PHYS 1441 – Section 002
Lecture #4

Wednesday, Sept. 2, 2009
Dr. Jaehoon Yu

- Summary of previous classes
- Acceleration
- Motion under constant acceleration
- One Dimensional Motion
- Kinematic Equations of Motion on a Straight Line
- Free Fall

Announcements

- E-mail distribution list: 54 of you subscribed to the list so far
  - 5 point extra credit if done by tonight and 3 points if done by Friday, Sept. 4
  - Test message will be sent out this weekend!!
    - Please make sure that you ONLY reply to me!! Don't hit reply all.
- Homework
  - 79 of you registered.
    - That still leaves 7 of you to register
      - If in doubt, come and check with me after the class
      - Common mistake in HW registration was registering to "Spring09"
    - Roster closes tonight
    - Free bee homework due is 9pm tomorrow, Thursday, night!
- Remember the quiz next Wednesday!!
  - Beginning of the class
  - Appendices A1 – A8 and CH1
- Reading assignment: CH2.8

Special Problems for Extra Credit

- Derive the quadratic equation for $yx^2-zx+v=0$ ➔ 5 points
- 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
- Due next Wednesday, Sept. 9

How to study for this course?

- Keep up with the class for comprehensive understanding of materials
  - Come to the class and participate in the discussions and problems solving sessions
  - Follow through the lecture notes
  - Work out example problems in the book yourself without looking at the solution
  - Have many tons of fun in the class!!!!!
- Keep up with the homework to put the last nail on the coffin
  - One can always input the answers as you solve problems. Do not wait till you are done with all problems.
  - Form a study group and discuss how to solve problems with your friends, then work the problems out yourselves!
- Prepare for upcoming classes
  - Read the textbook for the material to be covered in the next class
- The extra mile
  - Work out additional problems in the back of the book starting easiest problems to harder ones

How do we convert quantities from one unit to another?

Unit 1 = Conversion factor X Unit 2

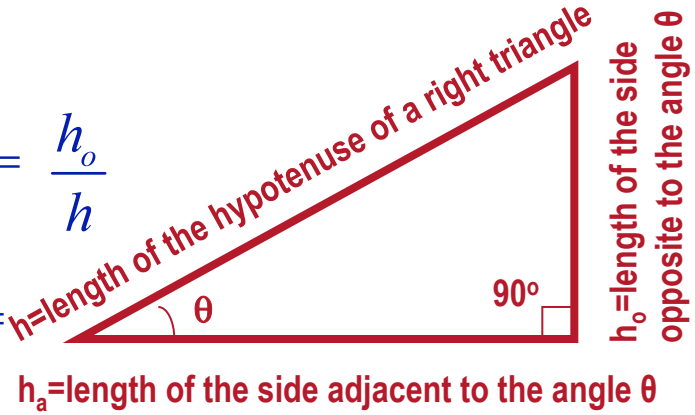
1 inch	2.54	cm
1 inch	0.0254	m
1 inch	2.54×10^{-5}	km
1 ft	30.3	cm
1 ft	0.303	m
1 ft	3.03×10^{-4}	km
1 hr	60	minutes
1 hr	3600	seconds
And many	More	Here….

Trigonometry Reminders

- Definitions of sinθ, cosθ and tanθ

$$\sin\theta = \frac{\text{Length of the opposite side to } \theta}{\text{Length of the hypotenuse of the right triangle}} = \frac{h_o}{h}$$

$$\cos\theta = \frac{\text{Length of the adjacent side to } \theta}{\text{Length of the hypotenuse of the right triangle}} = \frac{h_a}{h}$$



$$\tan\theta = \frac{\text{Length of the opposite side to } \theta}{\text{Length of the adjacent side to } \theta} = \frac{h_o}{h_a}$$

