PHYS 1441 – Section 002
Lecture #4

Monday, Jan. 28, 2008
Dr. Jaehoon Yu

- Some Fundamentals
- One Dimensional Motion
- Displacement
- Speed and Velocity
- Acceleration
- Motion under constant acceleration

Homework #2 is due 9pm, next Monday, Feb. 4!!

Announcements

- E-mail distribution list: 30 of you subscribed to the list so far
    - 3 point extra credit if done by midnight Wednesday, Jan. 30
    - I will send out a test message Thursday evening
        - Need your confirmation reply ➔ Just to me not to all class please….
- 40 of you have registered to homework roster, of whom 40 submitted homework #1
    - Excellent!!
- Physics Department colloquium schedule at
    - http://www.uta.edu/physics/main/phys_news/colloquia/2008/Spring2008.html
- Quiz results
    - Average: 4.9/11
        - Equivalent to 40/100
    - Top score: 11/11
- Exam dates
    - 1st Term: Wednesday, Feb. 20
    - 2nd Term: Wednesday, Mar. 26
    - 3rd Term: Monday, Apr. 21
    - Final comprehensive: Monday, May 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 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 straight 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

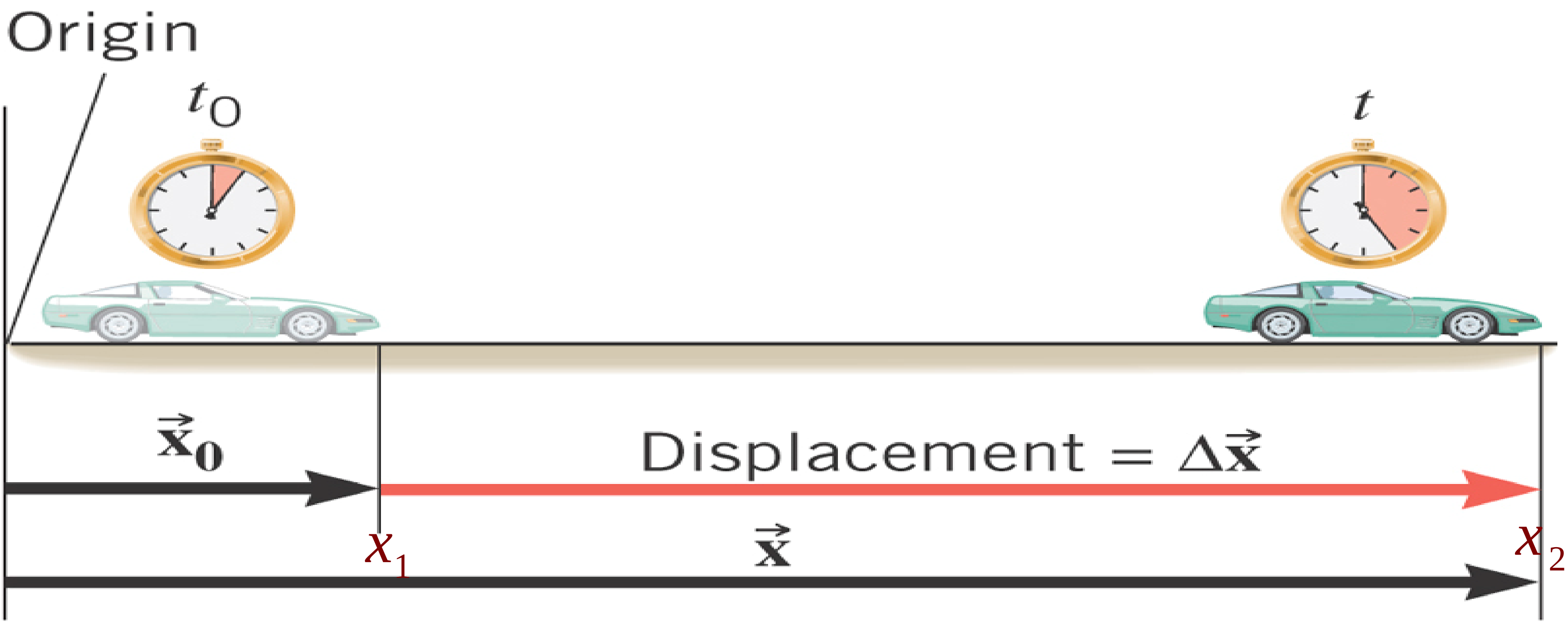
Displacement per unit time in the period throughout the motion

