PHYS 1441 – Section 002
Lecture #4

Monday, Jan. 28, 2013

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- Chapter 2:
  - One Dimensional Motion
  - Instantaneous Velocity and Speed
  - Acceleration
  - Motion under constant acceleration

Announcements

- Quiz results
  - Class average: 13/20
    - Equivalent to 65/100!
    - Top score: 20/20
- E-mail subscription
  - 79/104 subscribed! ➔ Please subscribe ASAP
  - A test message was sent out Thursday morning!
    - Thanks for your replies!
    - Please check your e-mail and reply to ME and ONLY ME if you haven't done so yet!
- Homework
  - 97/104 registered ➔ You really need to get this done ASAP
  - Homework is 25% of your grade so without doing it well, it will be very hard for you to obtain good grade!
  - Please take an action TODAY if you aren't already registered!!

Reminder: Special Project #1

- Derive the quadratic equation for $yx^2-zx+v=0$ ➔ 5 points
  - This means that you need to solve the above equation and find the solutions for x!
- Derive the kinematic equation $v^2 = v_0^2 + 2a(x - x_0)$ from first principles and the known kinematic equations ➔ 10 points
- You must **show your OWN work in detail** to obtain the full credit
  - Must be in much more detail than in this lecture note!!!
  - Please do not copy from the lecture note or from your friends. You will all get 0!
- Due Monday, Feb. 4

Refresher: Displacement, Velocity and Speed

One dimensional displacement is defined as:

$$\Delta x \equiv x_f - x_i$$

Displacement is the difference between initial and final potions of the motion and is a vector quantity. How is this different than distance?

Unit? m

The average velocity is defined as: $$v_x \equiv \frac{x_f - x_i}{t_f - t_i} = \frac{\Delta x}{\Delta t} \equiv \frac{\text{Displacement}}{\text{Elapsed Time}}$$

Unit? m/s

Displacement per unit time in the period throughout the motion

The average speed is defined as: $$v \equiv \frac{\text{Total Distance Traveled}}{\text{Total Elapsed Time}}$$

Unit? m/s

Example Distance Run by a Jogger

How far does a jogger run in 1.5 hours if his average speed is 2.22 m/s?

$$\text{Average speed} = \frac{\text{Distance}}{\text{Elapsed time}}$$

$$\text{Distance} = (\text{Average speed})(\text{Elapsed time}) =$$

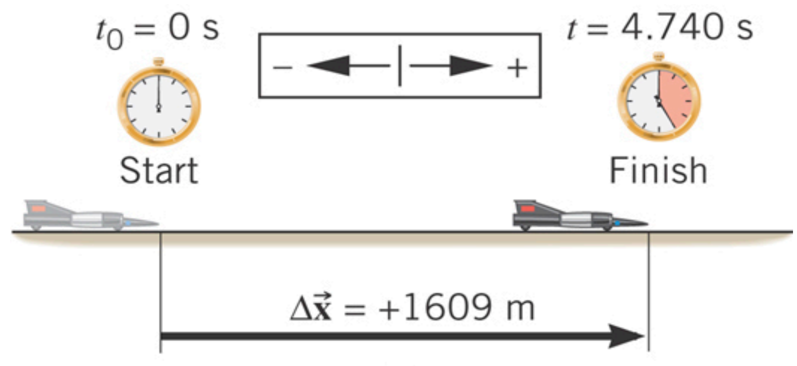
$$= (2.22\ \text{m/s})(5400\ \text{s}) = 12000\ \text{m}$$

Example: The World's Fastest Jet-Engine Car

Andy Green in the car *ThrustSSC* set a world record of 341.1 m/s in 1997. To establish such a record, the driver makes two runs through the course, one in each direction to nullify wind effects. From the data, determine the average speed for each run.

$$\bar{\vec{\mathbf{v}}} = \frac{\Delta\vec{\mathbf{x}}}{\Delta t} = \frac{+1609 \text{ m}}{4.740 \text{ s}} = +339.5 \,\text{m/s}$$

