PHYS 1441 – Section 001
Lecture #2

Tuesday, June 9, 2015

Dr. Jaehoon Yu

- Chapter 2: One Dimensional Motion
    - Instantaneous Velocity and Speed
    - Acceleration
    - Motion under constant acceleration
    - One dimensional Kinematic Equations
    - How do we solve kinematic problems?
    - Falling motions

Today's homework is homework #2, due 11pm, Sunday, June 14!!

Announcements

- Homework registration
  - 66/71 have registered as of early this morning
    - 60 have submitted answers!!
    - Those of you who haven't enrolled in must do so ASAP.
- 1st non-comprehensive term exam
  - In class Monday, June 15
  - Covers: CH1.1 through what we finish tomorrow, Thursday, June 11, plus appendix A
  - Bring your calculator but DO NOT input formula into it!
    - Cell phones or any types of computers cannot replace a calculator!
  - BYOF: You may bring a one 8.5x11.5 sheet (front and back) of **handwritten** formulae and values of constants for the quiz
  - No derivations, word definitions or solutions of any problems!
  - No additional formulae or values of constants will be provided!
- The final exam is 10:30 – 12:30pm, Monday, July 13, in this room

Reminder: Special Project #1 for Extra Credit

- Find the solutions for $yx^2-zx+v=0$ → 5 points
  - You cannot just plug into the quadratic equations!
  - You must show a complete algebraic process of obtaining the solutions!
- 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 tomorrow Thursday, June 11

Displacement, Velocity and Speed

One dimensional displacement is defined as:

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

A vector quantity

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

Unit? $\boxed{\text{m}}$

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? $\boxed{\text{m/s}}$ A vector quantity

Displacement per unit time in the period throughout the motion

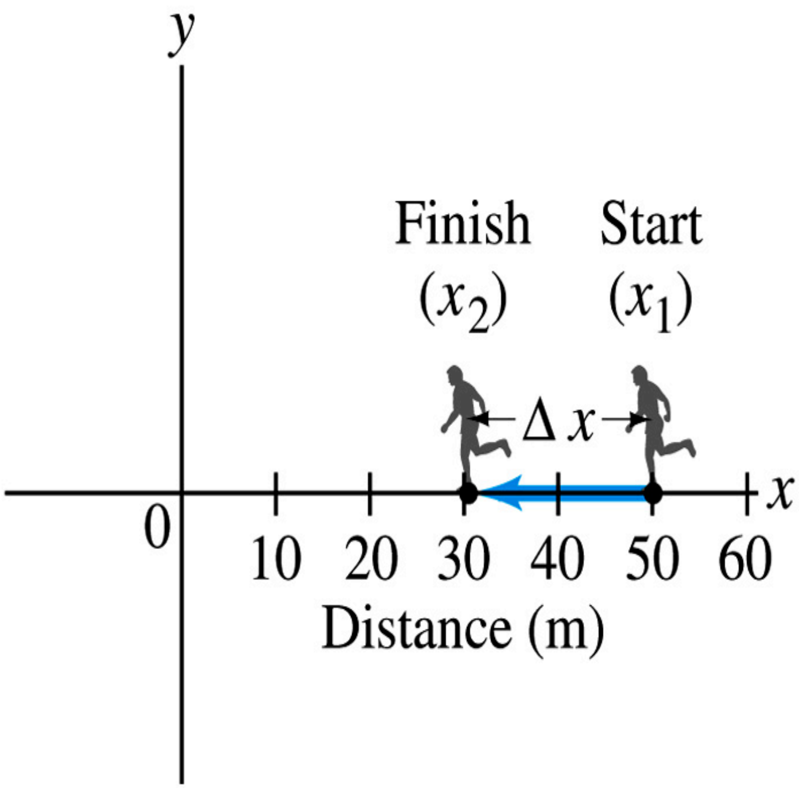
The average speed is defined as: $$v \equiv \frac{\text{Total Distance Traveled}}{\text{Total Elapsed Time}}$$

Unit? $\boxed{\text{m/s}}$

A scalar quantity

Example 2.1: Runner's Average Velocity

The position of a runner as a function of time is plotted as moving along the x axis of a coordinate system. During a 3.00-s time interval, the runner's position changes from x_1=50.0m to x_2=30.5 m, as shown in the figure. What is the runner's average velocity? What is the average speed?



