PHYS 1441 – Section 001
Lecture #3

Wednesday, June 4, 2014

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

Announcements

- Homework registration
  - 65/66 have registered as of early this morning
    - 62 have submitted answers!!
    - You must complete the process all the way to the submission to obtain the free full credit for homework #1!!
- First term exam
  - In the class coming Monday, June 9
  - Covers CH1.1 through what we learn tomorrow, Thursday, + Appendix A
  - Bring your calculator but DO NOT input formula into it!
  - You can prepare a one 8.5x11.5 sheet (front and back) of **handwritten** formulae and values of constants for the exam → no solutions or derivations!
    - No additional formulae or values of constants will be provided!

Reminder: Special Project #1 for Extra Credit

- Find the solutions for x from 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 Thursday, June 5

Some Fundamentals

- Kinematics: Description of Motion without understanding the cause of the motion
- Dynamics: Description of motion accompanied with understanding the cause of the motion
- Vector and Scalar quantities:
  - Scalar: Physical quantities that require magnitude but no direction
    - Speed, length, mass, height, volume, area, magnitude of a vector quantity, etc
  - Vector: Physical quantities that require both magnitude and direction
    - Velocity, Acceleration, Force, Momentum
    - It does not make sense to say "I ran with velocity of 10miles/hour."
- Objects can be treated as point-like if their sizes are smaller than the scale in the problem
  - Earth can be treated as a point like object (or a particle)in celestial problems
    - Simplification of the problem (The first step in setting up to solve a problem…)
  - Any other examples?

Some More Fundamentals

- Motions: Can be described as long as the position is known at any given time (or position is expressed as a function of time)
  - Translation: Linear motion along a line
  - Rotation: Circular or elliptical motion
  - Vibration: Oscillation
- Dimensions
  - 0 dimension: A point
  - 1 dimension: Linear drag of a point, resulting in a line ➔ Motion in one-dimension is a motion on a line
  - 2 dimension: Linear drag of a line resulting in a surface
  - 3 dimension: Perpendicular Linear drag of a surface, resulting in a stereo object

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? **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**