What is the speed? $v = \left|\bar{\vec{\mathbf{v}}}\right| = 339.5 \,\text{m/s}$



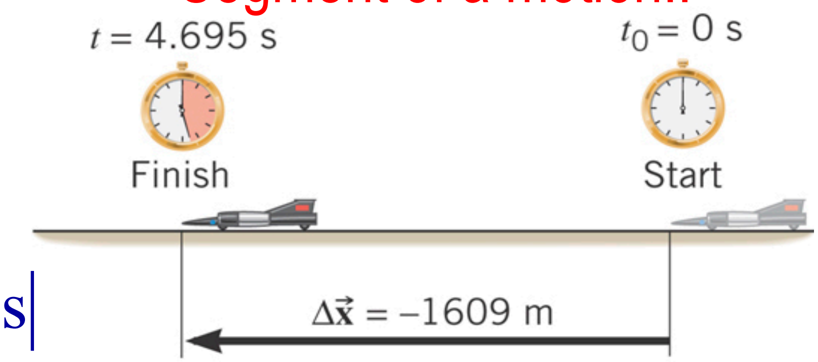
(*a*)

Segment of a motion!!

$$\bar{\vec{\mathbf{v}}} = \frac{\Delta\vec{\mathbf{x}}}{\Delta t} = \frac{-1609 \text{ m}}{4.695 \text{ s}} = -342.7 \,\text{m/s}$$

What is the speed? $v = \left|\bar{\vec{\mathbf{v}}}\right| = \left|-342.7 \,\text{m/s}\right|$

$$= 342.7 \,\text{m/s}$$



(*b*)

Segment of a motion!!

Instantaneous Velocity and Speed

- Can average quantities tell you the detailed story of the whole motion? **NO!!**
- Instantaneous velocity is defined as:
  - What does this mean?
    - Displacement in an infinitesimal time interval
    - Average velocity over a very, very short amount of time

