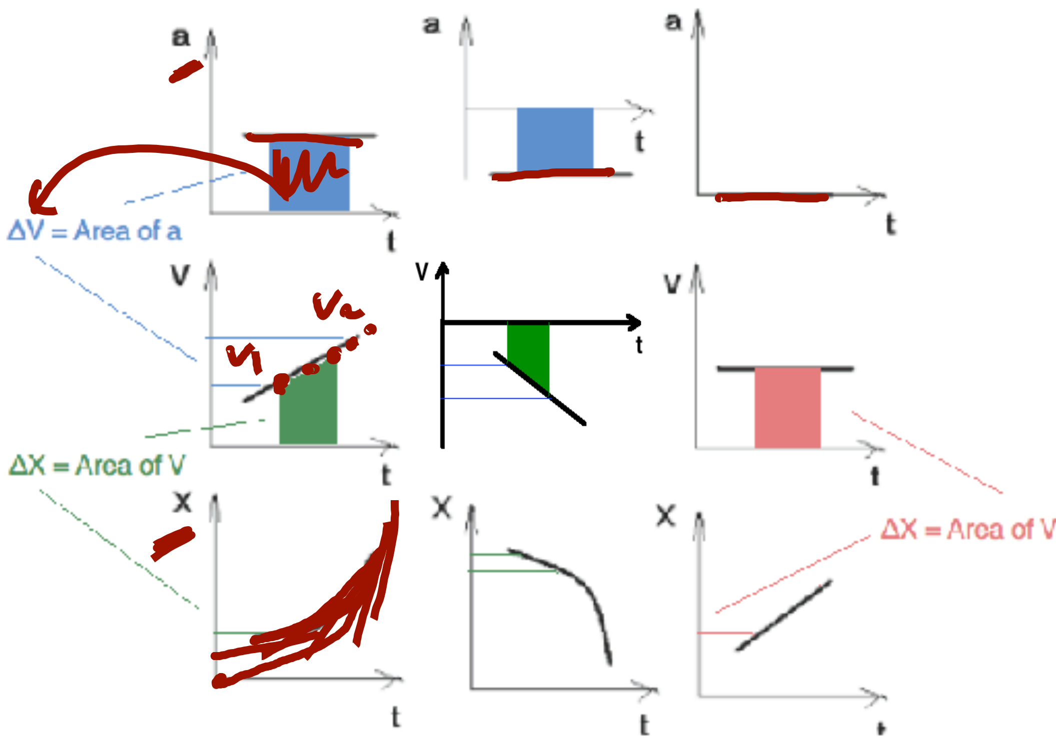


Constant-acceleration equations

These equations relate displacement, velocity, acceleration, and time, and apply under the following conditions:

- the acceleration is constant

$$\Delta v = a\Delta t$$

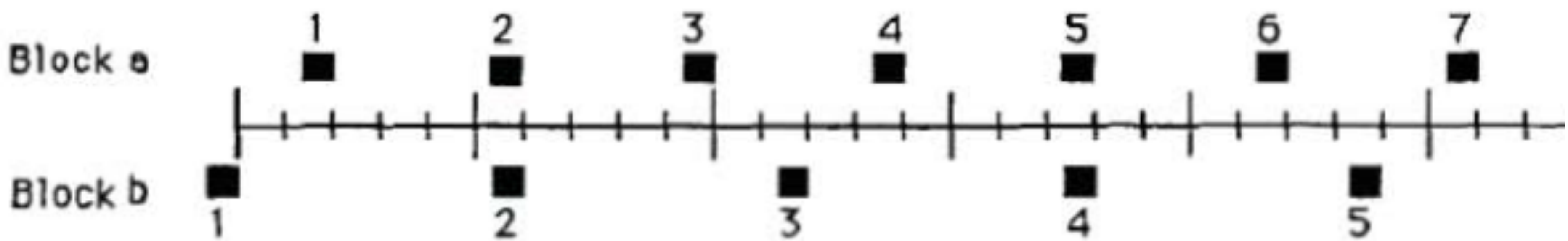
$$\Delta x = v_0\Delta t + \frac{a(\Delta t)^2}{2}$$

Everything except the time *t* is a vector component – a scalar with a sign. The appropriate plus or minus sign indicates the direction of the vector.

These equations can be used for 1-D motion with constant acceleration (usually along the x-axis pointing to the right).

Δv = Area(a), Δx = Area(v), a = slope(v), v = slope (x)

In the picture, numbered squares represent the positions of two blocks at successive equal time intervals. The blocks are moving toward the right.



The acceleration of the blocks are related as follows:

(A) acceleration of "a" > acceleration of "b"

(B) acceleration of "a" = acceleration "b" > 0

(C) acceleration of " b" > acceleration "a"

(D) acceleration of "a" = acceleration of "b" = 0

(E) not enough information to answer.