- Displacement:

$$\Delta x \equiv x_f - x_i = x_2 - x_1 = 30.5 - 50.0 = -19.5(m)$$

- Average Velocity:

$$v_x \equiv \frac{x_f - x_i}{t_f - t_i} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t} = \frac{-19.5}{3.00} = -6.50(m/s)$$

- Average Speed:

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

$$= \frac{50.0 - 30.5}{3.00} = \frac{+19.5}{3.00} = +6.50(m/s)$$

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?

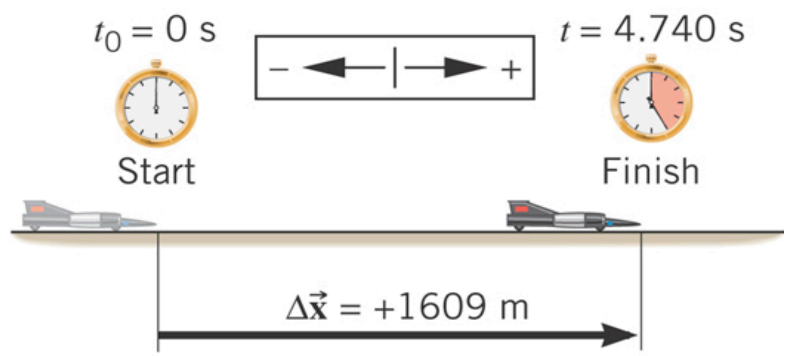
$$\text{Average speed} = \frac{\text{Distance}}{\text{Elapsed time}}$$

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

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

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.

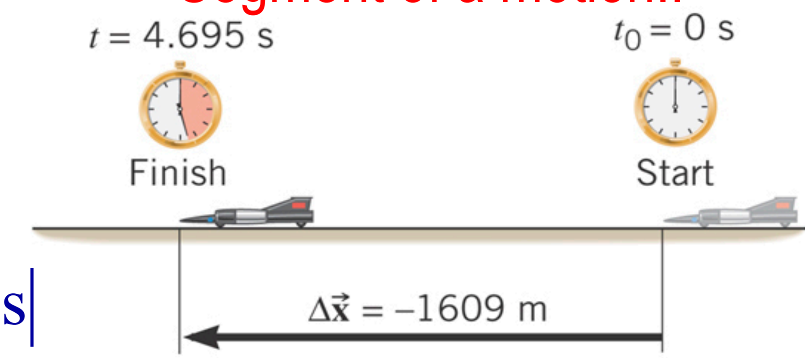


(a)

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

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

Segment of a motion!!



(b)

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

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

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

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, very small amount of time

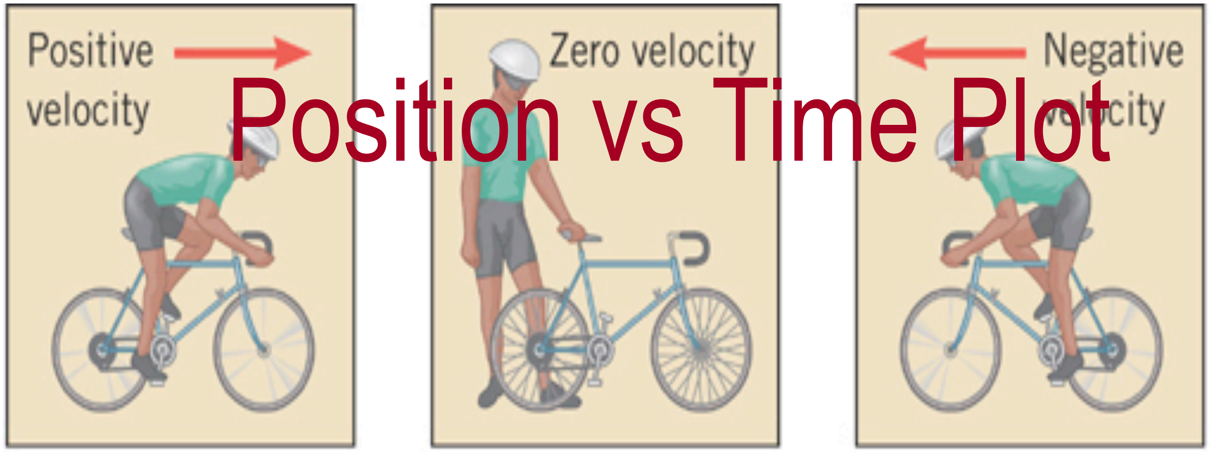
$$v_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