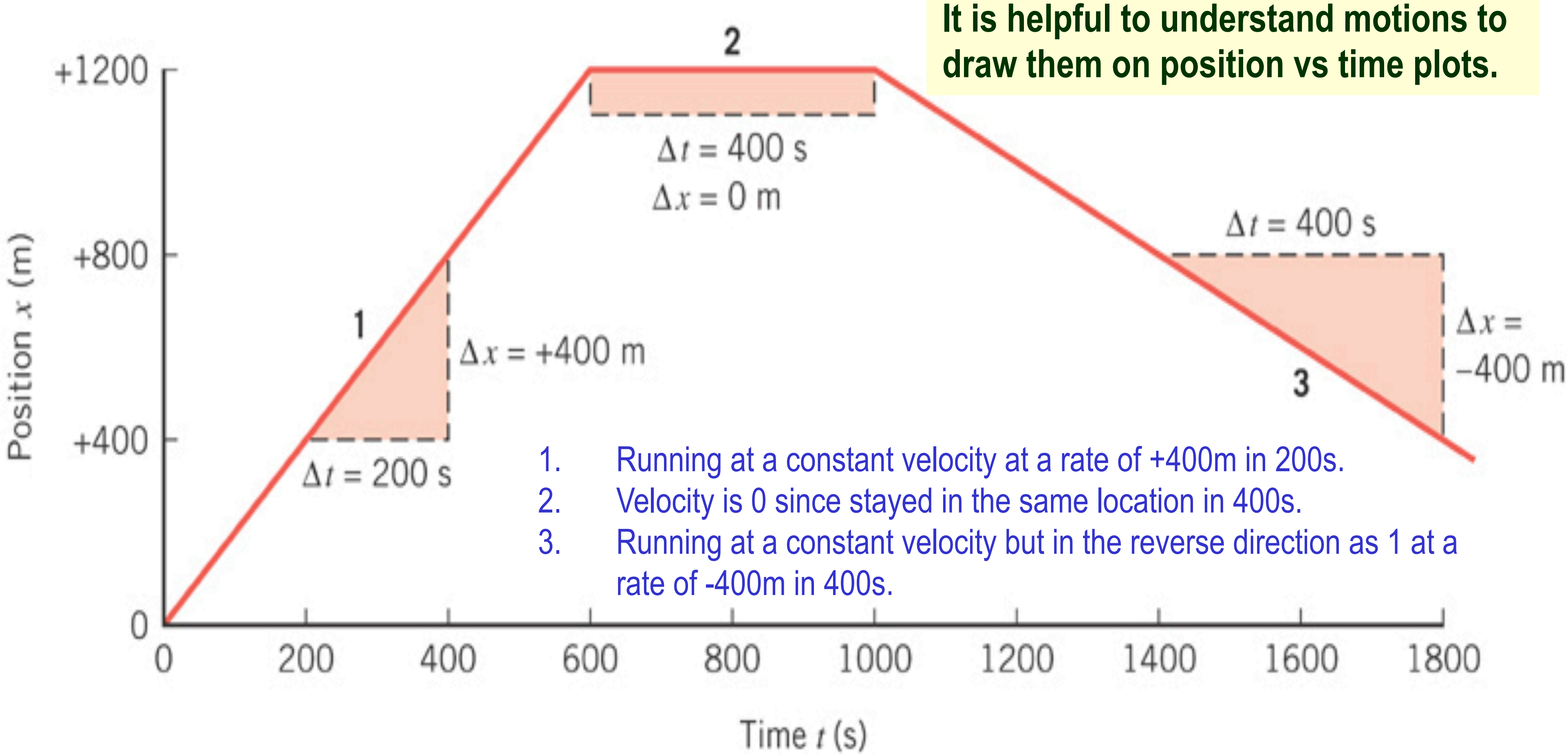
$$v_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

•Instantaneous speed is the size (magnitude) of the velocity vector:

$$|v_x| = \left| \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} \right|$$

