Good morning!

Please, sign in, login into webassing, locate LectureMCQ_L3  (PY105) and answer question 1 (but  ONLY  Q1 !)

Lab 2 is in SCI 134

Slides
Enabled: Statistics Tracking

Textbook

some old exams
Enabled: Adaptive Release

Equation sheets
Enabled: Statistics Tracking

IL (labs)
Enabled: Adaptive Release, Statistics Tracking

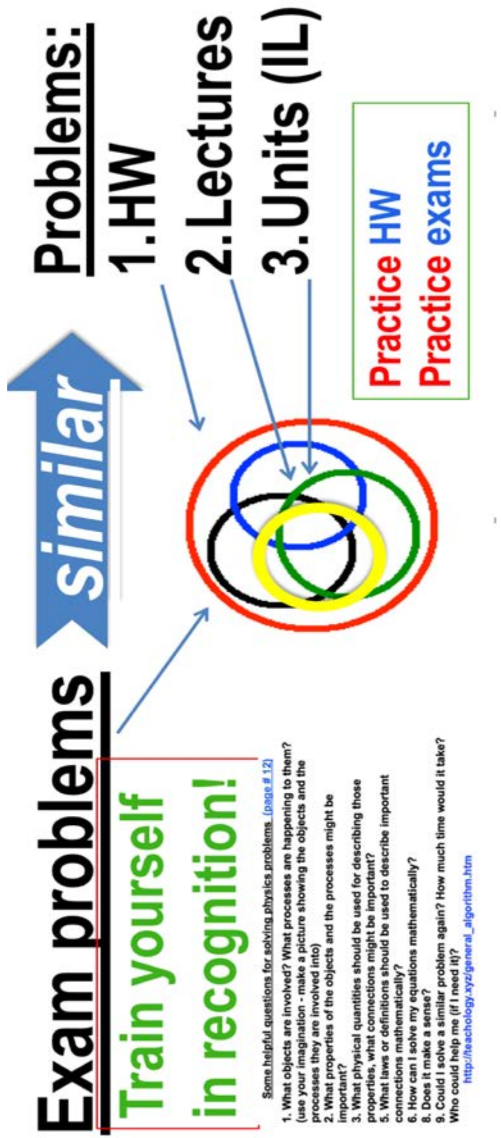
Old Slides (2017)
Enabled: Adaptive Release, Statistics Tracking

EchoCenter

Math_Answers
Enabled: Statistics Tracking

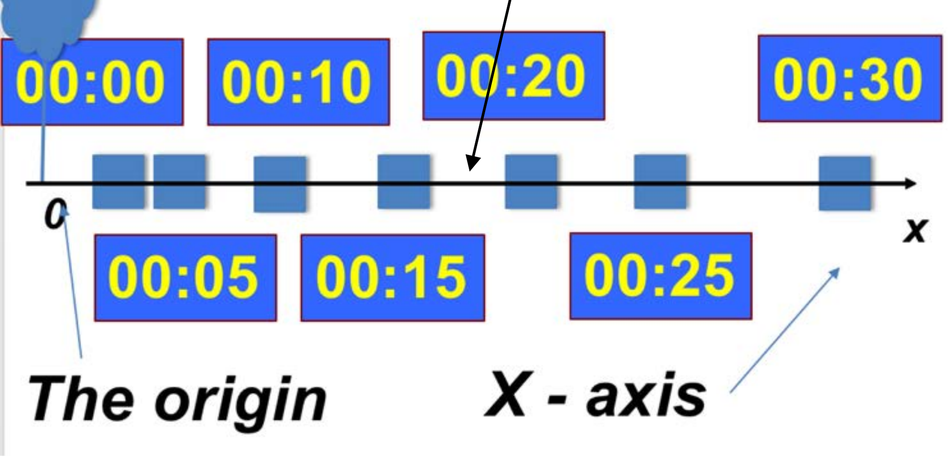
LectureMCQ_L1 (PY105)
Testing webassign acount
FCI - pretest
Math Self Test for PY105
Pre-Survey for PY105
LectureMCQ_L2 (PY105)
PY105 HW1 P1 (S2018)
PY105 HW1 P3 (S2018)
PY105 HW1 P2 (S2018)
PY105 HW1 P4 (S2018)
PY105 HW1 practice problems

**Practice makes results**



## 1D-M

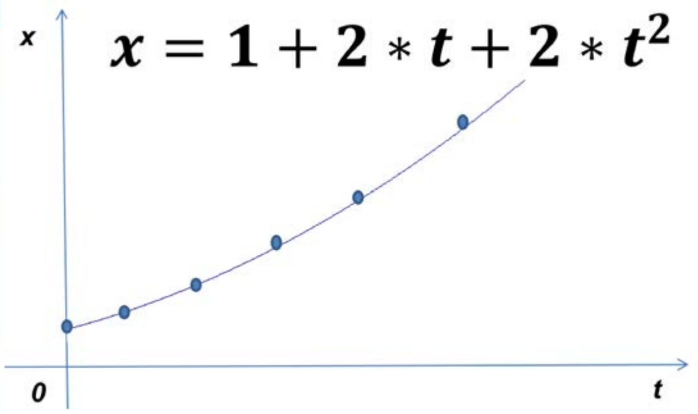
**X - coordinates**



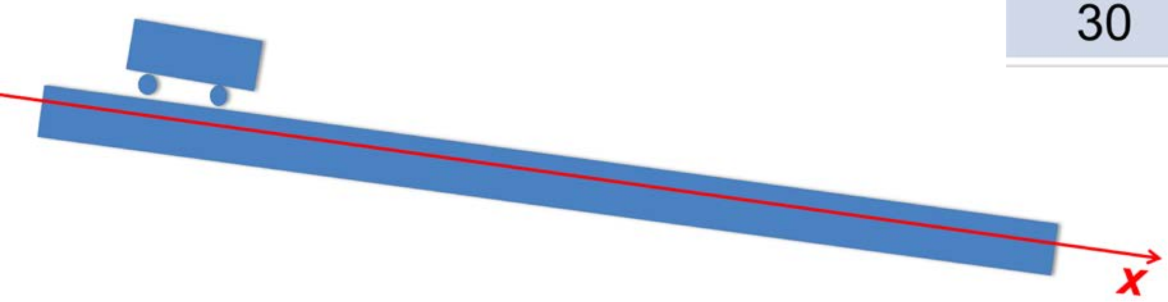

**A table**

| t | x |
|---|---|
| 0 | 1 |
| 5 | 61 |
| 10 | 221 |
| 15 | 481 |
| 20 | 841 |
| 25 | 1301 |
| 30 | 1861 |

**A graph: $x = x(t)$**




**Motion Equation: $x = x(t)$**




$$x_f = x_i + \Delta x$$

$$\Delta x = x_f - x_i$$

displacement

**Average speed**

$$v_{ave} = \frac{L}{\Delta t}$$

distance (length of the trajectory)

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

**Average velocity**

1) For 6 seconds a fly flies 4 m West, makes a U-turn and for 4 more seconds flies 3 m East. What is the ***magnitude*** of its average velocity?

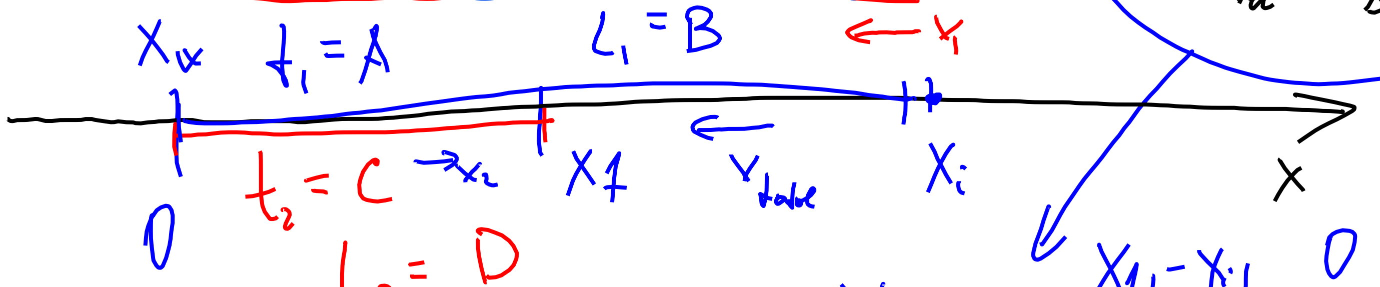
LectureMCQ_L3__Q2

Problems ↕ are 1. the same 2 different

2) For A seconds a fly flies B m West, makes a U-turn and for C more seconds flies D m East. What is the ***magnitude*** of its average velocity?

**For A seconds a fly flies B m West, makes a U-turn and for C more seconds flies D m East. What is the *magnitude* of its average velocity?**

$$V_{ave\,vel} = \frac{\Delta X}{\Delta t}$$




$X_i = L_1 = B$

$X_f = L_2 = D$

$X_w = 0$

1) W: $V_{1\,ave} = \frac{X_{f1} - X_{i1}}{\Delta t_1} = \frac{0 - L_1}{A}$

2) E: $V_{2\,ave} = \frac{X_{f2} - X_{i2}}{\Delta t_2} = \frac{D - 0}{C}$

3) Total: $V_{total} = \frac{X_{ft} - X_{it}}{\Delta t_t} = \frac{L_2 - L_1}{A + C}$

physics is done. | Math begins

**For 6 seconds a fly flies 4 m West, makes a U-turn and for 4 more seconds flies 3 m East. What is the *magnitude* of its average velocity?**

HW1 P1 Pr3

# The difference between SPEED and VELOCITY

**Names!**

$$\text{average velocity} = \frac{\text{net displacement}}{\text{total time}}, \text{ or, } \vec{v} = \frac{\Delta\vec{r}}{\Delta t}$$

**Definitions!**

**Equations!**

$$\text{average speed} = \frac{\text{total distance}}{\text{total time}}, \text{ or } v = \frac{L}{\Delta t}$$

## Both are AVERGAGE!

# The difference between AVERAGE and INSTANTANEOUS

1D, 2D - motion **Instantaneous velocity**

$$\text{average velocity} = \frac{\text{net displacement}}{\text{total time}}, \text{ or, } \vec{v} = \frac{\Delta \vec{r}}{\Delta t}$$

$$\text{instantaneous velocity} = \vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{r}}{\Delta t}$$

**INSTANTANEOUS = AVERAGE over a tiny time interval!** $t_2$ **is almost =** $t_1$

# The difference between AVERAGE and INSTANTANEOUS

## 1D, 2D - motion Instantaneous velocity

$$\text{average velocity} = \frac{\text{net displacement}}{\text{total time}}, \text{ or, } \vec{v} = \frac{\Delta \vec{r}}{\Delta t}$$

$$\text{instantaneous velocity} = \vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{r}}{\Delta t}$$

**Instantaneous *speed* = | instantaneous velocity |**

# LectureMCQ L3 Q3

**While driving a car, the speedometer shows …**

1. Average velocity
2. Average speed
3. Instantaneous velocity
4. Instantaneous speed

# LectureMCQ L3 Q3

While driving a car, the speedometer shows …

1. Average velocity
2. Average speed
3. Instantaneous velocity
4. Instantaneous speed

# Instantaneous vs. average values

When driving, what, in your car, would you use to find your ***instantaneous speed***? **The speedometer.**

When you pass the state trooper on the Mass Pike, is the trooper interested in your ***average speed or your instantaneous speed***? **Your instantaneous speed.**

If you drive from Boston to New York City, what, in your car, would you use to find your ***average speed*** for the trip? **The odometer and the clock.**

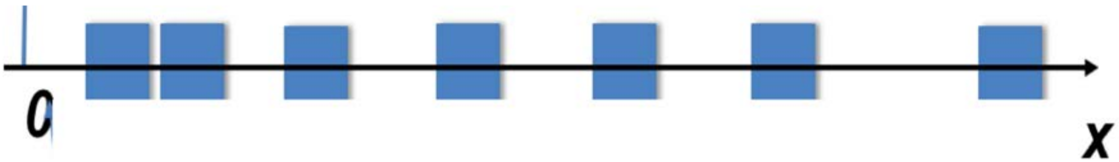
From A. Duffy

# Velocity

## Average

The *average* rate of change of displacement

$$v_{ave} = \frac{\Delta x}{\Delta t}$$




## Instantaneous

The *instantaneous* rate of change of displacement ("*instantaneous* displacement over tiny time")

$$\mathbf{v} = \left.\frac{\Delta x}{\Delta t}\right|_{\substack{\Delta x \to 0 \\ \Delta t \to 0}}$$