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

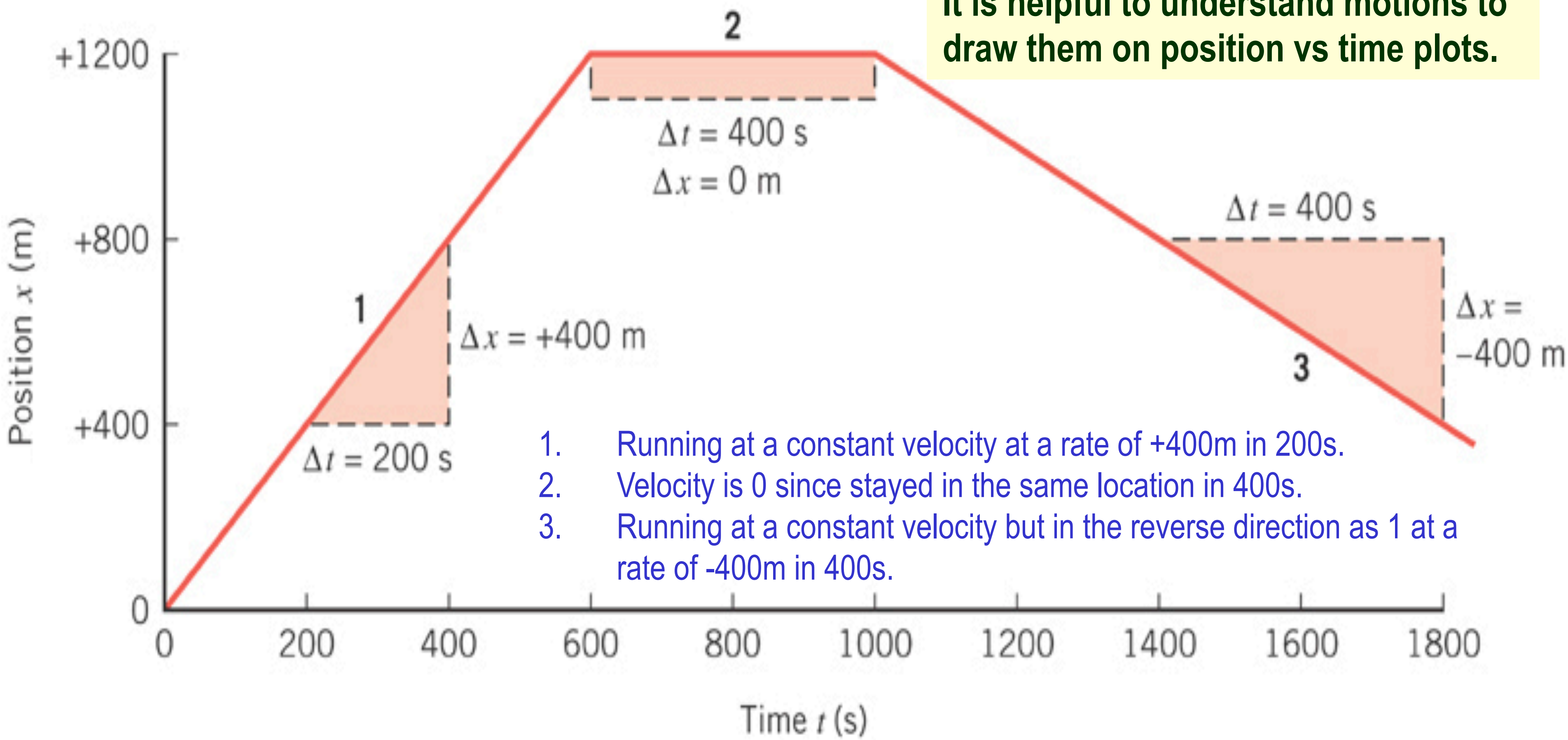
$$|v_x| = \left| \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} \right|$$