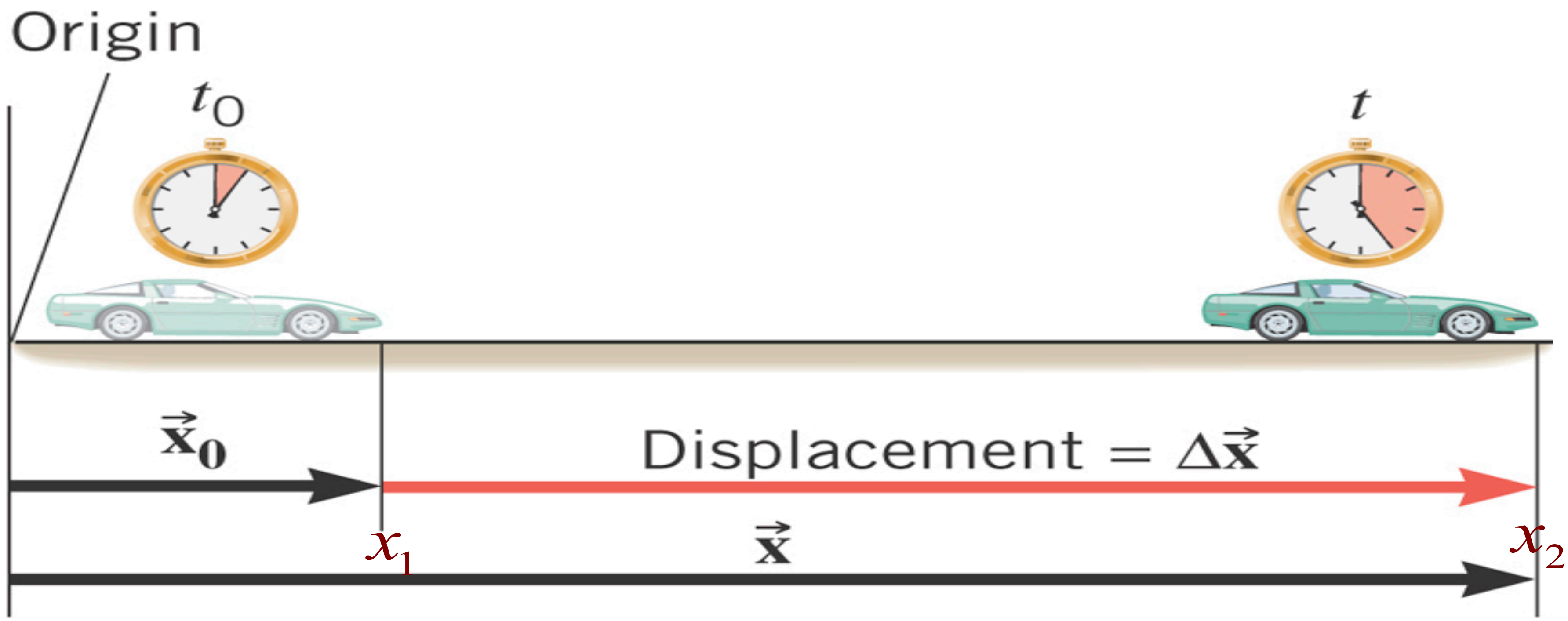
A vector quantity

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? **m/s**

A scalar quantity



What is the displacement? $\Delta x = x_2 - x_1$

How much is the elapsed time? $\Delta t = t - t_0$

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

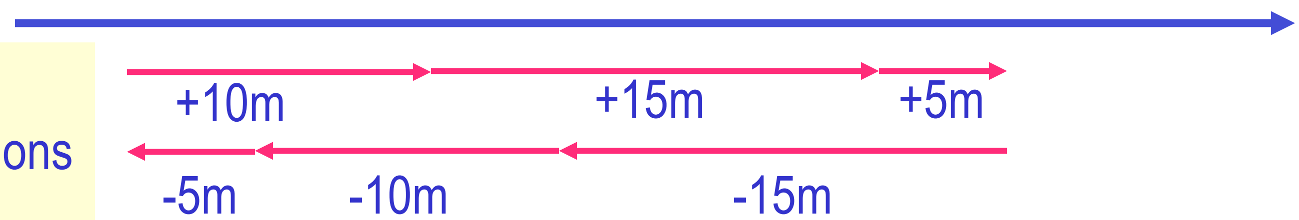
Can someone tell me what the difference between speed and velocity is?

Difference between Speed and Velocity

- Let's take a simple one dimensional translation that has many steps:

Let's call this line as X-axis

Let's have a couple of motions in a total time interval of 20 sec.



Total Displacement: $\Delta x \equiv x_f - x_i = x_i - x_i = 0(m)$

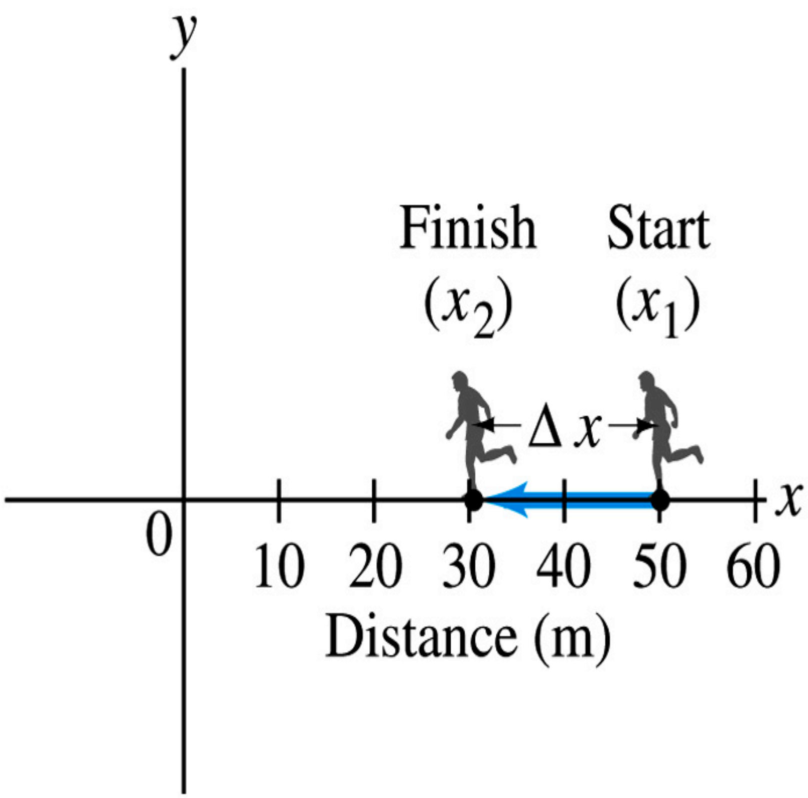
Average Velocity: $v_x \equiv \frac{x_f - x_i}{t_f - t_i} = \frac{\Delta x}{\Delta t} = \frac{0}{20} = 0(m/s)$