# In general: $L \neq \Delta X$

## Speed (the rate of change in distance) =

### Average speed

= total distance traveled on average every second

$$v_{ave} = \frac{L}{\Delta t}$$

### Instantaneous speed

= the magnitude of the instantaneous velocity

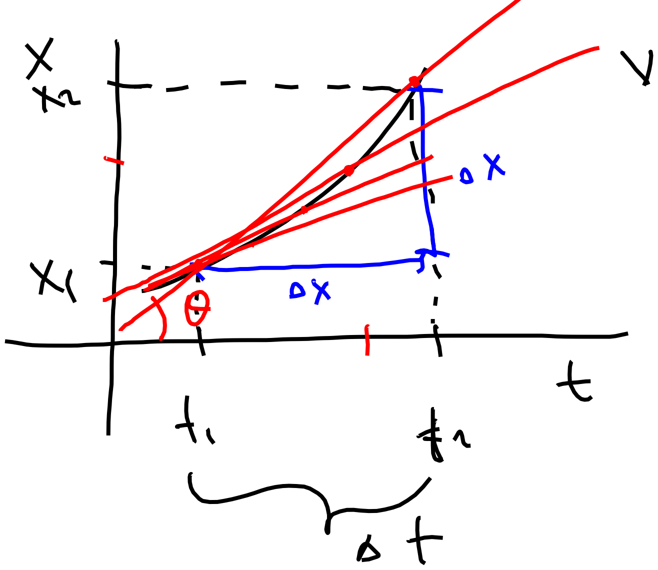
$$v = \left| \left. \frac{\Delta x}{\Delta t} \right|_{\substack{\Delta t \to 0 \\ \Delta x \to 0}} \right|$$

Both canNOT be < 0

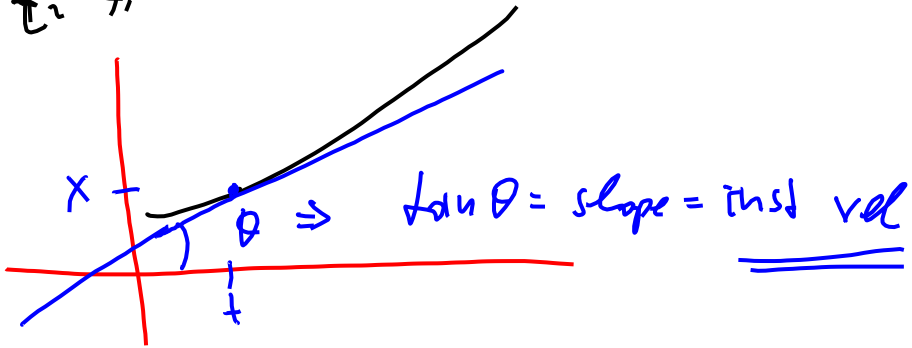
# Making sense of average v. instantaneous velocity: *x*(*t*) graph.

**Velocity =**

| **Average** | **Instantaneous** |
|---|---|
| The *average* rate of change of displacement | The *instantaneous* rate of change of displacement |
| $v_{ave} = \frac{\Delta x}{\Delta t}$ | $\mathbf{v} = \frac{\Delta x}{\Delta t}$ ($\Delta x \to 0$, $\Delta t \to 0$) |

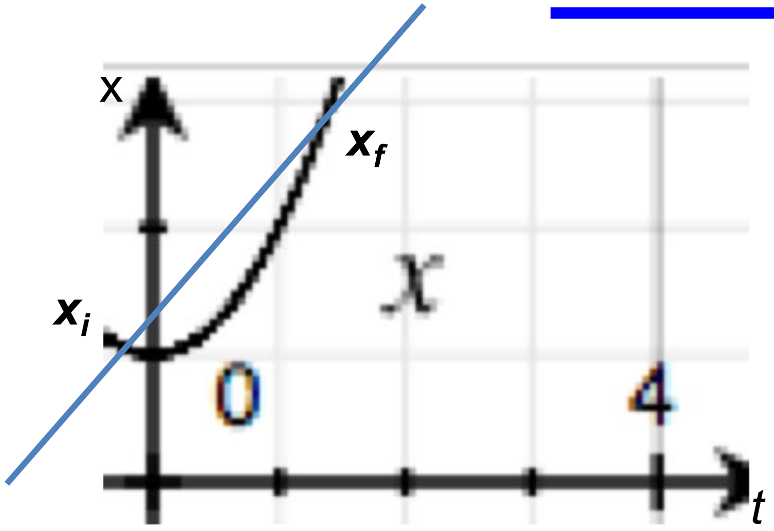



$$V_{Ave} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1} = \tan\theta = \text{slope}$$



# 1 – D Velocity

## Average



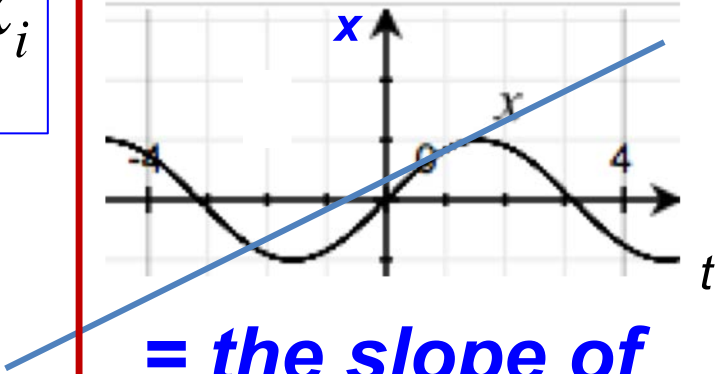

= the slope of the line passing initial and final coordinates on the position graph *x*(*t*):

$$v_{ave} = \frac{\Delta x}{\Delta t}$$

$$\Delta x = x_f - x_i$$

Displacement

## Instantaneous

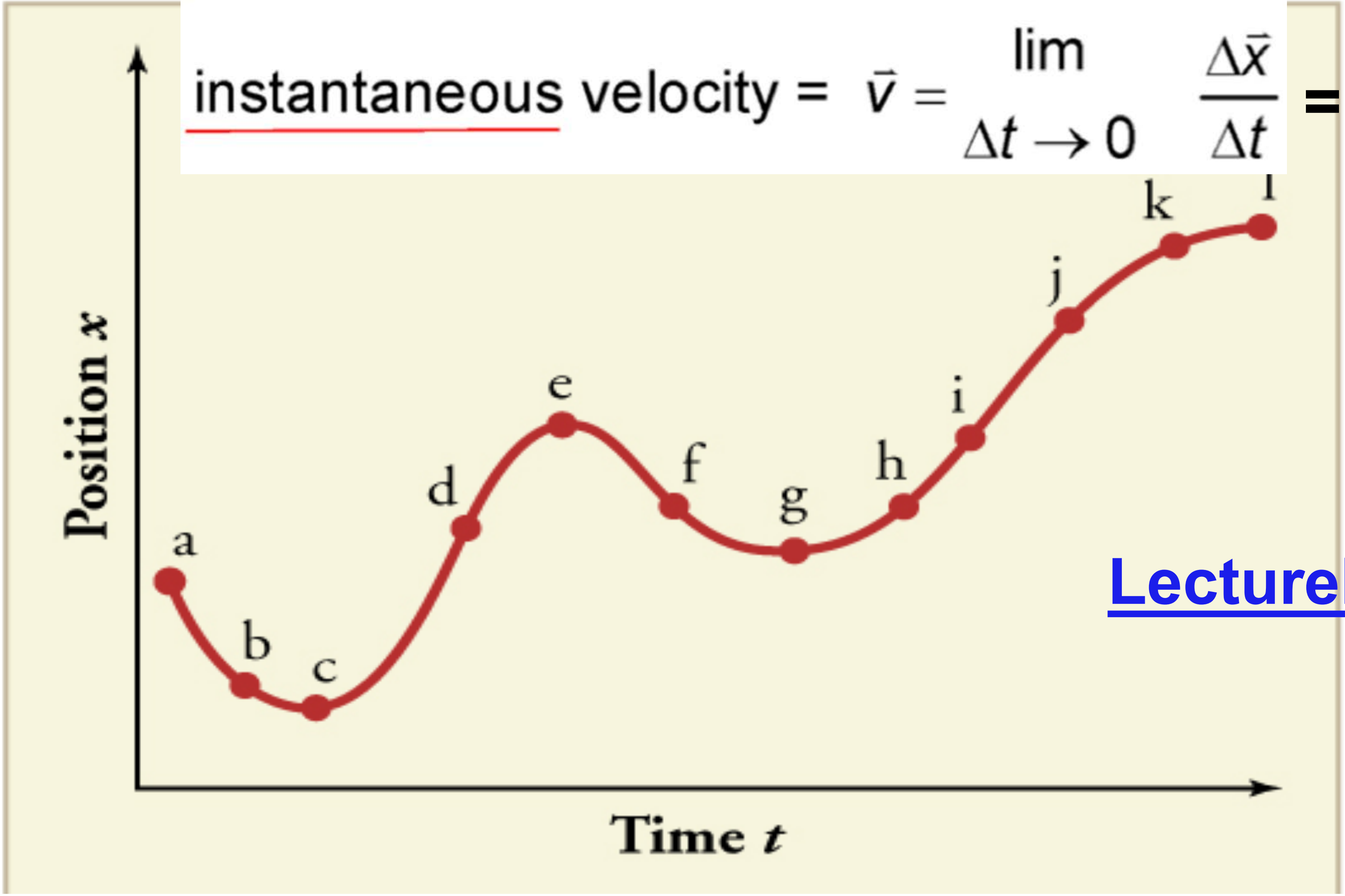



***= the slope of the line tangent to the position graph x(t):***

$$v = \left.\frac{\Delta x}{\Delta t}\right|_{\substack{\Delta t \to 0 \\ \Delta x \to 0}}$$

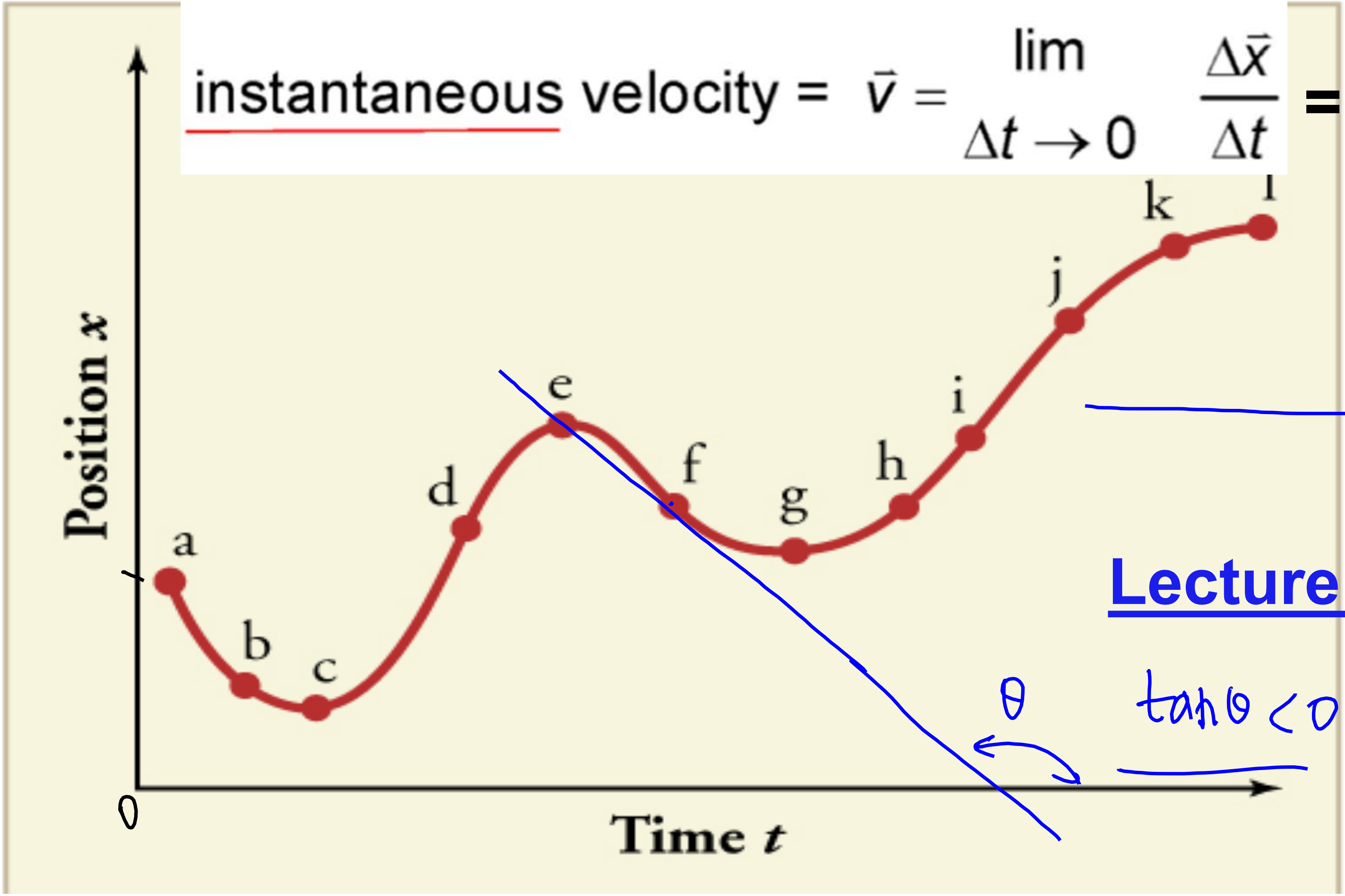
**Both can be <, or 0, or > 0**

instantaneous velocity = $\vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t}$ = the "slope"