*Magnitude of Vectors are Expressed in absolute values

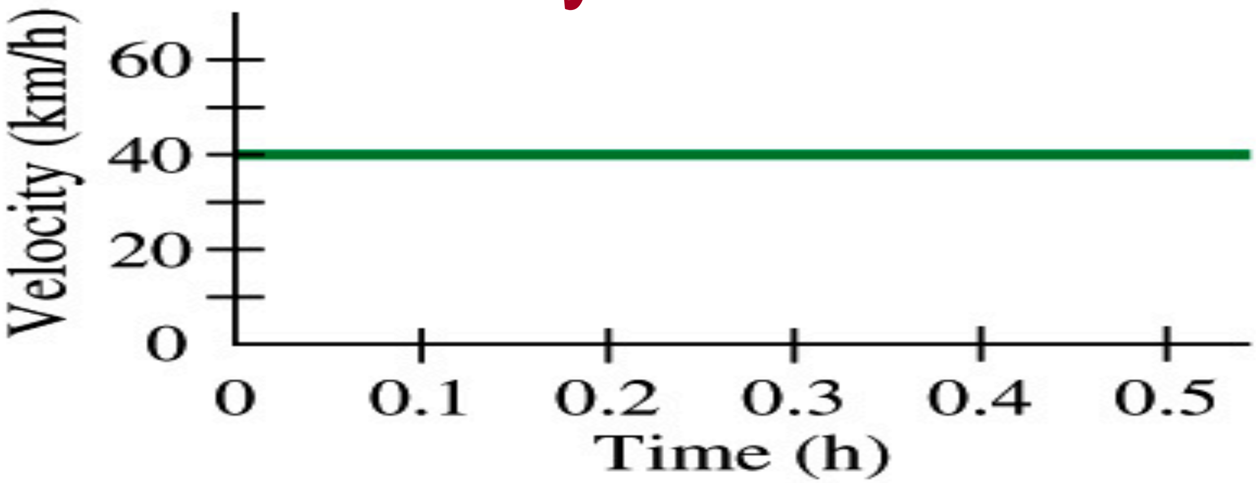
Position vs Time Plot

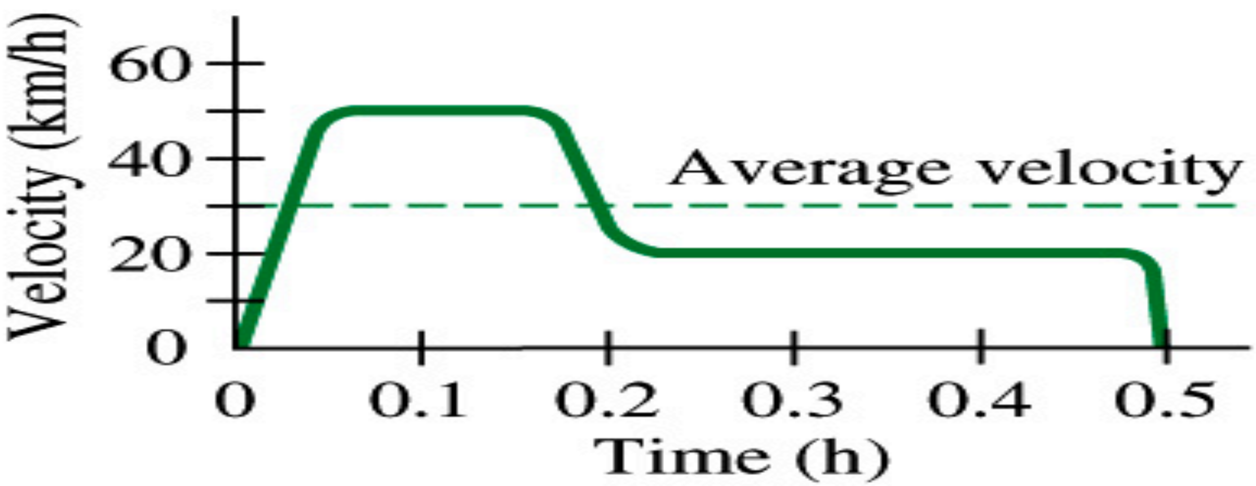


It is helpful to understand motions to draw them on position vs time plots.

1. Running at a constant velocity at a rate of +400m in 200s.
2. Velocity is 0 since stayed in the same location in 400s.
3. Running at a constant velocity but in the reverse direction as 1 at a rate of -400m in 400s.

Velocity vs Time Plot





Displacement, Velocity and Speed

Displacement

$$\boxed{\Delta x \equiv x_f - x_i}$$

Average velocity

$$\boxed{v_x \equiv \frac{x_f - x_i}{t_f - t_i} = \frac{\Delta x}{\Delta t}}$$

Average speed

$$\boxed{v \equiv \frac{\text{Total Distance Traveled}}{\text{Total Time Spent}}}$$

Instantaneous velocity

$$\boxed{v_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}}$$

Instantaneous speed

$$\boxed{\left|v_x\right| = \left|\lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}\right| = \left|\frac{dx}{dt}\right|}$$

Acceleration

Change of velocity in time (what kind of quantity is this?)

Vector!

- Average acceleration:

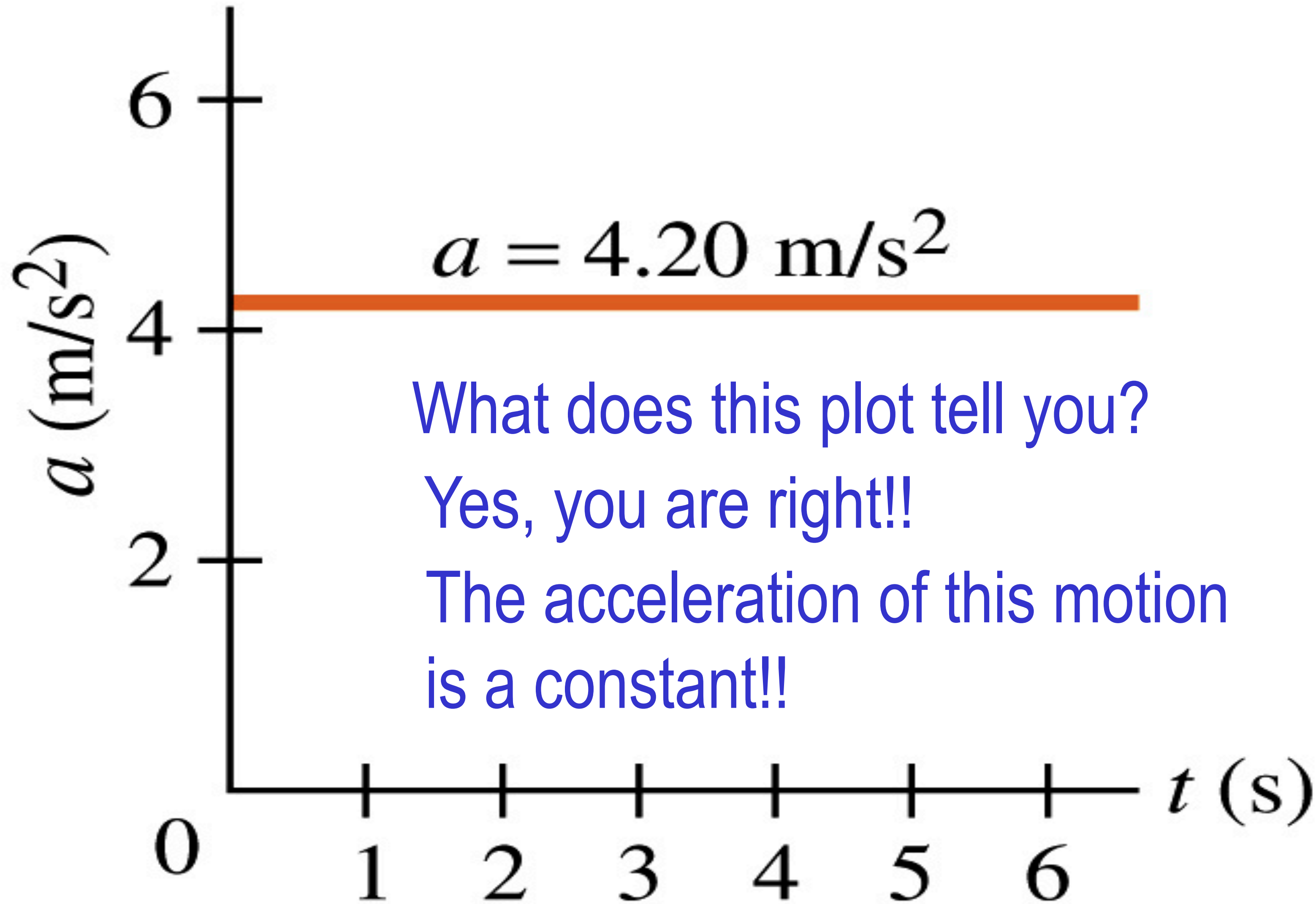
$$a_x \equiv \frac{v_{xf} - v_{xi}}{t_f - t_i} = \frac{\Delta v_x}{\Delta t}$$ analogs to $$v_x \equiv \frac{x_f - x_i}{t_f - t_i} = \frac{\Delta x}{\Delta t}$$

Dimension? [LT^{-2}] Unit? m/s^2

- Instantaneous acceleration: Average acceleration over a very short amount of time.

$$a_x \equiv \lim_{\Delta t \to 0} \frac{\Delta v_x}{\Delta t}$$ analogs to $$\boxed{v_x \equiv \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}}$$