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

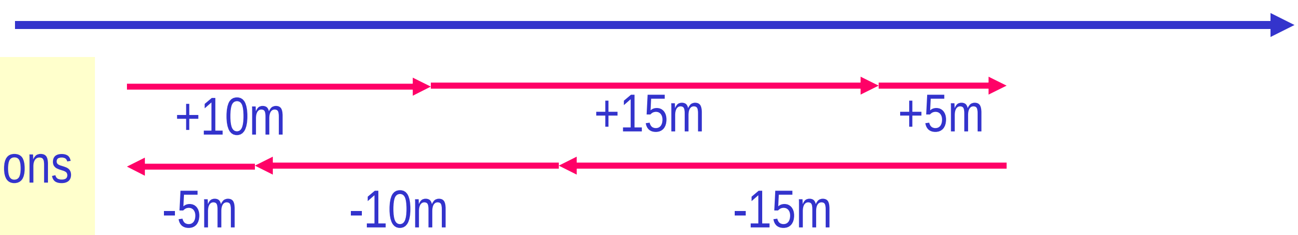
Can someone tell me what the difference between speed and velocity is?

Difference between Speed and Velocity

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

Let's call this line 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: $v_x \equiv \dfrac{x_f - x_i}{t_f - t_i} = \dfrac{\Delta x}{\Delta t} = \dfrac{0}{20} = 0(m/s)$

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

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

Example 1 Distance Run by a Jogger

How far does a jogger run in 1.5 hours (5400 s) if his average speed is 2.22 m/s?

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

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

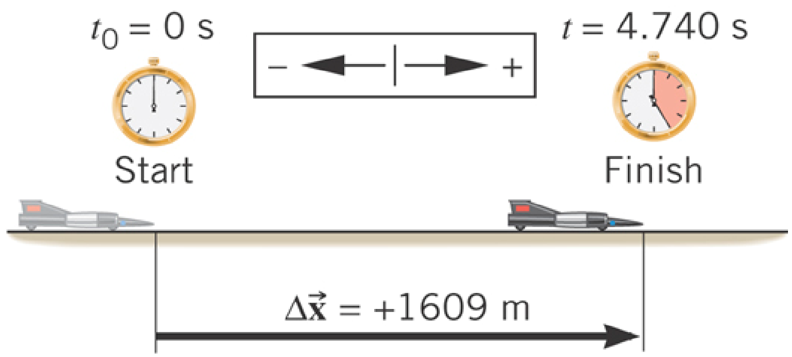
$$= (2.22\ \text{m/s})(5400\ \text{s}) = 12000\ \text{m}$$

Example 2 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 velocity for each run.

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

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

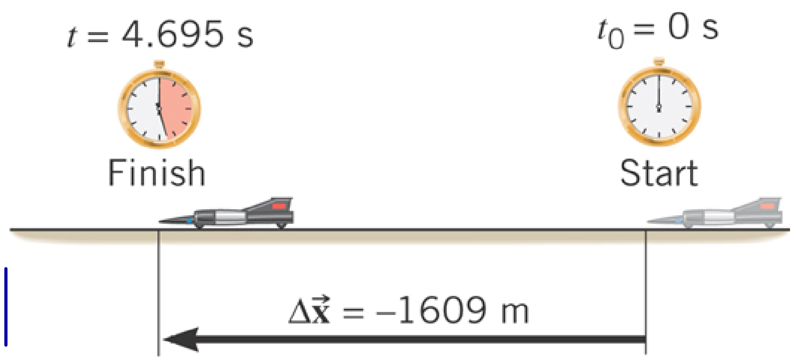


(*a*)