LectureMCQ_L3__Q4

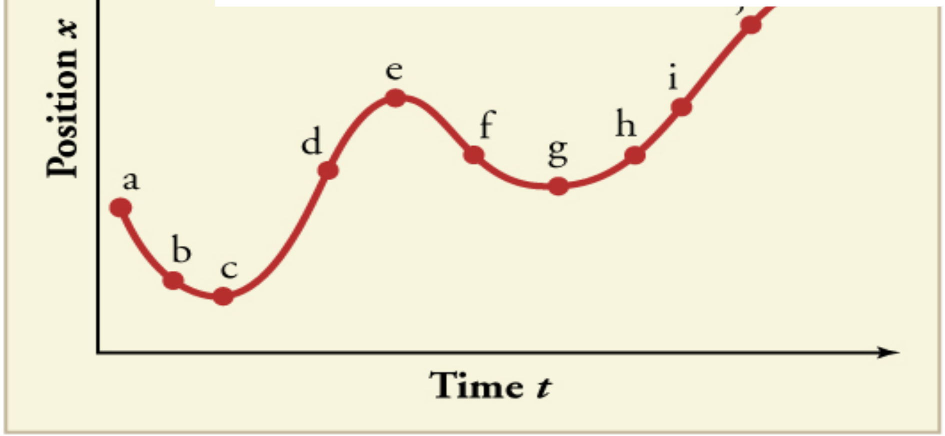
A $t = t_f$ velocity is 1. positive 2. zero 3. negative instantaneous velocity = $\vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t}$ = the “slope”

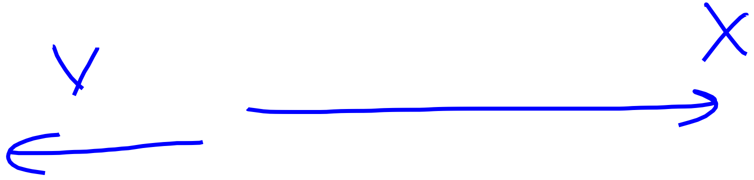



LectureMCQ L3 Q4

**A $t = t_f$ velocity is 1. positive 2. zero 3. negative**

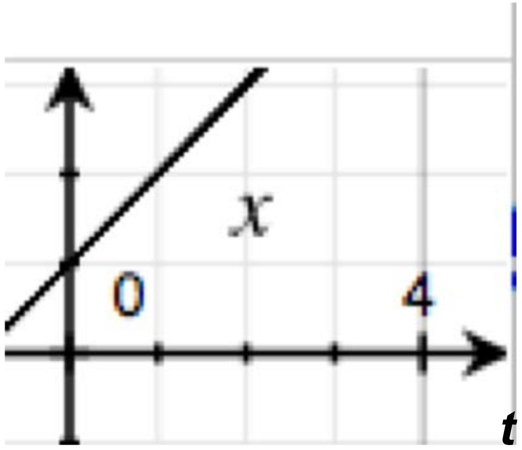
instantaneous velocity = $\vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t}$ = **the "slope"**




What does *negative* velocity mean?

# Motion with constant velocity (MCV)



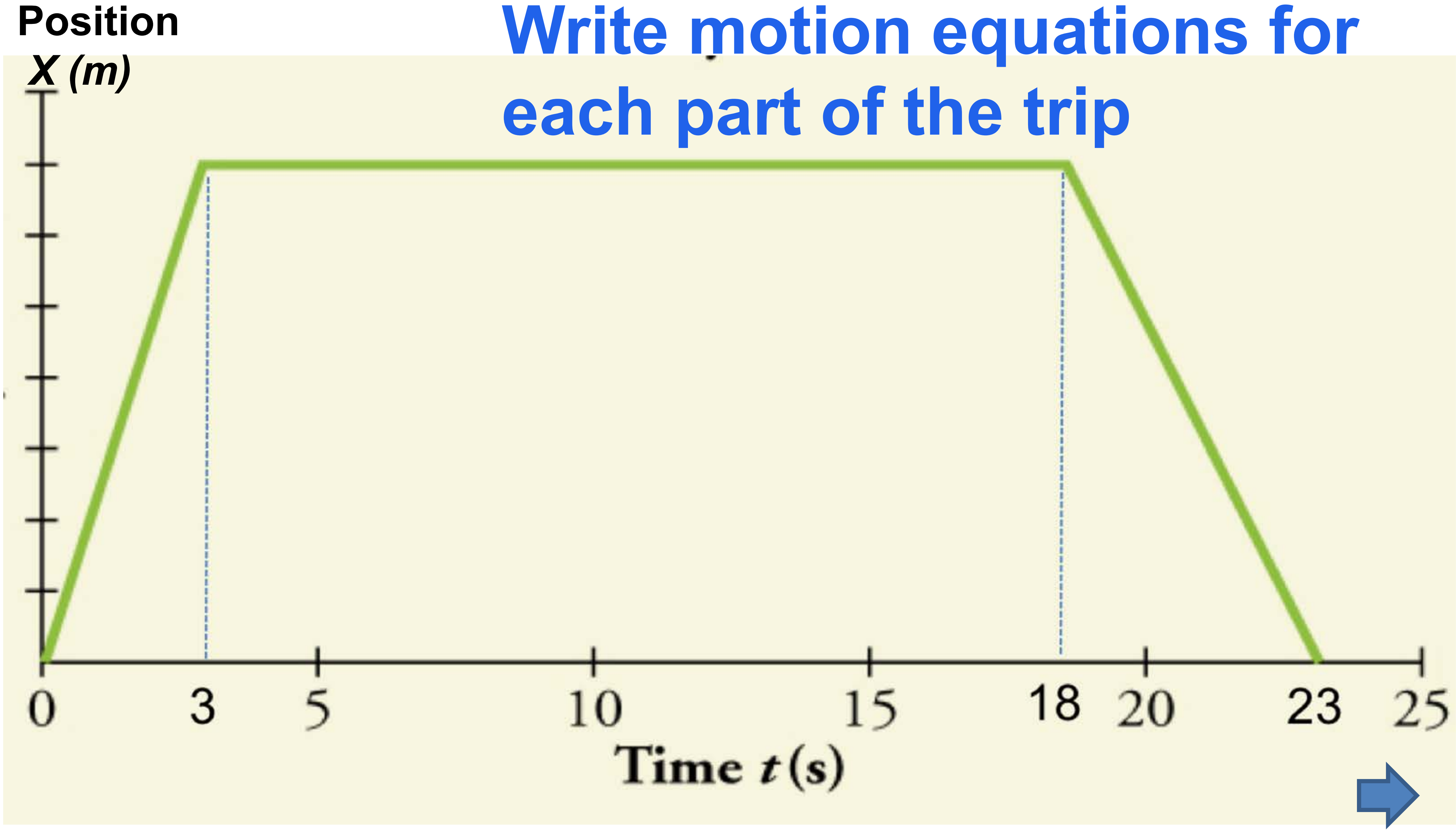

$$v_{AVE} = v_{INST} = v$$

$$v = \left.\frac{\Delta x}{\Delta t}\right|_{\substack{\Delta t \to 0 \\ \Delta x \to 0}} = v_{ave} = \frac{\Delta x}{\Delta t} = m$$