*Magnitude of Vectors are Expressed in absolute values

Position vs Time Plot

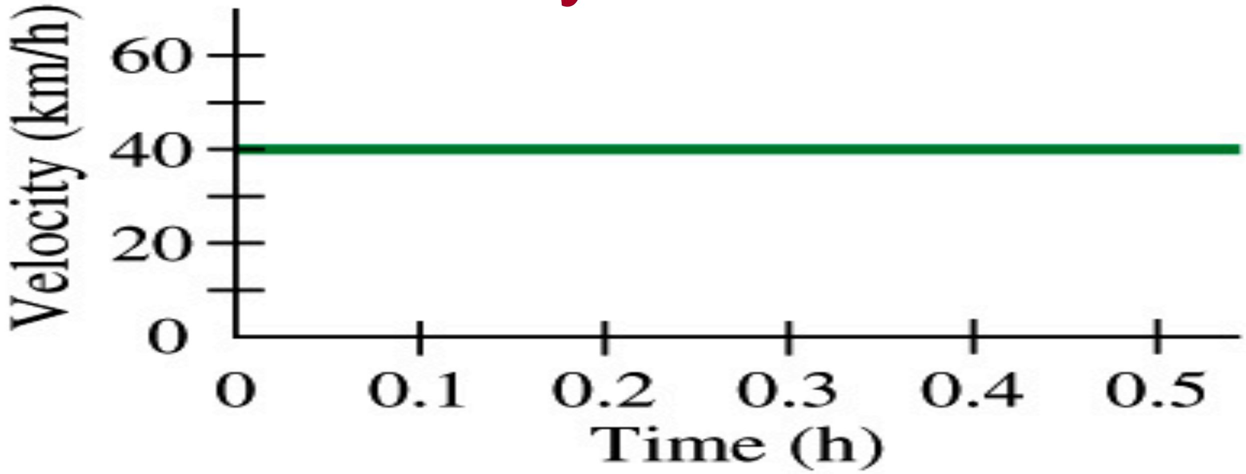


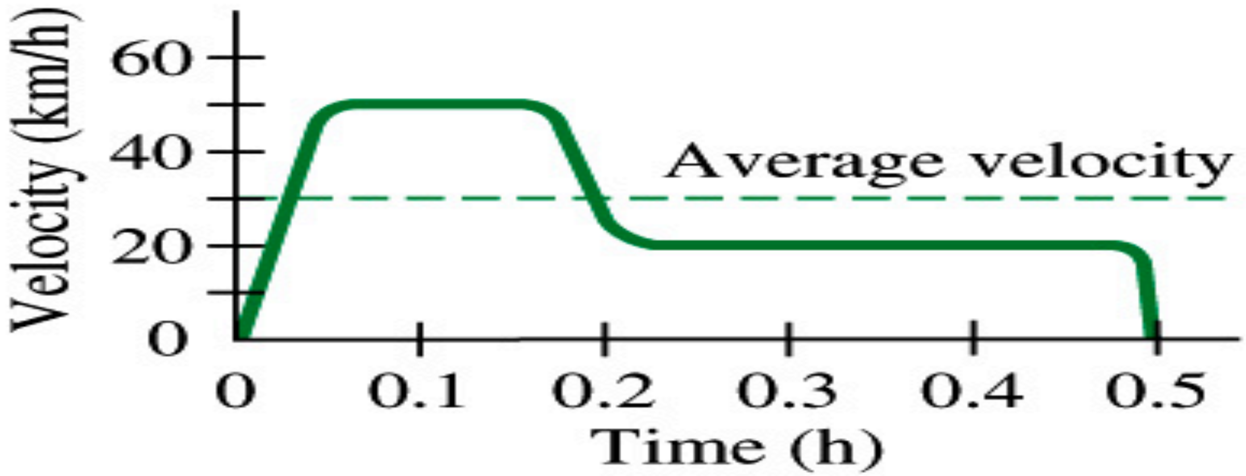
It is helpful to understand motions to draw them on position vs time plots.



