PHYS 1443 – Section 002
Lecture #3

Wednesday, Sept. 5, 2007
Dr. Jaehoon Yu

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

Today's homework is homework #2, due 7pm, Monday, Sept. 10!!

Announcements

- E-mail distribution list: 52 of you subscribed to the list so far
  - 3 point extra credit if done by Wednesday, Sept. 5
  - I will send out a test message Wednesday
    - Need your confirmation reply ➔ Just to me not to all class please….
- 71 of you have registered to homework roster, of whom 64 submitted homework #1
  - Good job!
- Physics Department colloquium schedule at
  - http://www.uta.edu/physics/main/phys_news/colloquia/2007/Fall2007.html
  - Today's topic is Pulsating White Dwarfs and The Search for Exotic particles
- The first term exam is to be on Wednesday, Sept. 26
  - Used to be on Sept. 24

Physics Department
The University of Texas at Arlington

COLLOQUIUM

Probing Exotic Physics with Pulsating White Dwarfs

Dr. Agnes Kim
University of Texas at Austin

4:00 pm Wednesday September 5, 2007
Room 101 SH

Abstract

We now have a good measurement of the cooling rate of the cool pulsating white dwarf G117-B15A. In the near future, we will have equally well determined cooling rates for other pulsating white dwarfs, including R548. The ability to measure their cooling rates offers us a unique way to study weakly interacting particles that would contribute to their cooling, such as axions. I begin by presenting results of the asteroseismological analysis of observationally similar G117-B15A and R548, using a fine grid search method. This is the first systematic, 4 parameter asteroseismolgy of those two stars. Based on these results, I compute rates of period change (dP/dt) for the 215s mode in G117-B15A and the 213s mode in R548, first for models without axions, and then for models with axions of increasing mass. Given the region of parameter space occupied by the models, I estimate error bars on the calculated dP/dt using Monte Carlo simulations. Together with the observed dP/dt for G117-B15A, this analysis yields strong limits on the DFSZ axion mass. This method can potentially be applied to other weakly interacting particles that would be emitted in the interiors of white dwarf stars. I present preliminary results on a similar analysis of a hotter pulsating white dwarf, EC20058, to constrain plasmon neutrino emission rates.

Refreshment at 3:30pm in SH108

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:

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

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

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

Displacement per unit time in the period throughout the motion

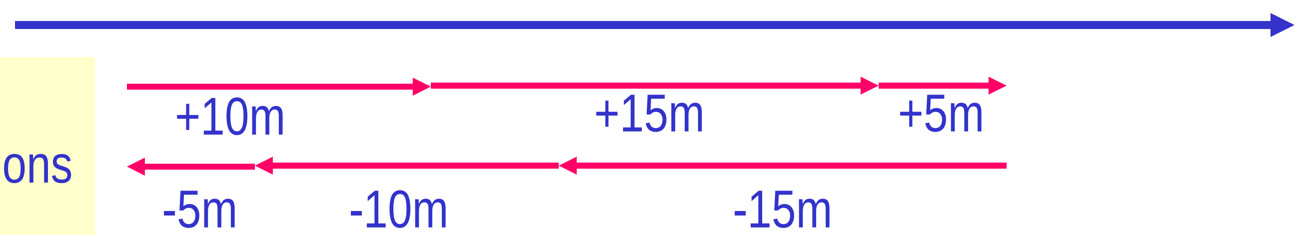
The average speed is defined as: $$v \equiv \frac{\text{Total Distance Traveled}}{\text{Total Time Spent}}$$