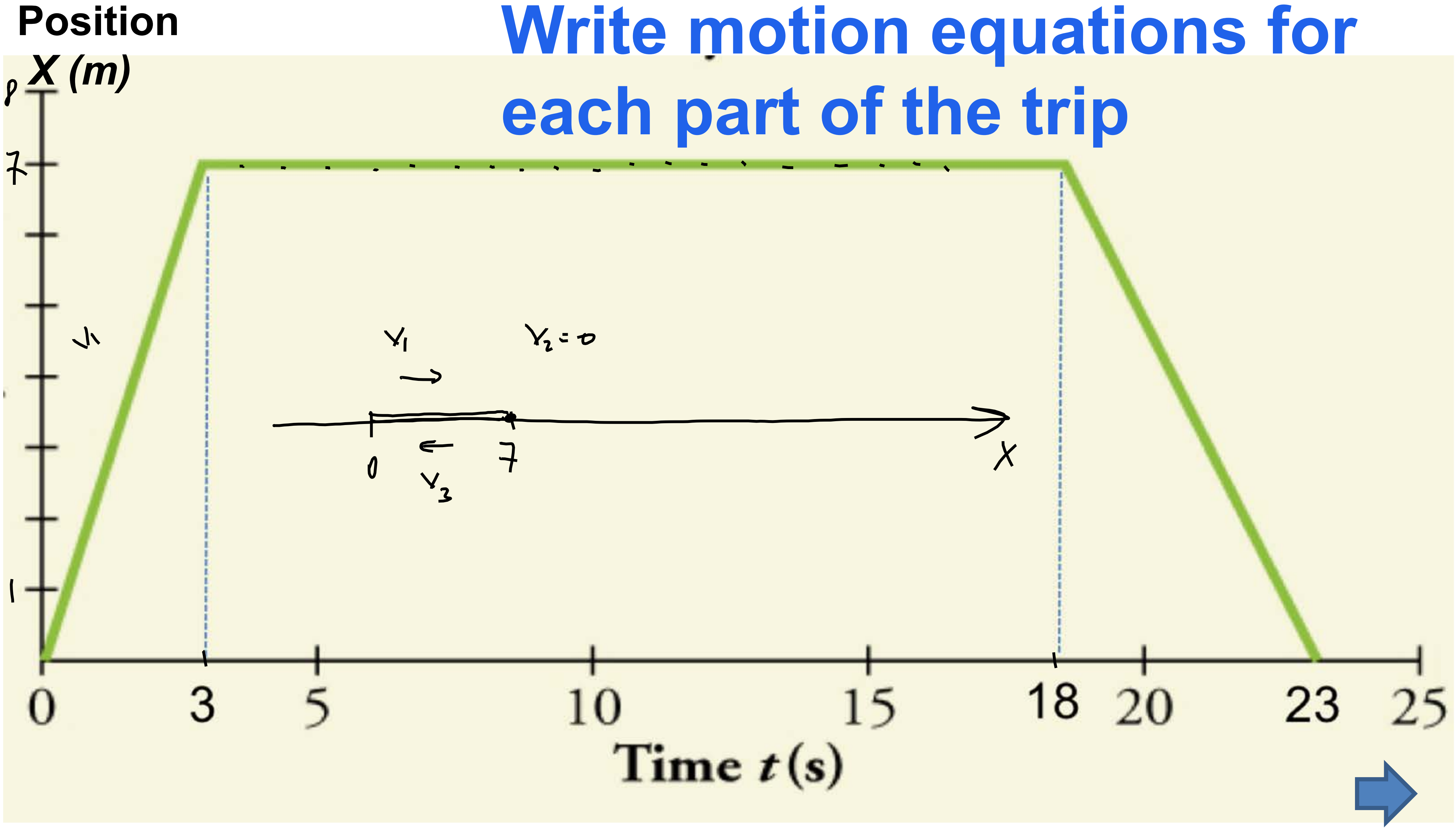
$$X = mt + b$$

***Motion equation:*** $X = X_i + v * t$

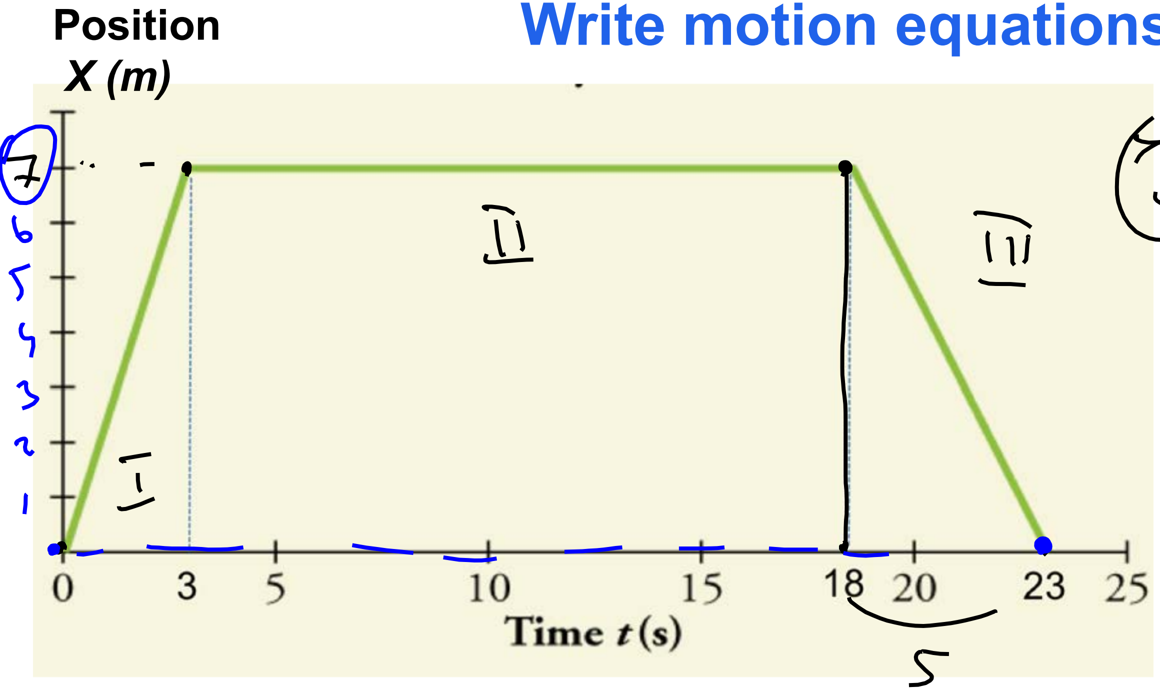
## Write motion equations for each part of the trip



# Write motion equations for each part of the trip



# Write motion equations for each part of the trip




**II** $X_2 = 7$  $3 < t < 18$

**I**

$X = X_i + v \cdot t$

$X_i = 0$; $v = \frac{7}{3}$

$X = 0 + \frac{7}{3} \cdot t$

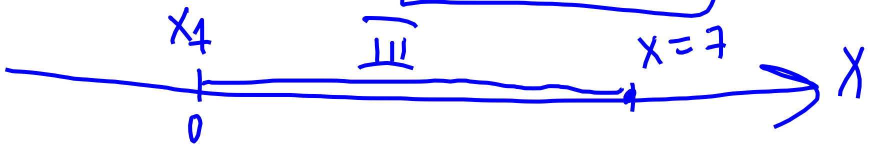
$X = \frac{7}{3} t$,  $0 < t < 3$

**III**

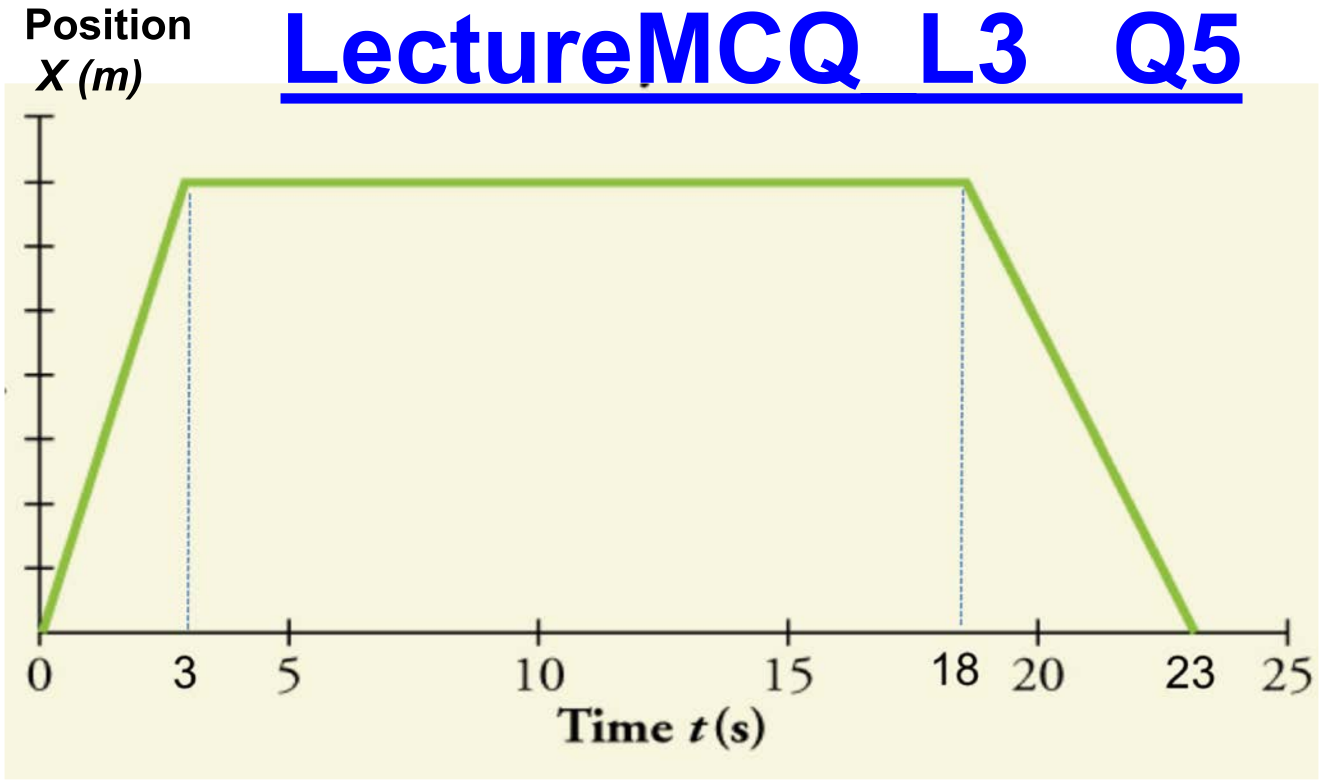
$X = X_i + v t$

$X_i = 7$; $v = \frac{-7}{5}$;

$= \frac{0-7}{23-18} = -\frac{7}{5}$;  $X = 7 - \frac{7}{5} \cdot t$



# LectureMCQ_L3 Q5

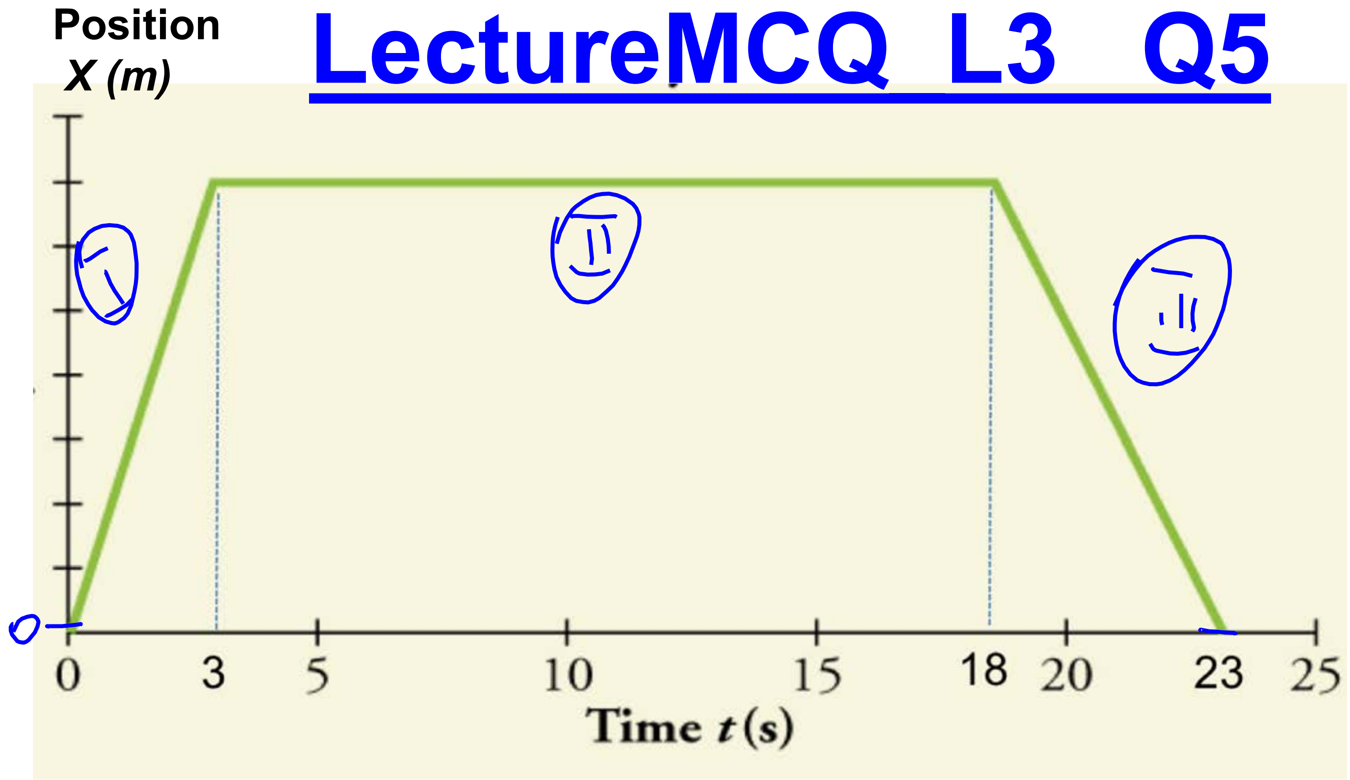



Average velocity for the whole trip is …

1. -17 m/s
2. -4 m/s
3. 0 m/s

4. 7/23 m/s 5. 23 /7 m/s. 6. does not exist

# LectureMCQ_L3 Q5




Average velocity for the whole trip is …

1. -17 m/s
2. -4 m/s
3. 0 m/s
4. 7/23 m/s
5. 23 /7 m/s.
6. does not exist

$$V_{Ave} = \frac{\Delta x}{\Delta t} = \frac{0-0}{23}$$

# When **velocity** ***changes***

**"Speeding up"**

**An object is moving faster and faster**

***Speed*** **increases**

NOT velocity!