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 $\Delta x \equiv x_f - x_i$

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

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

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

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

Acceleration

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

Vector!

- Definition of Average acceleration:

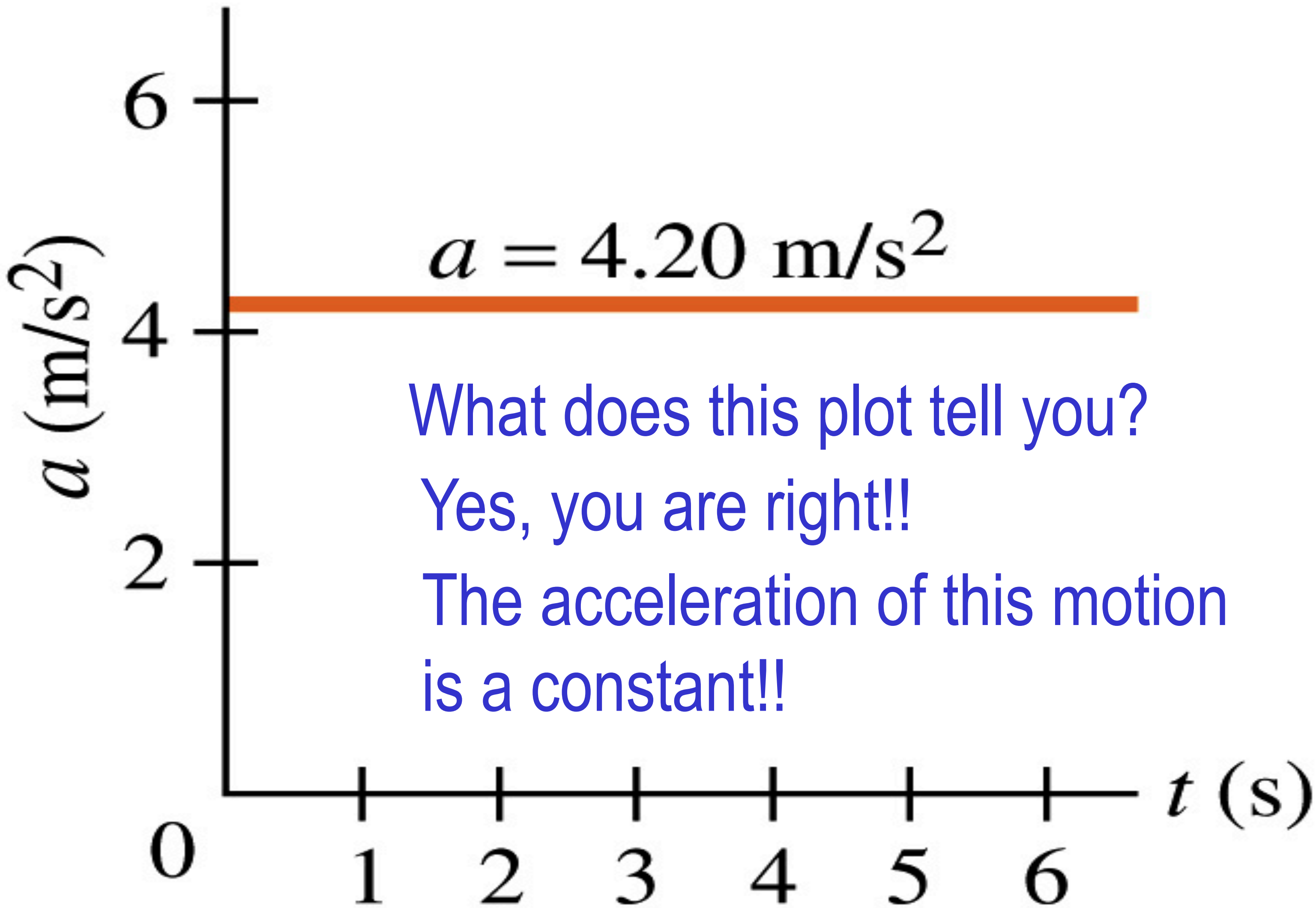
$$a_x \equiv \frac{v_{xf} - v_{xi}}{t_f - t_i} = \frac{\Delta v_x}{\Delta t} \quad \text{analogs to} \quad v_x \equiv \frac{x_f - x_i}{t_f - t_i} = \frac{\Delta x}{\Delta t}$$