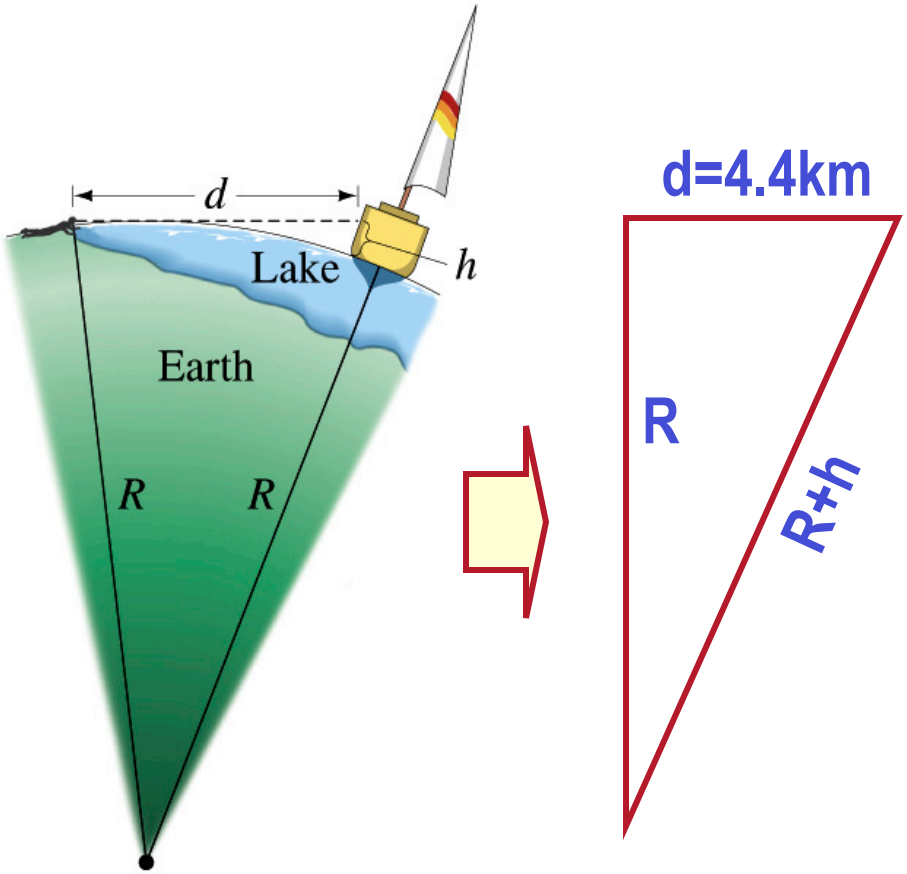
$$\tan\theta = \frac{\sin\theta}{\cos\theta} = \frac{\frac{h_o}{h}}{\frac{h_a}{h}} = \frac{h_o}{h_a}$$

Pythagorian theorem: For right triangles

$$h^2 = h_o^2 + h_a^2 \Rightarrow h = \sqrt{h_o^2 + h_a^2}$$

Example for estimates using trig..

Estimate the radius of the Earth using triangulation as shown in the picture when d=4.4km and h=1.5m.



Pythagorian theorem

$$(R+h)^2 \approx d^2 + R^2$$

$$R^2 + 2hR + h^2 \approx d^2 + R^2$$

Solving for R

$$R \approx \frac{d^2 - h^2}{2h}$$

$$= \frac{(4400m)^2 - (1.5m)^2}{2 \times 1.5m}$$

$$= 6500km$$

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?

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 positions 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

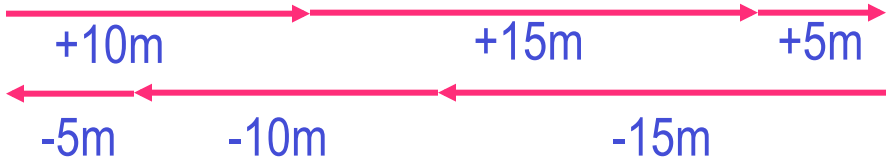
Can someone tell me what the difference between speed and velocity is?