**"Slowing down"**

**An object is moving slower and slower**

***Speed*** **decreases**

1-D motion

# A SLIDING CART = MCA !

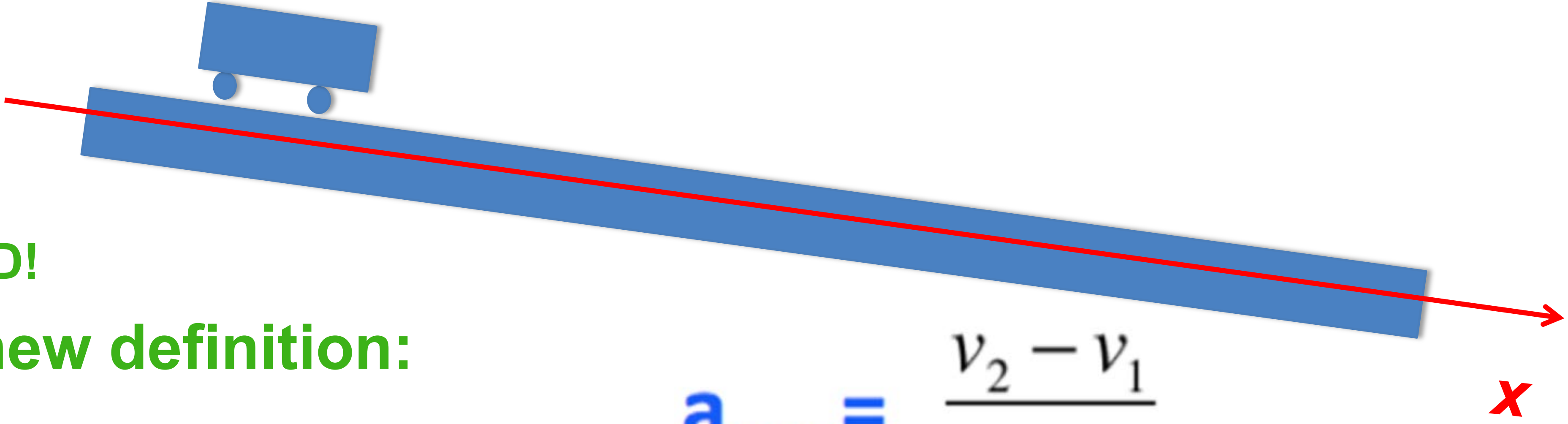
## Average velocity

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

## Average speed

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

L ← distance



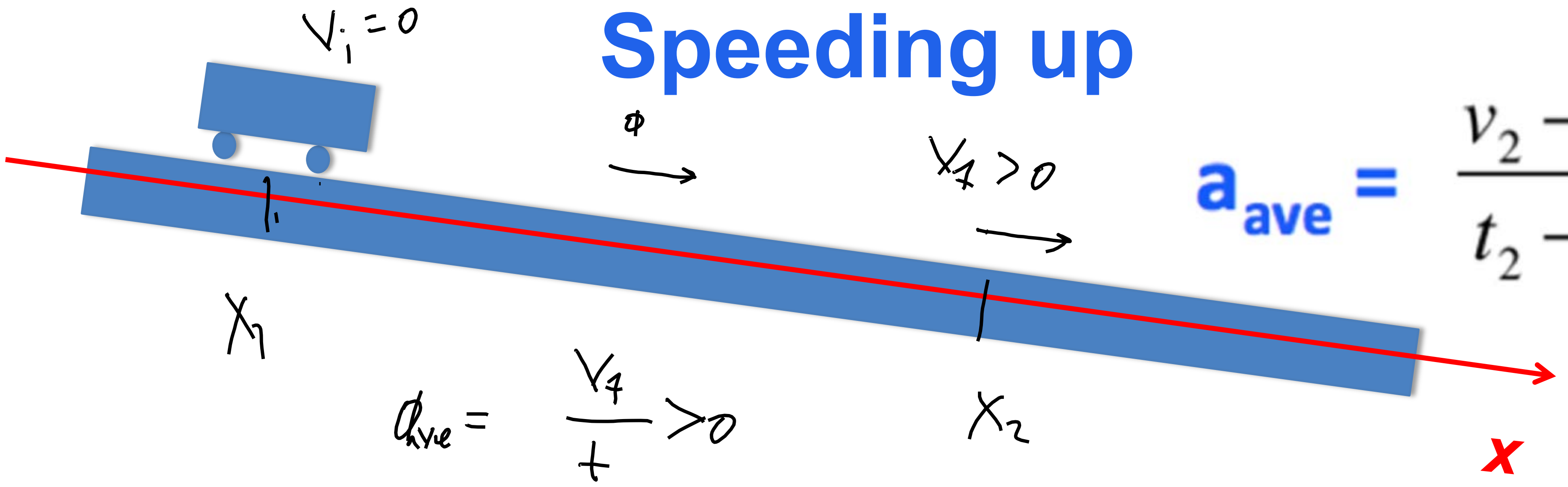

AND!

a new definition:

Average Acceleration

$$a_{ave} = \frac{v_2 - v_1}{t_2 - t_1}$$

# Speeding up



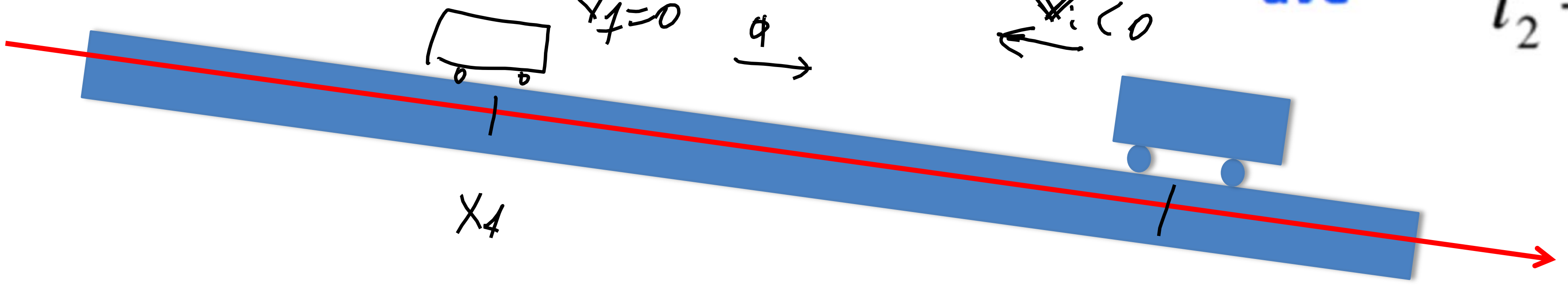

$$a_{ave} = \frac{v_2 - v_1}{t_2 - t_1}$$

# Slowing down up

1-D

$$a_{ave} = \frac{v_2 - v_1}{t_2 - t_1}$$

$v_f = 0$ $\quad a \rightarrow \quad v_i < 0$




$$a_{ave} = \frac{0 - v_i}{t}$$

$> 0$

$= 0$

$< 0$

$v_i = -5$ m/s

$$a_{ave} = \frac{0 - -5}{t} > 0$$

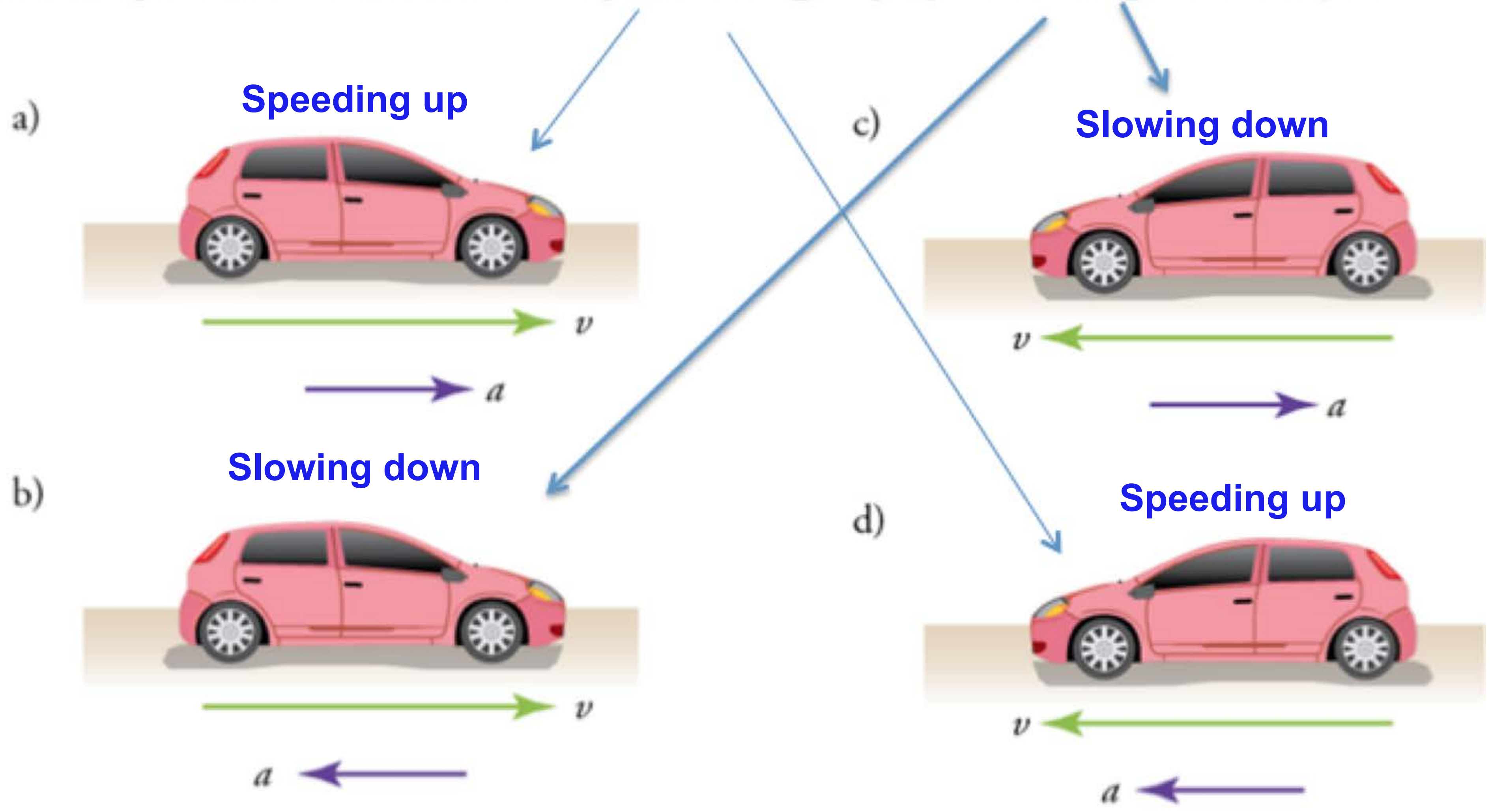
$X < 0$ | $0$ | $X > 0$ | $x$

$v_x > 0$ → $v_x < 0$ ← $a_x > 0$ → $a_x < 0$ ←

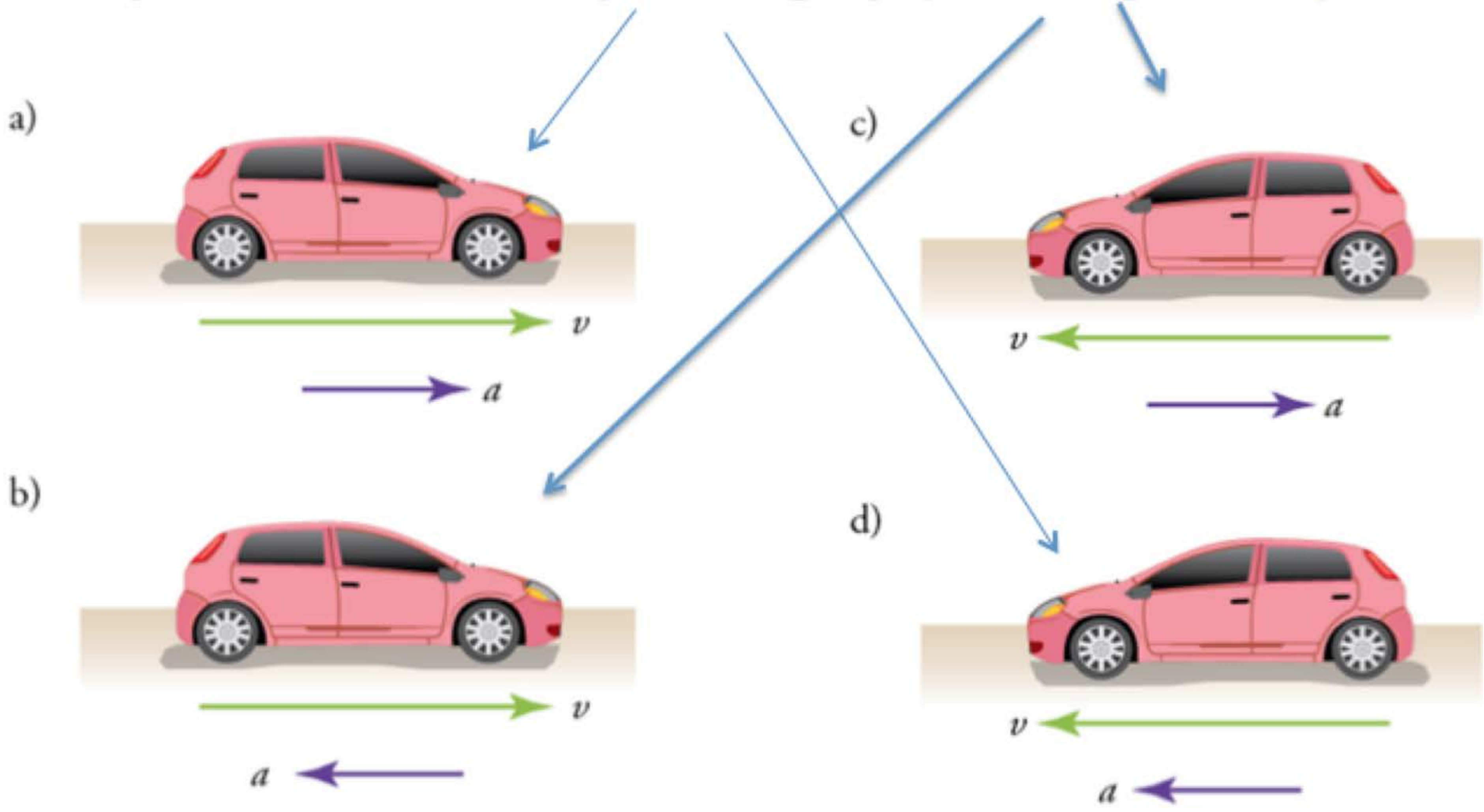
$v_x > 0$ → ***AND*** $a_x > 0$ → ***OR*** $v_x < 0$ ← ***AND*** $a_x < 0$ ← ⇒ **Speeding up**

$v_x > 0$ → ***AND*** $a_x < 0$ ← ***OR*** $v_x < 0$ ← ***AND*** $a_x > 0$ → ⇒ **Slowing down**

# Which picture shows a speeding up (slowing down) car?



# Which picture shows a speeding up (slowing down) car?



# LectureMCQ L3 Q6

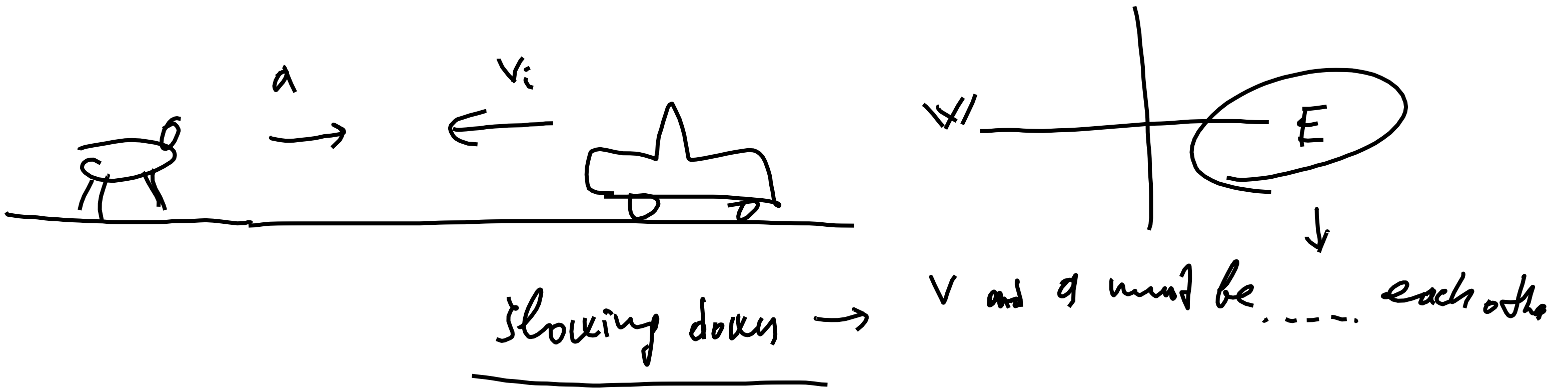
**A driver driving due West suddenly sees a deer and applies the breaks. What is the direction of the acceleration of the driver's car?**

1. **West**
2. **North**
3. **East**
4. **South**

# LectureMCQ L3 Q6

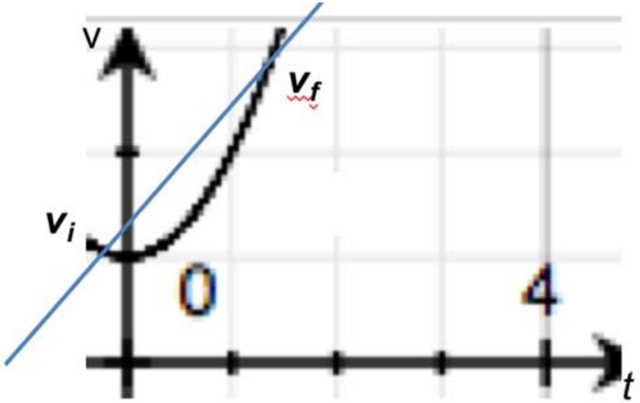
**A driver driving due West suddenly sees a deer and applies the breaks. What is the direction of the acceleration of the driver's car?**

1. **West**
2. **North**
3. **East**
4. **South**



# Average acceleration

$$a_{ave} = \frac{v_2 - v_1}{t_2 - t_1}$$

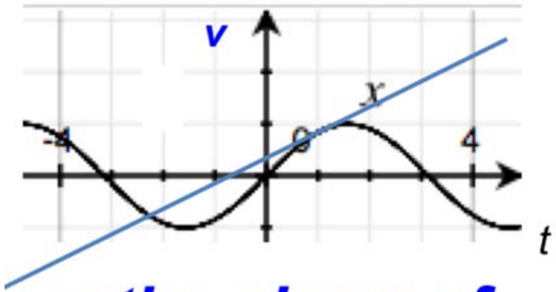



= the slope of the line passing initial and final velocities on the velocity graph $v(t)$:

# Instantaneous acceleration

$$a = \frac{v_2 - v_1}{t_2 - t_1} \quad t_2 \rightarrow t_1$$

Instantaneous




*= the slope of the line tangent to the velocity graph v(t):*

# Motion with Constant Acceleration (MCA)

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 $t_2$ (!)

# MCA: motion with *constant* acceleration

**Average acceleration = Instantaneous acceleration**

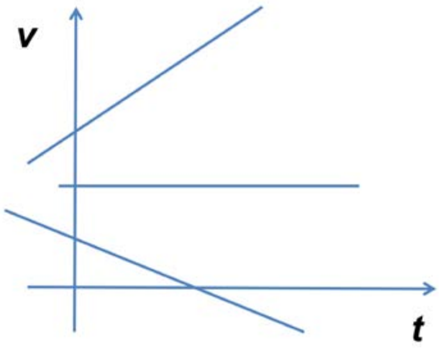
**Average acceleration**

$$a_{ave} = \frac{v_2 - v_1}{t_2 - t_1}$$

**=**

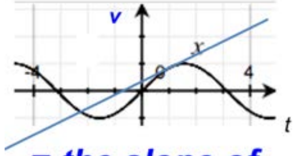
**Instantaneous acceleration**

$$a = \frac{v_2 - v_1}{t_2 - t_1} \quad t_2 \rightarrow t_1$$




**Constant acceleration = constant slope on velocity graph => straight line!**

**Instantaneous**




*= the slope of the line tangent to the velocity graph v(t):*

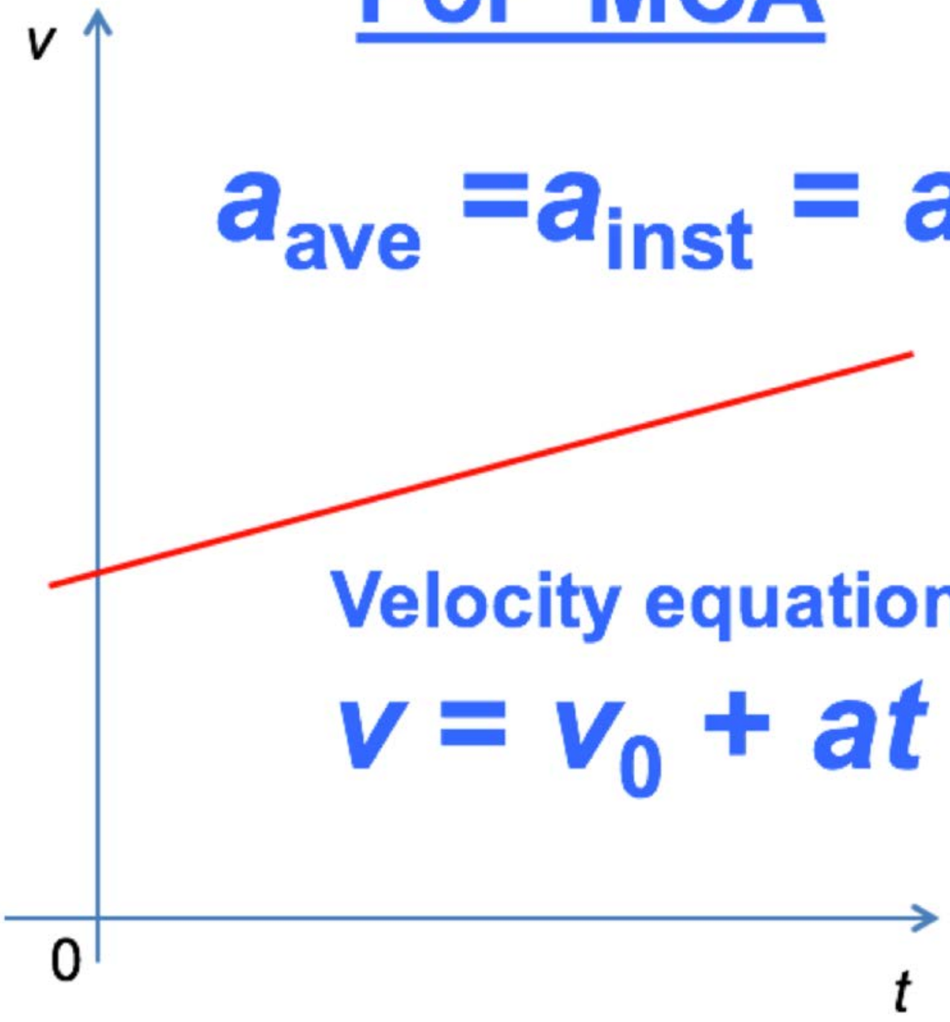
$$a_{inst} = \lim_{\Delta t \to \infty} \frac{v_2 - v_1}{\Delta t}$$ => *slope*