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

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

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

Acceleration vs Time Plot



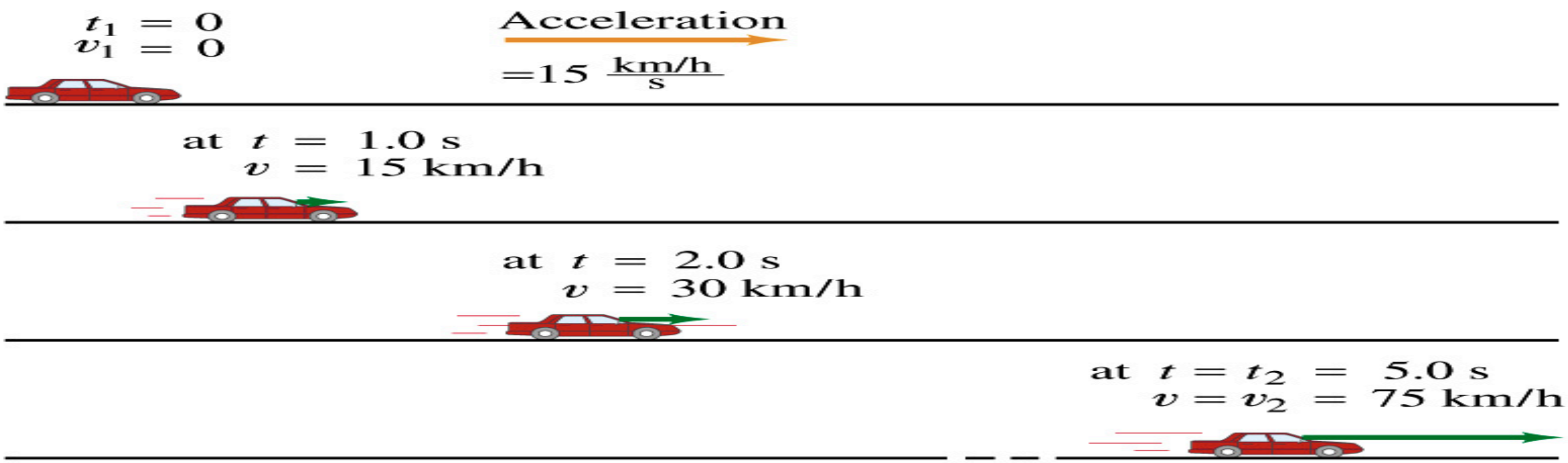
What does this plot tell you?

Yes, you are right!!

The acceleration of this motion is a constant!!

Example 2.4

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



What is the magnitude of its average acceleration?

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

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

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

$$= \frac{4.2\times(3600)^2}{1000} = 5.4\times10^4(km/h^2)$$