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

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

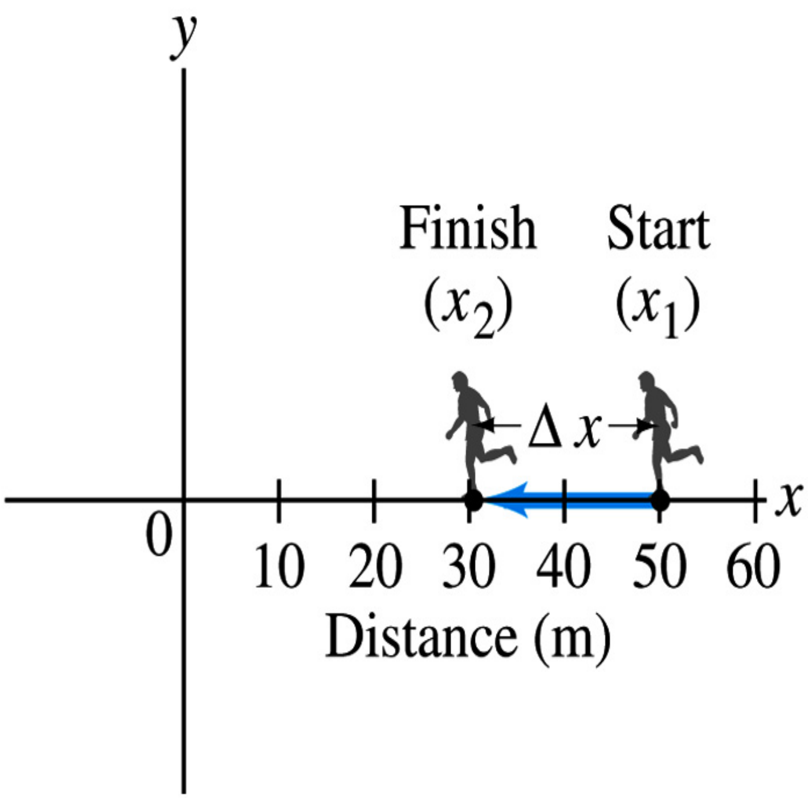
$$= 342.7\,\mathrm{m/s}$$



(*b*)

Example for displacement, velocity and speed

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:

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

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

Instantaneous Velocity and Speed

- Can average quantities tell you the detailed story of the whole motion?
- Instantaneous velocity is defined as:
  – What does this mean?
    - Displacement in an infinitesimal time interval
    - Velocity at any given moment

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

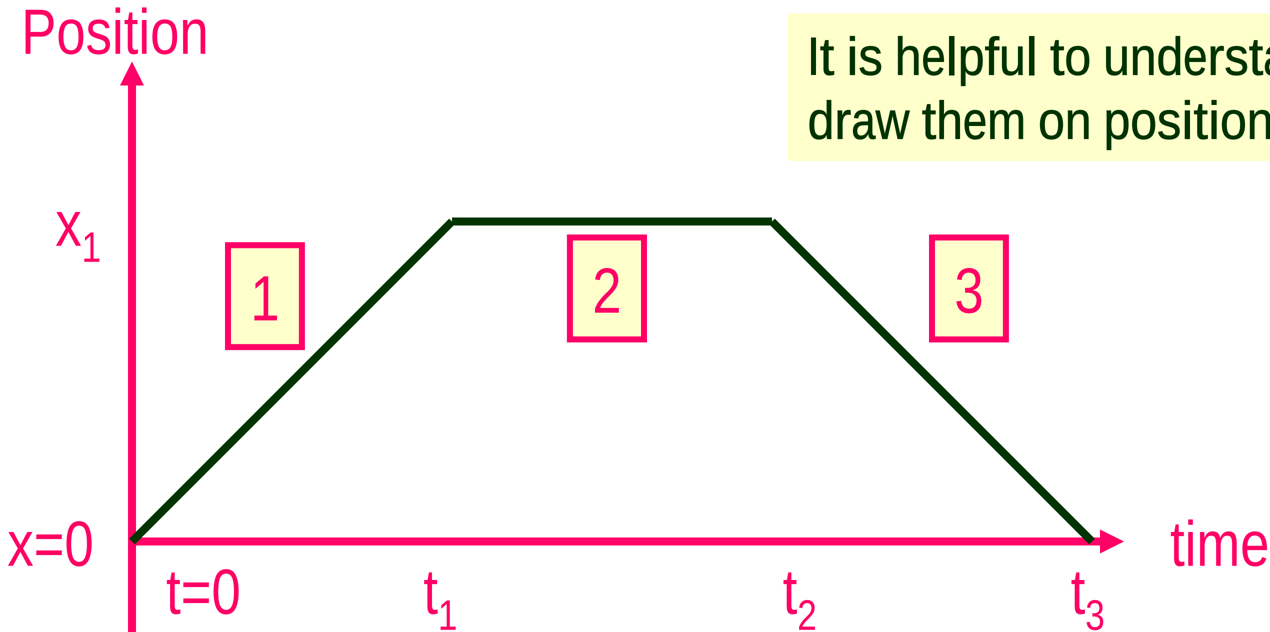
•Instantaneous speed is the size (magnitude) of the velocity vector: Speed at any given moment