$$a_{ave} = \frac{v_2 - v_1}{t_2 - t_1}$$

$$a_{ave} = a_{inst} = a$$

**acceleration**

## For MCA

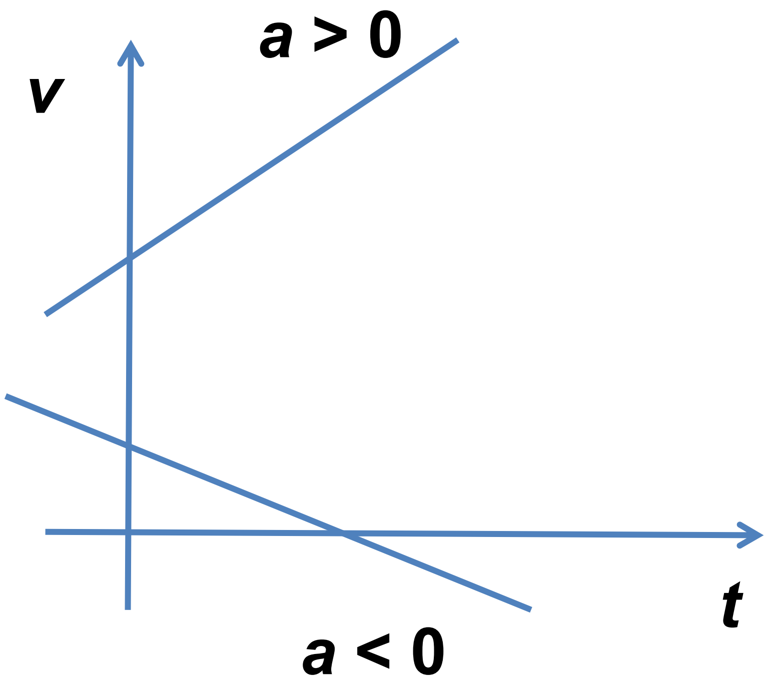


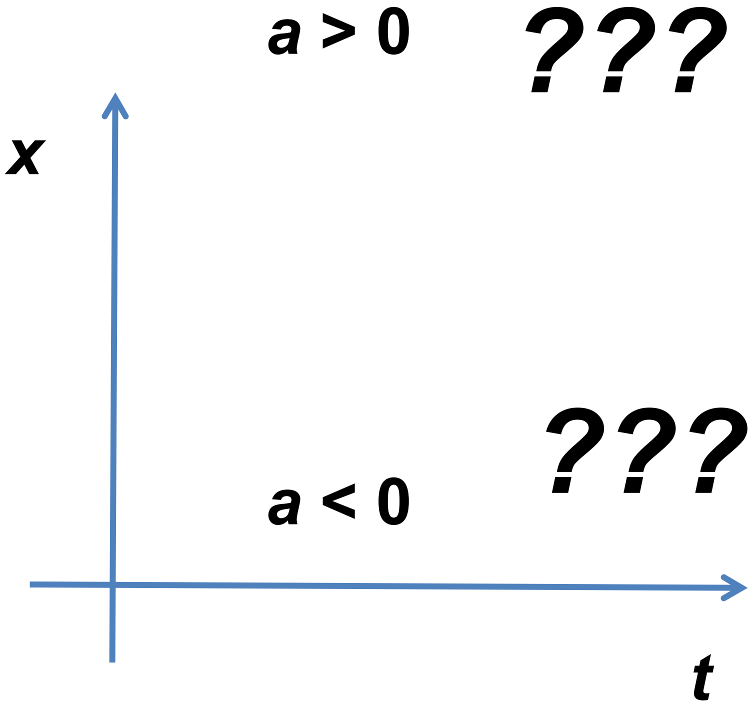

$$a_{ave} = a_{inst} = a$$

**Velocity equation:**

$$v = v_0 + at$$

# MCA




## Velocity equation

$v = m * t + b$

$b = v_i$ = initial velocity

$v = v_i + a * t$

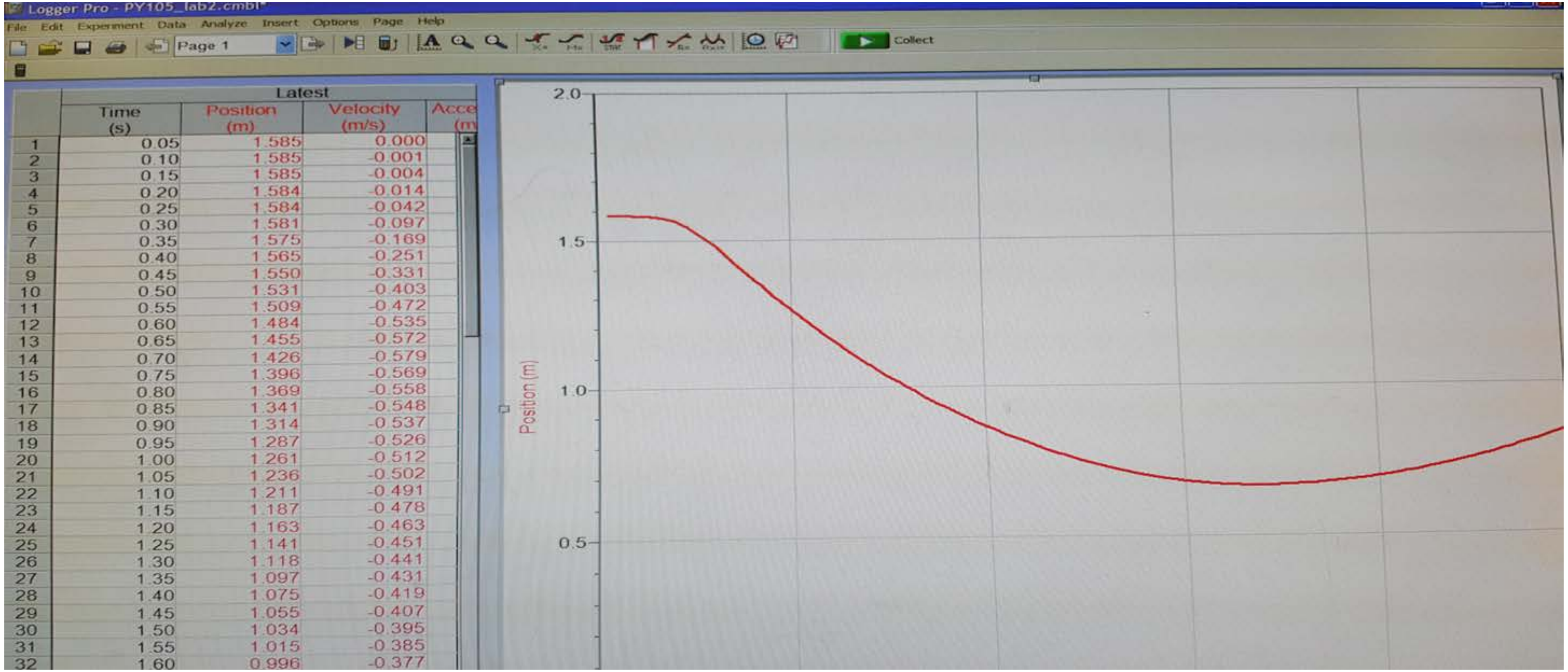
$m = a$ = acceleration

## Motion equation

$x$ = ???

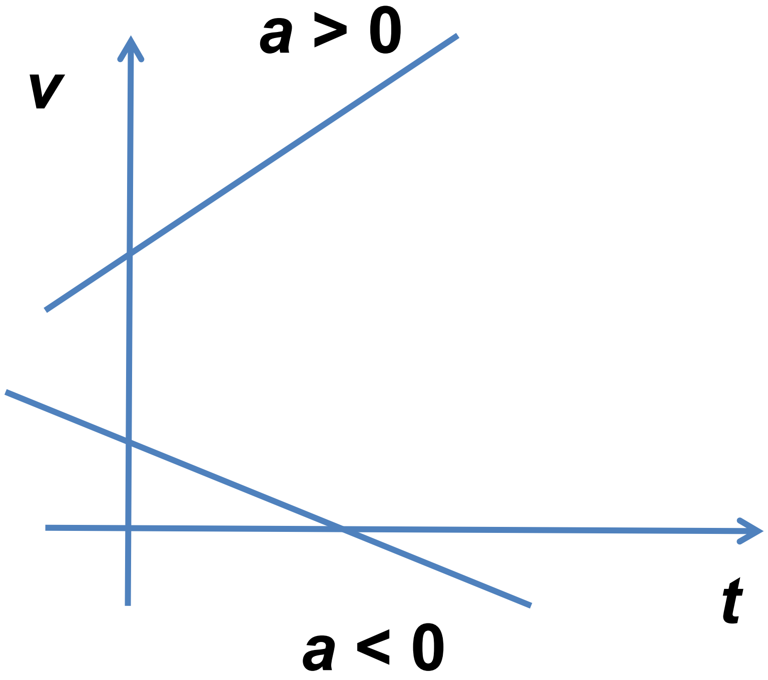
$x$ = ???

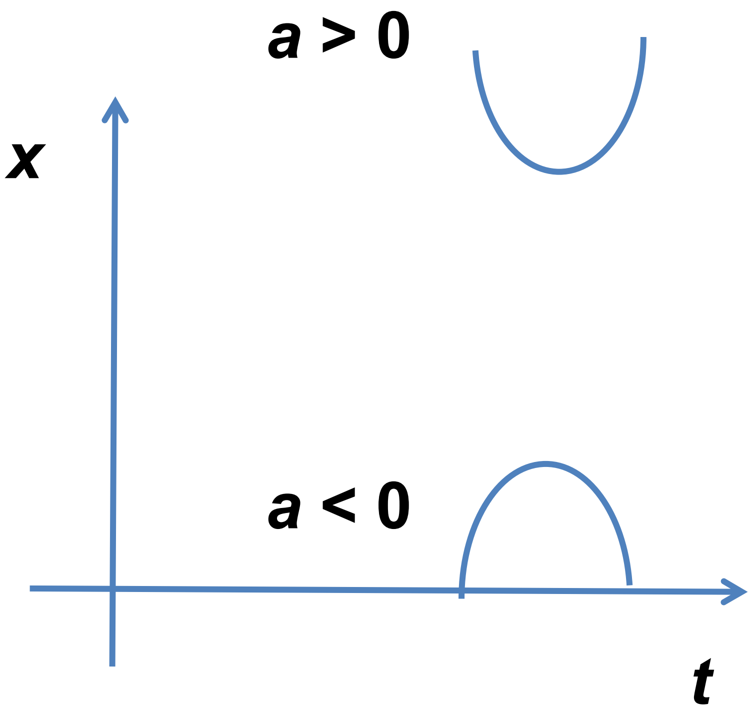
# LAB 2




| | Time (s) | Position (m) | Velocity (m/s) | Acce (m |
|---|---|---|---|---|
| 1 | 0.05 | 1.585 | 0.000 | |
| 2 | 0.10 | 1.585 | -0.001 | |
| 3 | 0.15 | 1.585 | -0.004 | |
| 4 | 0.20 | 1.584 | -0.014 | |
| 5 | 0.25 | 1.584 | -0.042 | |
| 6 | 0.30 | 1.581 | -0.097 | |
| 7 | 0.35 | 1.575 | -0.169 | |
| 8 | 0.40 | 1.565 | -0.251 | |
| 9 | 0.45 | 1.550 | -0.331 | |
| 10 | 0.50 | 1.531 | -0.403 | |
| 11 | 0.55 | 1.509 | -0.472 | |
| 12 | 0.60 | 1.484 | -0.535 | |
| 13 | 0.65 | 1.455 | -0.572 | |
| 14 | 0.70 | 1.426 | -0.579 | |
| 15 | 0.75 | 1.396 | -0.569 | |
| 16 | 0.80 | 1.369 | -0.558 | |
| 17 | 0.85 | 1.341 | -0.548 | |
| 18 | 0.90 | 1.314 | -0.537 | |
| 19 | 0.95 | 1.287 | -0.526 | |
| 20 | 1.00 | 1.261 | -0.512 | |
| 21 | 1.05 | 1.236 | -0.502 | |
| 22 | 1.10 | 1.211 | -0.491 | |
| 23 | 1.15 | 1.187 | -0.478 | |
| 24 | 1.20 | 1.163 | -0.463 | |
| 25 | 1.25 | 1.141 | -0.451 | |
| 26 | 1.30 | 1.118 | -0.441 | |
| 27 | 1.35 | 1.097 | -0.431 | |
| 28 | 1.40 | 1.075 | -0.419 | |
| 29 | 1.45 | 1.055 | -0.407 | |
| 30 | 1.50 | 1.034 | -0.395 | |
| 31 | 1.55 | 1.015 | -0.385 | |
| 32 | 1.60 | 0.996 | -0.377 | |

# MCA




## Velocity equation

$$v = m*t + b$$

$$v = v_i + a*t$$

$B = b = v_i$ = initial velocity

$A/2 = m = a$ = acceleration

## Motion equation

$$x = A*t^2 + B*t + C$$

$$x = x_i + v_i*t + 1/2*a*t^2$$

# Constant-acceleration equations

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

- the acceleration is constant => $a_{ave} = a_{inst} = a$
- the motion is measured from $t = 0$ => $\Delta t = t$

$$v = v_i + at$$

$$x = x_i + v_i t + \frac{1}{2}at^2$$

$$v^2 = v_i^2 + 2a(x - x_i)$$

$$v_{ave} = (v_0 + v_f)/2$$

(*prove it*!)