Acceleration vs Time Plot



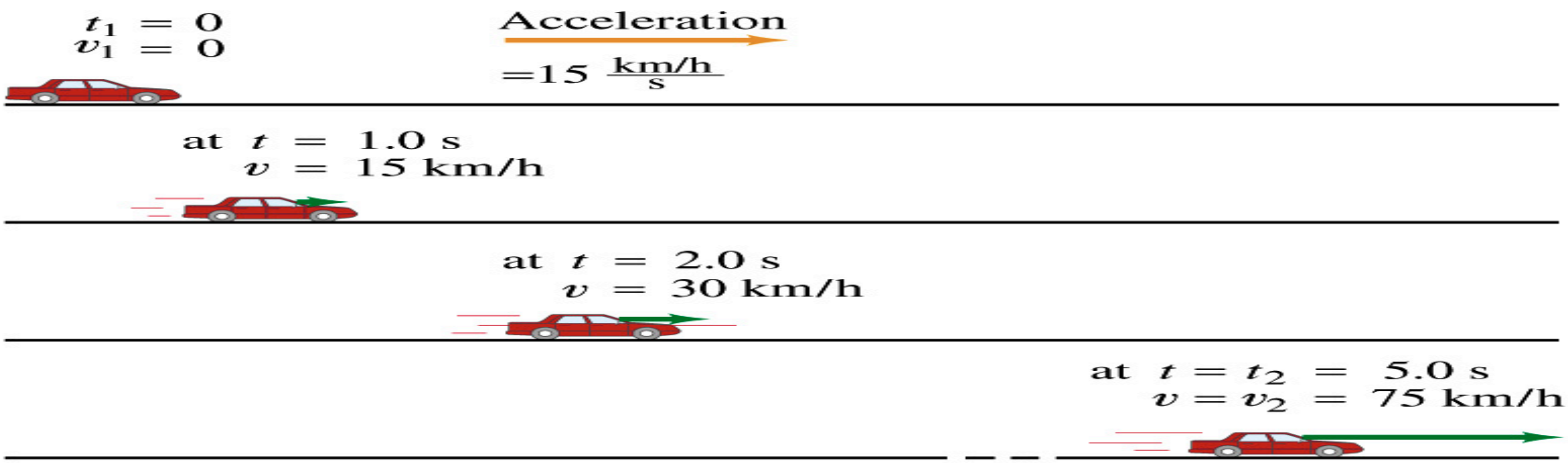
What does this plot tell you?

Yes, you are right!!

The acceleration of this motion is a constant!!

Example 2.3

A car accelerates along a straight road from rest to 75km/h in 5.0s.



What is the magnitude of its average acceleration?

$$v_{xi} = 0\ m/s$$

$$v_{xf} = \frac{75000m}{3600s} = 21\ m/s$$

$$\bar{a}_x = \frac{v_{xf} - v_{xi}}{t_f - t_i} = \frac{\Delta v_x}{\Delta t} = \frac{21 - 0}{5.0} = \frac{21}{5.0} = 4.2(m/s^2)$$

$$= \frac{4.2 \times (3600)^2}{1000} = 5.4 \times 10^4 (km/h^2)$$

A Few Confusing Things on Acceleration

- When an object is moving in a constant velocity ($v=v_0$), there is no acceleration ($a=0$)
  - Is there any acceleration when an object is not moving?
- When an object is moving faster as time goes on, ($v=v(t)$), acceleration is positive ($a>0$).
  - Incorrect, since the object might be moving in negative direction initially
- When an object is moving slower as time goes on, ($v=v(t)$), acceleration is negative ($a<0$)
  - Incorrect, since the object might be moving in negative direction initially
- In all cases, velocity is positive, unless the direction of the movement changes.
  - Incorrect, since the object might be moving in negative direction initially
- Is there acceleration if an object moves in a constant speed but changes direction?

The answer is YES!!