Total Distance Traveled: $D = 10 + 15 + 5 + 15 + 10 + 5 = 60(m)$

Average Speed: $v \equiv \frac{\text{Total Distance Traveled}}{\text{Total Time Interval}} = \frac{60}{20} = 3(m/s)$

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 was the runner's average velocity? What was 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?

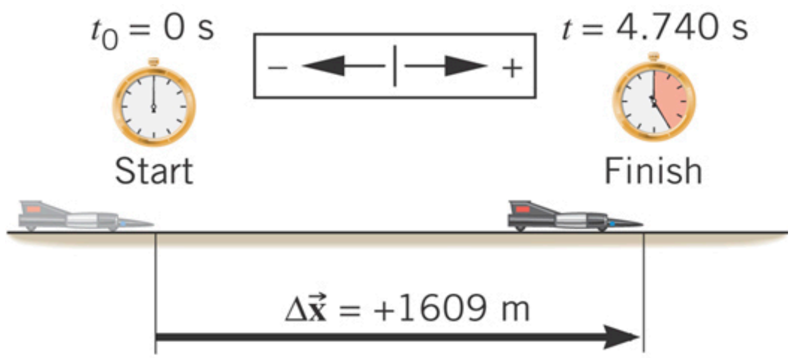
$$\text{Average speed} = \frac{\text{Distance}}{\text{Elapsed time}}$$

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

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

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.

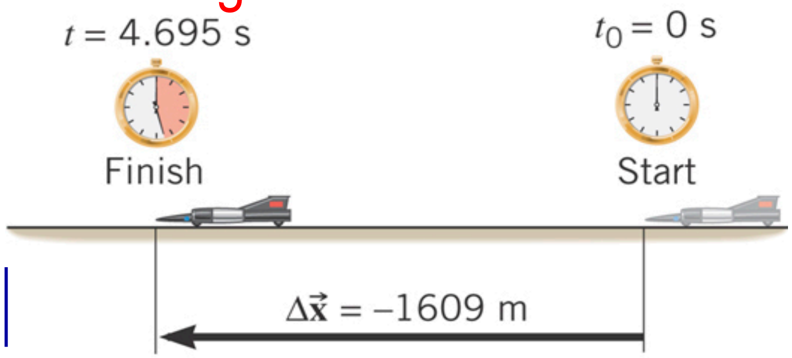


(a)

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

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

Segment of a motion!!



(b)

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

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

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

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 short amount of time

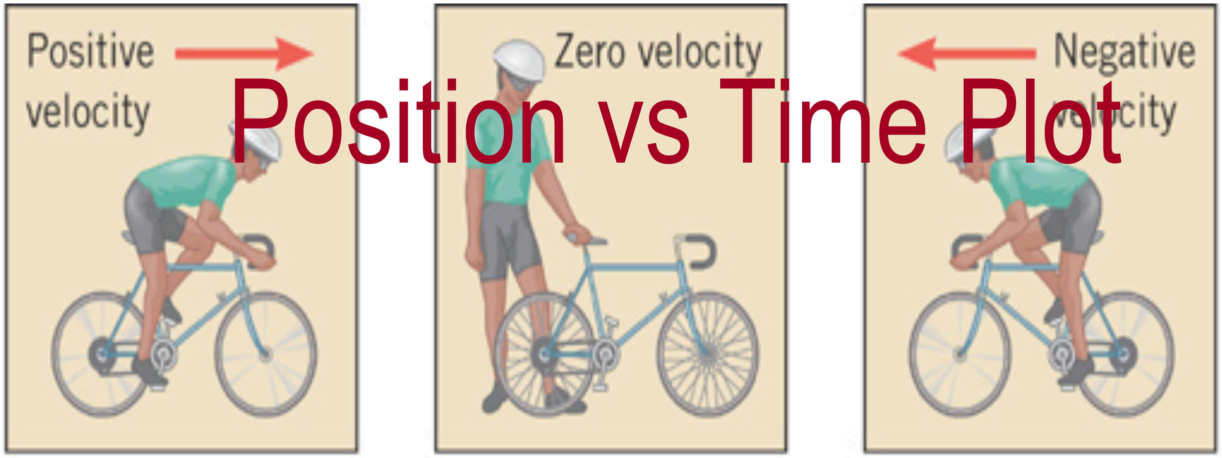
$$v_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