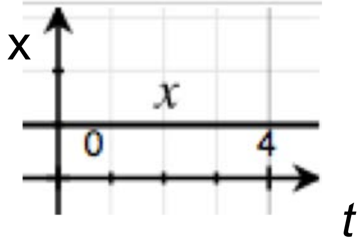
Everything except the time $t$ is a vector component – a scalar with a sign. The appropriate plus or minus sign indicates the direction of the vector.

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

# Types of 1 – D motion

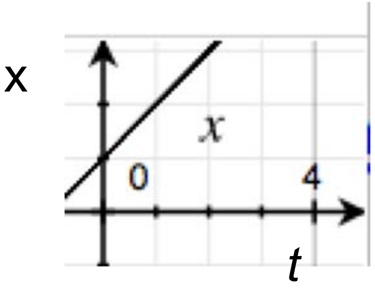
## Depending on the *rate of change of the position, a.k.a. velocity*:

## Rest




$X = C \quad v = 0$

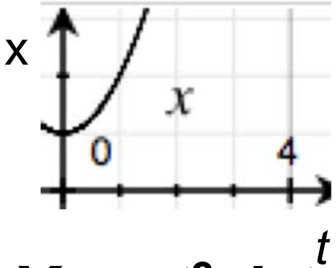
## MCV




$X = mt + b$

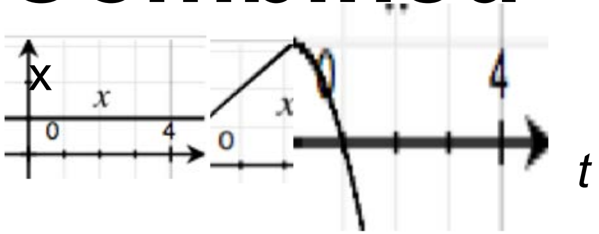
$\vec{v}_{AVE} = \vec{v}_{INST}$

## MCA

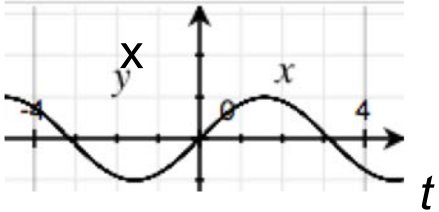



$X = at^2+bt+C$

## Combined




## Other (Any/General)



# Learned!

**Physical terms/parameters/quantities used to describe motion:**

position, trajectory, path, origin, reference frame, coordinate, position vector, radius-vector, displacement, magnitude of the displacement, distance traveled, time of motion, elapsed time, average velocity, average speed, instantaneous velocity, instantaneous speed, average acceleration,

## => Practice

**MCA**

$v = v_i + a*t$

$x = x_i + v_i*t + 1/2 *a*t^2$

For motion equation

$x = 24t - 6t^2 + 6$

# Find: position and velocity at $t = 1$ s, 2 s, 3 s.

$X = 6 + 24t - 6t^2$ → specific MCA

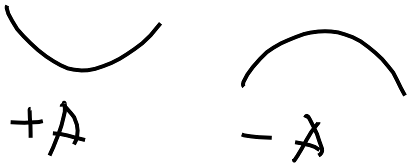
$X = X_i + V_i t + \frac{1}{2} a t^2$ → general MCA

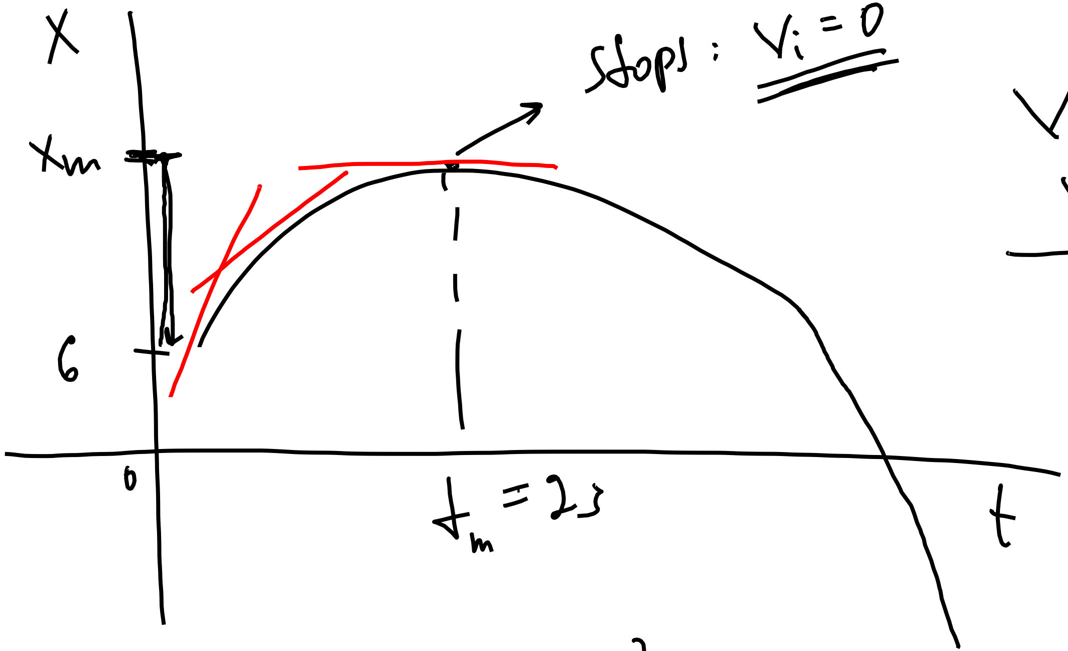
$X_i = 6$ m  $V_i = 24$ m/s  $a = -12$ m/s²

$24t = V_i t$

$-6 \cdot t^2 = \frac{1}{2} a t^2$ …

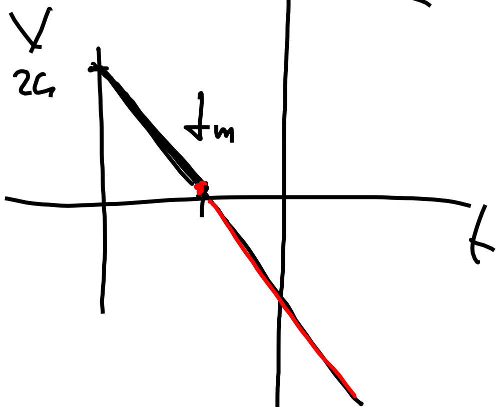
$$X = 6 + 24t - 6 \cdot t^2$$




$$V = V_i + a \cdot t$$

$$V = 24 - 12 \cdot t$$

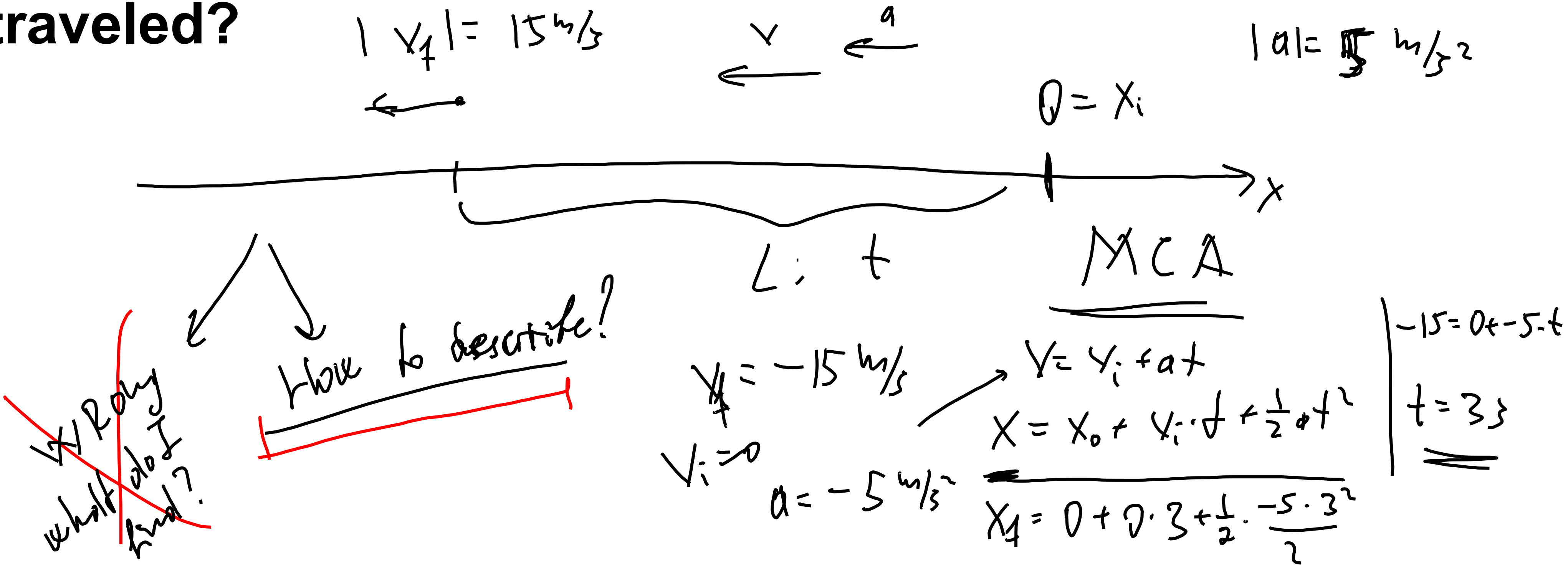


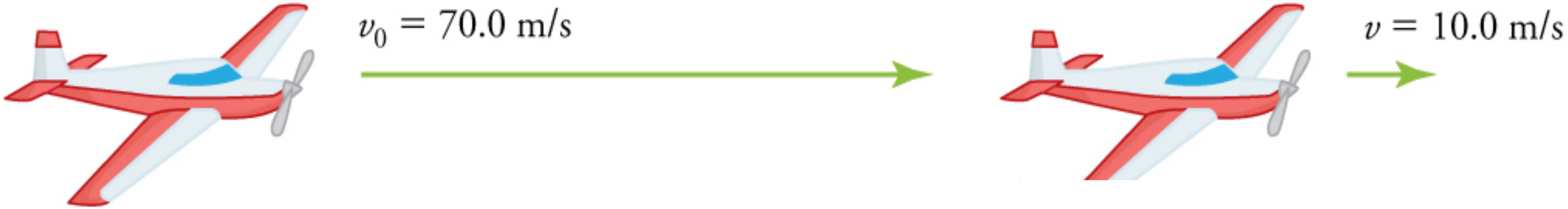

$$0 = 24 - 12 \cdot t_m \Rightarrow t_m = 2s$$

$$X_m = 6 + 24 \cdot 2 - 6 \cdot 2^2$$

**An object was moved to the left from rest with a constant acceleration. How much time did it take to reach the speed of 15 m/s, if the magnitude of the acceleration is 5 $m/s^2$? What was the distance traveled?**

**An object was moved to the left from rest with a constant acceleration. How much time did it take to reach the speed of 15 m/s, if the magnitude of the acceleration is 5 m/s$^2$? What was the distance traveled?**






**The airplane lands with an initial velocity of 70.0 m/s, after traveling 500 m slows to velocity of 10.0 m/s before heading for the terminal. What was the acceleration of the plain?**


MCA

**The airplane lands with an initial velocity of 70.0 m/s after traveling 500 m slows to velocity of 10.0 m/s before heading for the terminal. What was the acceleration of the plain?**

$v_i = 70$ m/s  $L = x_f = 500$ m  $v_f = 10$ m/s

0  $x_f = 500$ m  x

$V = V_i + at$

$X = X_0 + V_i \cdot t + \frac{1}{2}at^2$

$10 = 70 + a \cdot t$

$500 = 0 + 70 \cdot t + \frac{1}{2} a \cdot t^2$

System:

Physics is done!

Math begins

$V = V_i + at$

$X = X_0 + V_i t + \frac{1}{2} a t^2$

$V_f^2 = V_i^2 + 2 \cdot a \cdot \Delta X$

$10^2 = 70^2 + 2 \cdot a \cdot 500$

**1) A small ball was released from rest from a window 4.9 m above the ground. The ball hits the ground 1 second later. Find the acceleration of the ball.**

**2) If the same ball was shot straight up with the same acceleration and the initial speed of 10 m/s, how high would it go?**

**1) A small ball was released from rest from a window 4.9 m above the ground. The ball hits the ground 1 second later. Find the acceleration of the ball.**