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

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

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

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
    - Average velocity over a very short amount of time

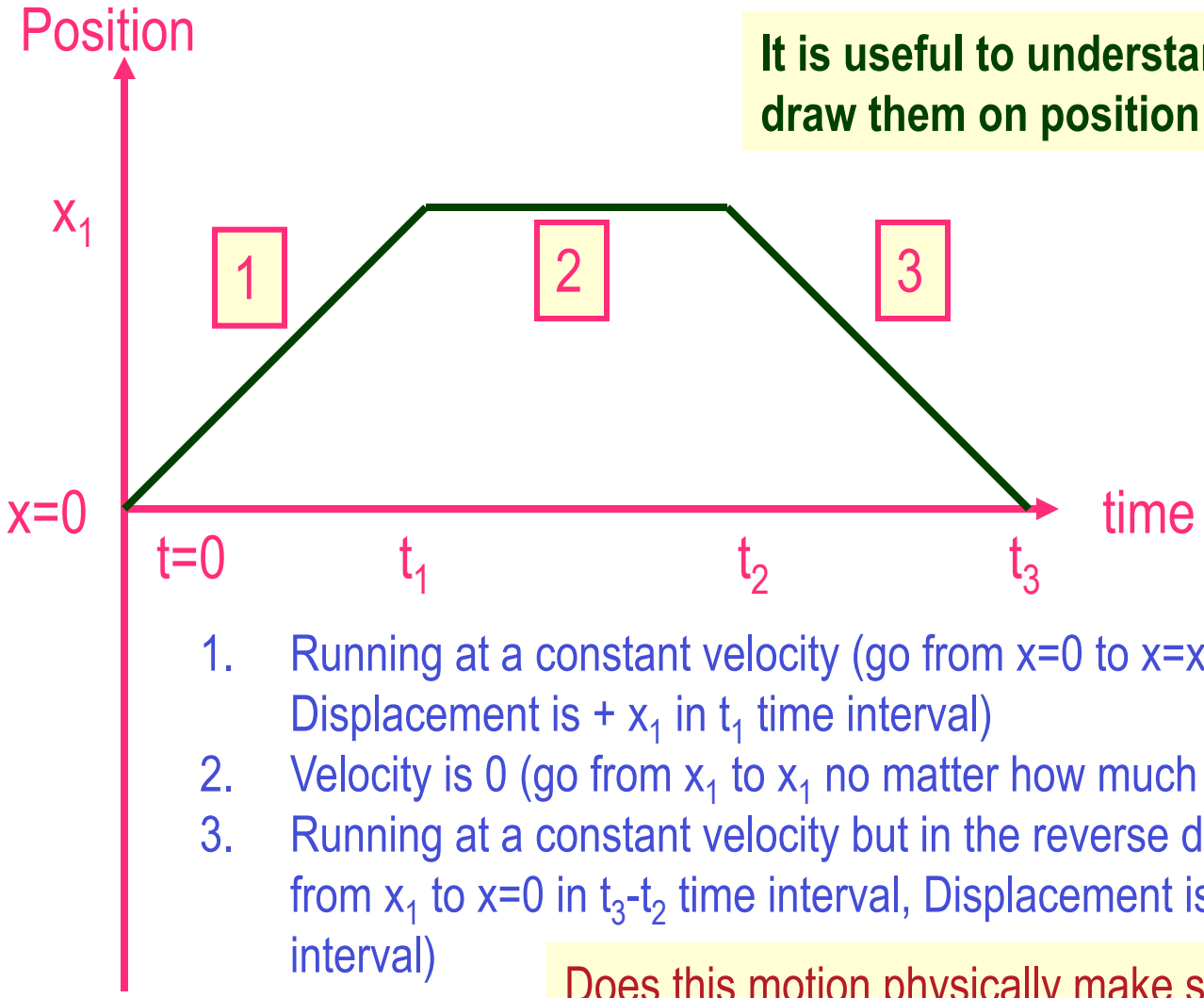
$$v_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