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

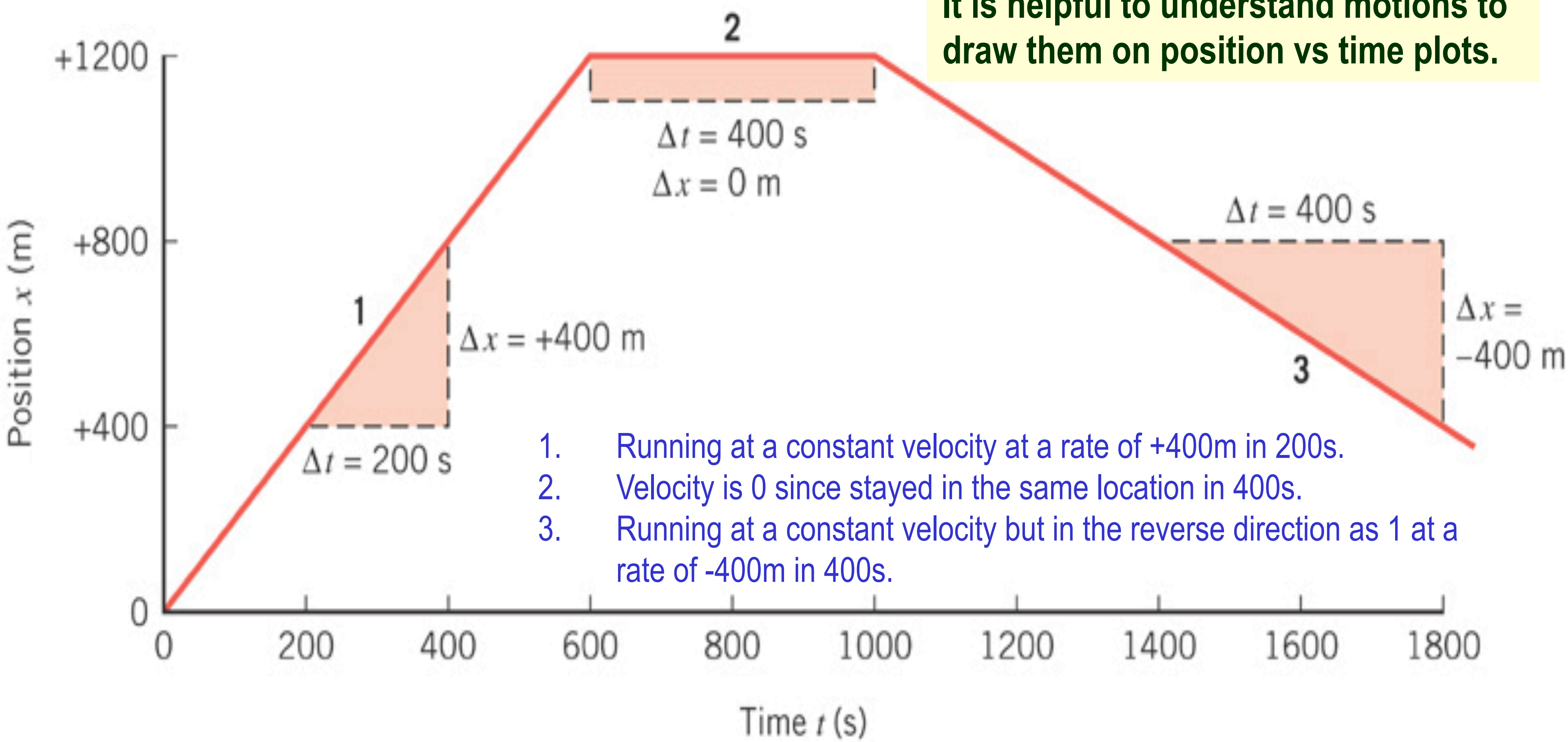
$$|v_x| = \left| \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} \right|$$