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

*Magnitude of Vectors are expressed in absolute values

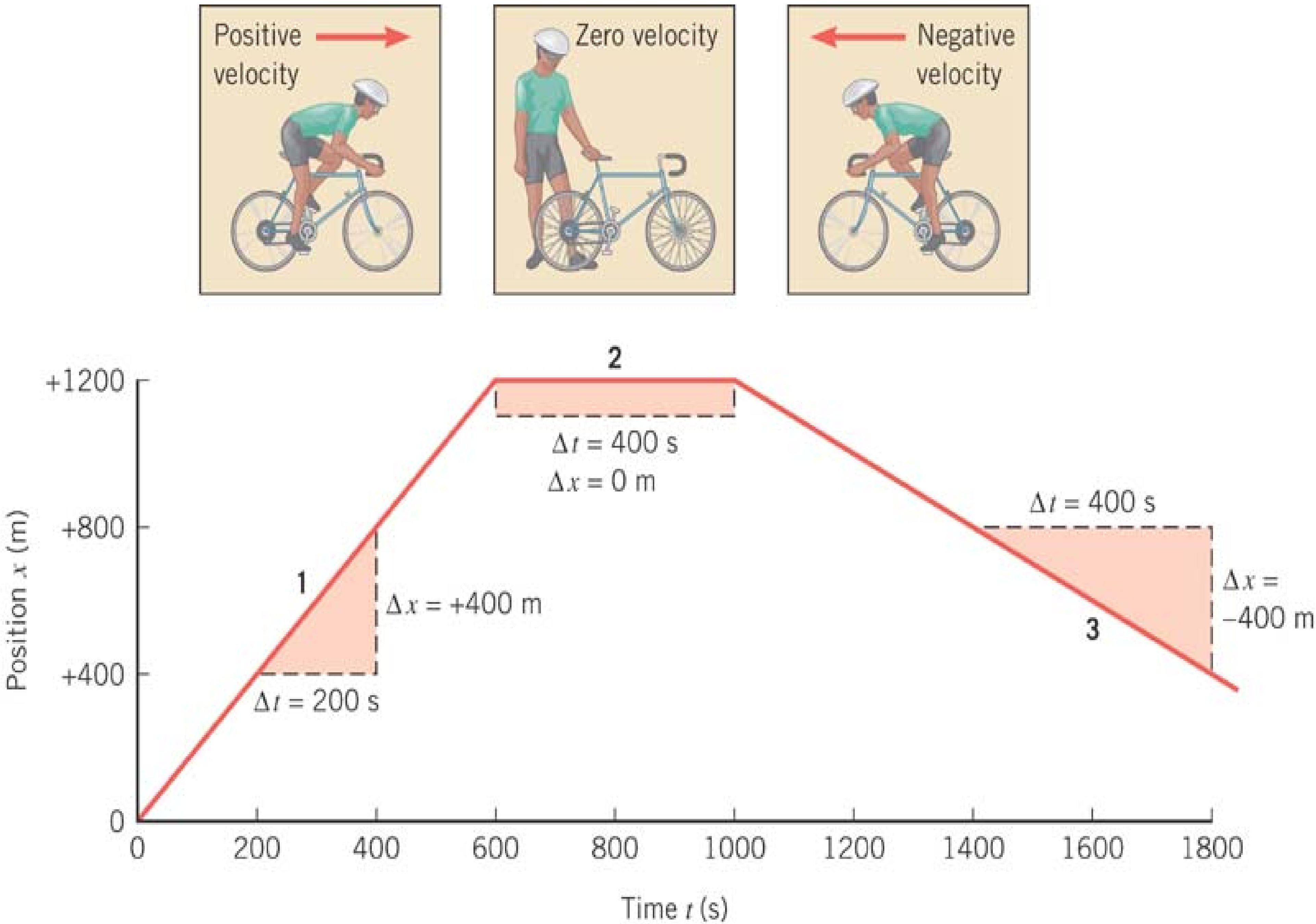
Position vs Time Plot

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



1. Running at a constant velocity (go from $x=0$ to $x=x_1$ in t_1, Displacement is $+ x_1$ in t_1 time interval)
2. Velocity is 0 (go from x_1 to x_1 no matter how much time changes)
3. Running at a constant velocity but in the reverse direction as the step 1 above. (go from x_1 to $x=0$ in t_3-t_2 time interval, Displacement is $- x_1$ in t_3-t_2 time interval)

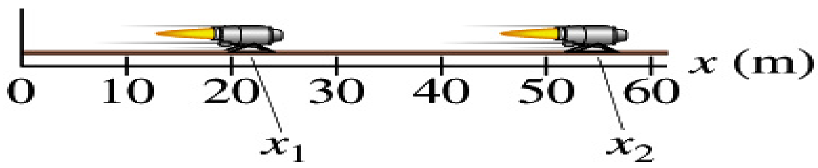
Does this motion physically make sense?

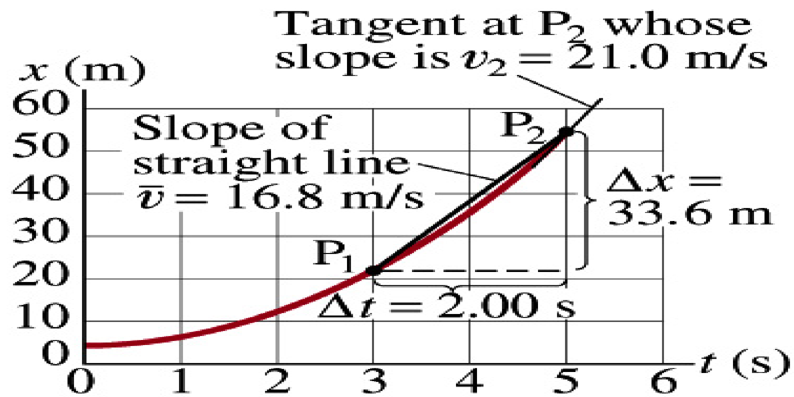


Positive velocity
Zero velocity
Negative velocity
2
+1200
Δt = 400 s
Δx = 0 m
+800
Δt = 400 s
1
Δx = +400 m
Δx = –400 m
3
+400
Δt = 200 s
0
Position x (m)
0
200
400
600
800
1000
1200
1400
1600
1800
Time t (s)

Example

A jet engine moves along a track. Its position as a function of time is given by the equation $x=At^2+B$ where A=2.10m/s^2 and B=2.80m.





(a) Determine the displacement of the engine during the interval from t_1=3.00s to t_2=5.00s.

$$x_1 = x_{t_1=3.00} = 2.10\times(3.00)^2 + 2.80 = 21.7m \qquad x_2 = x_{t_2=5.00} = 2.10\times(5.00)^2 + 2.80 = 55.3m$$

Displacement is, therefore:

$$\Delta x = x_2 - x_1 = 55.3 - 21.7 = +33.6(m)$$

(b) Determine the average velocity during this time interval.

$$\bar{v}_x = \frac{\Delta x}{\Delta t} = \frac{33.6}{5.00-3.00} = \frac{33.6}{2.00} = 16.8(m/s)$$

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

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

Instantaneous speed

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