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

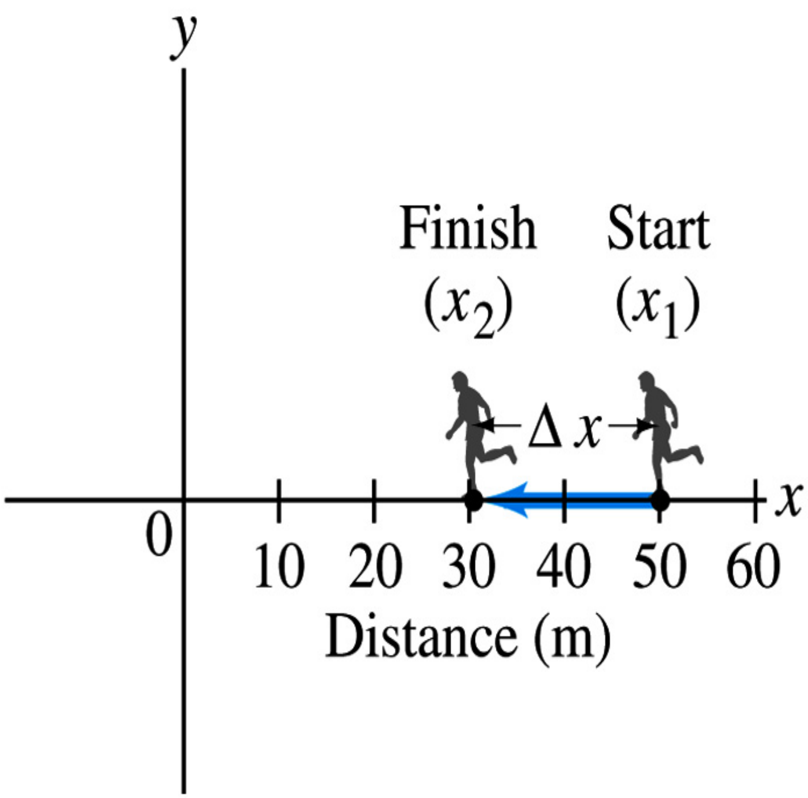
Average Velocity: $v_x \equiv \frac{x_f - x_i}{t_f - t_i} = \frac{\Delta x}{\Delta t} = \frac{0}{20} = 0(m/s)$

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

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

Example 2.1

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:

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

  - What does this mean?
    - Displacement in an infinitesimal time interval
    - Mathematically: Slope of the position variation as a function of time

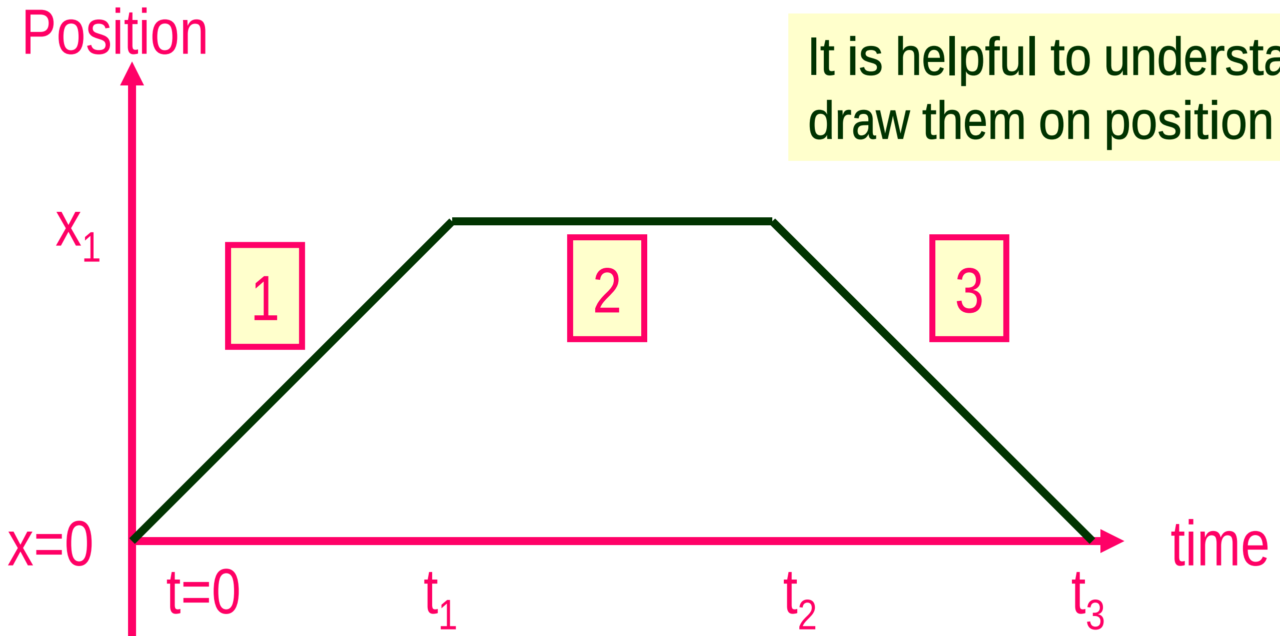
•Instantaneous speed is the size (magnitude) of the velocity vector:

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

*Magnitude of Vectors are expressed in absolute values

Position vs Time Plot

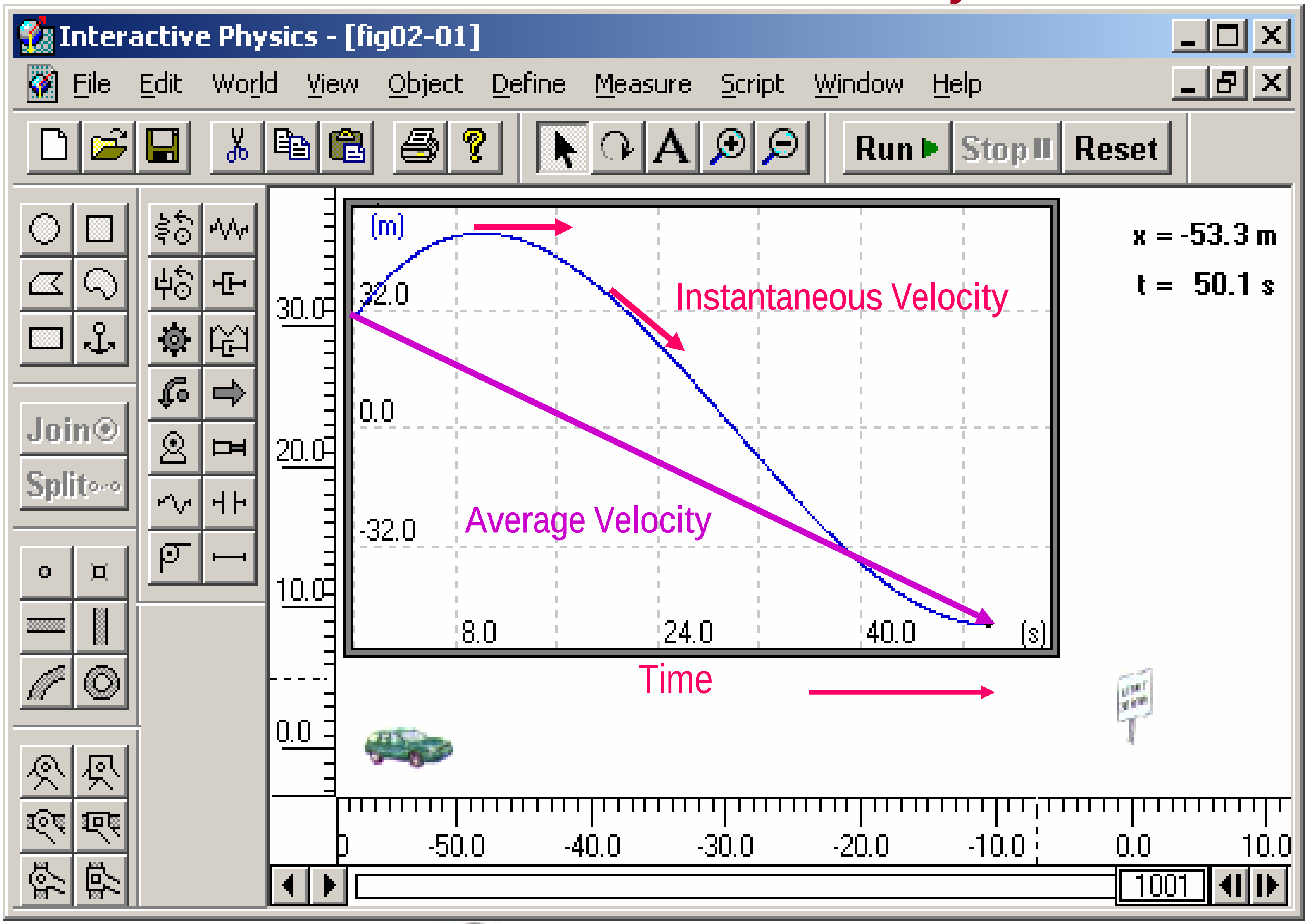
It is helpful to understand motions to draw them on position vs time plots.