*Magnitude of Vectors are Expressed in absolute values

Position vs Time Plot

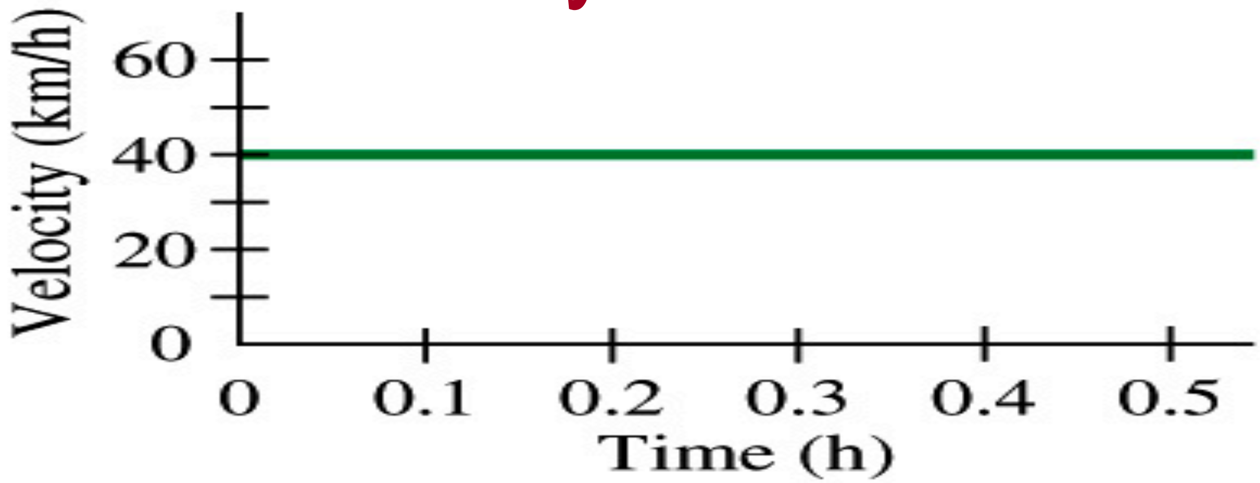


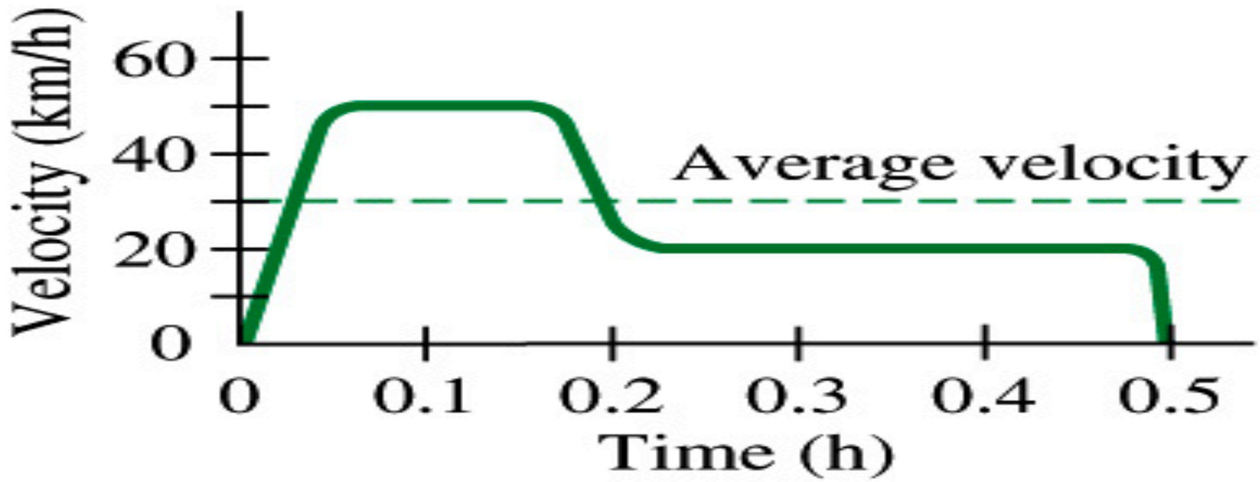
It is helpful to understand motions to draw them on position vs time plots.



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

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