- 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

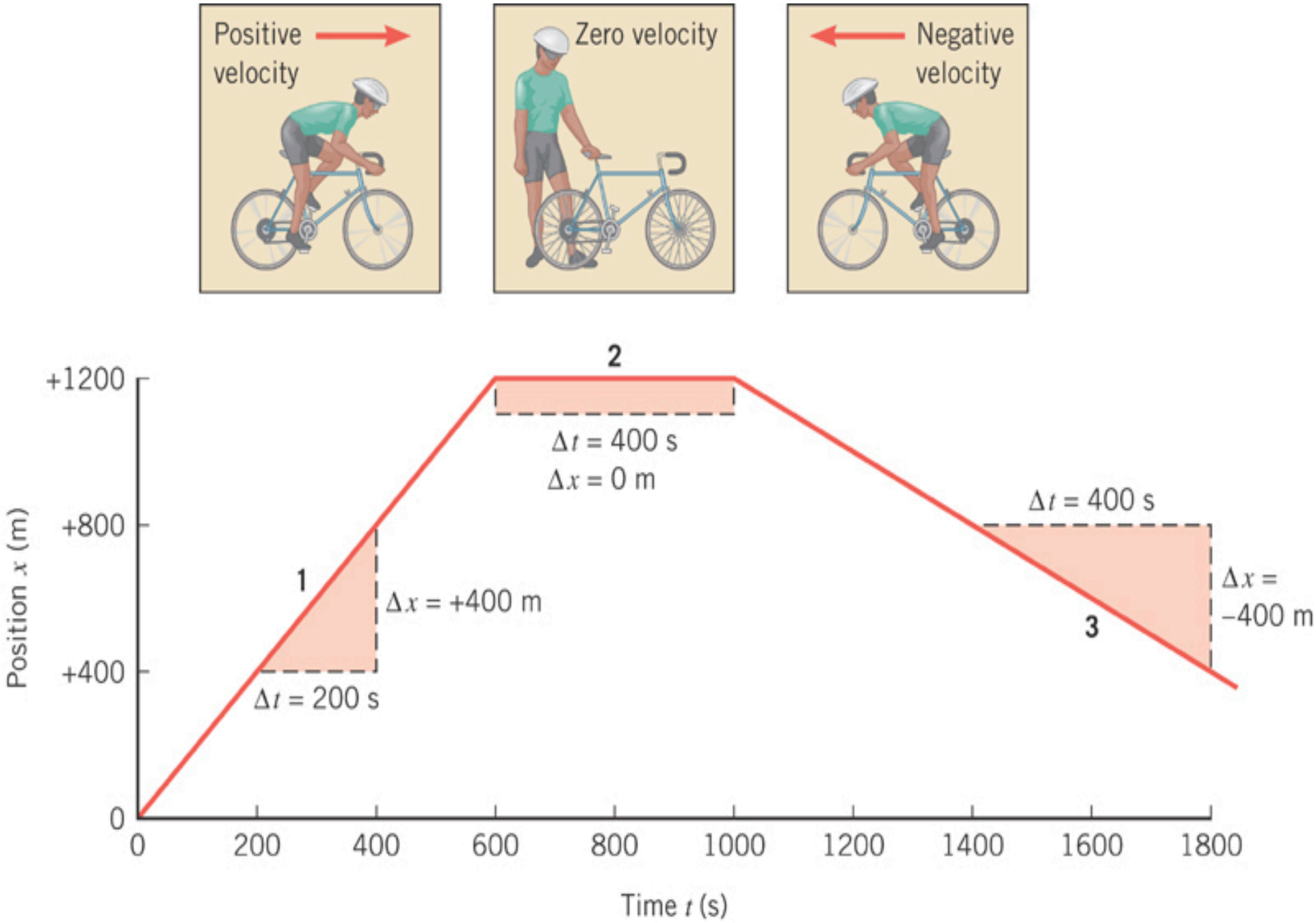
Position vs Time Plot



It is useful 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 1. (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
+1200
+800
+400
0
Position x (m)
2
Δt = 400 s
Δx = 0 m
1
Δx = +400 m
Δt = 200 s
Δt = 400 s
Δx = −400 m
3
0
200
400
600
800
1000
1200
1400
1600
1800
Time t (s)

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

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

Instantaneous speed

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