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 ti

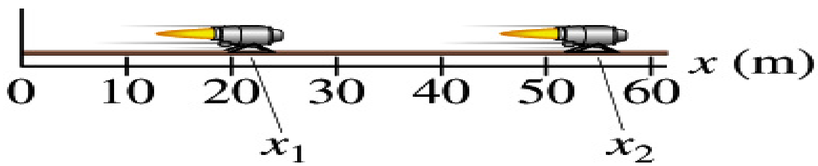
Does this motion physically make sense?

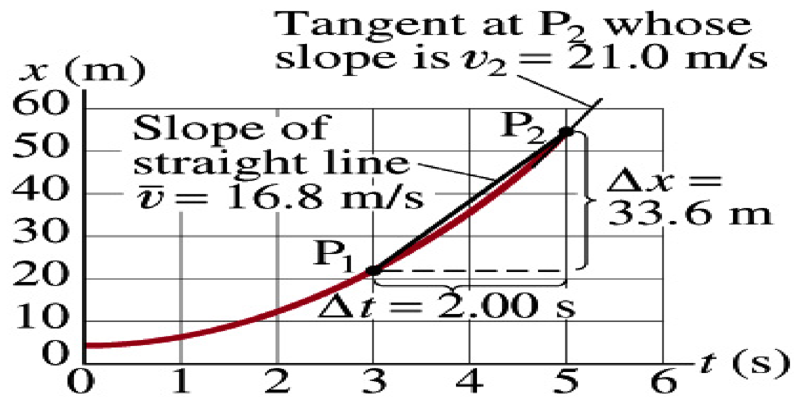
Instantaneous Velocity



Example 2.3

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.

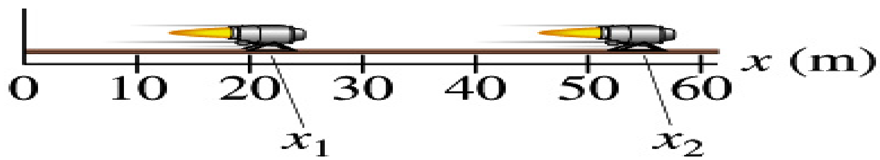
$$x_1 = x_{t_1=3.00} = 2.10\times(3.00)^2 + 2.80 = 21.7m \qquad x_2 = x_{t_2=5.00} = 2.10\times(5.00)^2 + 2.80 = 55.3m$$

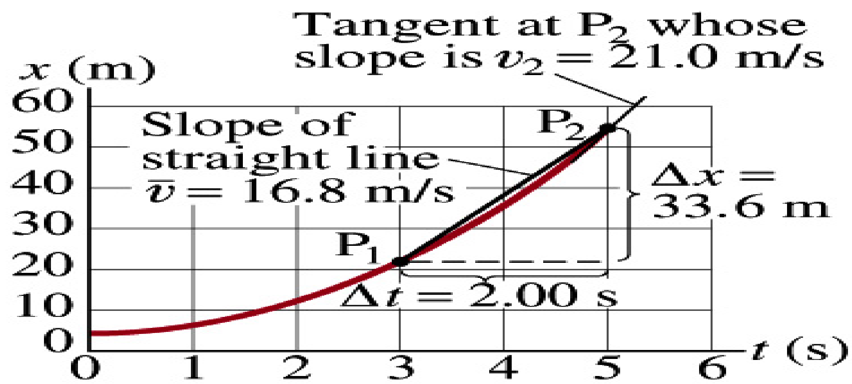
Displacement is, therefore: $\Delta x = x_2 - x_1 = 55.3 - 21.7 = +33.6(m)$

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

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

Example 2.3 cont'd





(c) Determine the instantaneous velocity at t=5.00s.

Calculus formula for derivative $\frac{d}{dt}\left(Ct^n\right) = nCt^{n-1}$ and $\frac{d}{dt}\left(C\right) = 0$

The derivative of the engine's equation of motion is

$$v_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt} = \frac{d}{dt}\left(At^2 + B\right) = 2At$$

The instantaneous velocity at t=5.00s is

$$v_x\left(t = 5.00s\right) = 2A \times 5.00 = 2.10 \times 10.0 = 21.0\left(m/s\right)$$

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

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