PHYS 1441 – Section 002
Lecture #3

Wednesday, Feb. 4, 2009

Dr. Jaehoon Yu

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

Announcements

- E-mail distribution list: 30 of you subscribed to the list so far
  - 3 point extra credit if done by midnight today, Feb. 4
  - I will send out a test message Thursday evening
    - Need your confirmation reply ➔ Just to me not to all class please….
- 79 of you have registered to homework roster
  - Excellent!!
  - Yet, 12 students still have not submitted HW#1.
  - One final chance for full credit of HW#1 ➔ submit by 11pm tonight.
  - Don't miss the last chance for free credit!!!
- First term exam
  - 1 – 2:20pm, Wednesday, Feb. 18
  - Covers: CH1.1 – what we complete on Monday, Feb. 16 + appendix A1 – A8
  - Style: Mixture of multiple choices and free responses
- Physics Department colloquium schedule at
  - http://www.uta.edu/physics/main/phys_news/colloquia/2009/Spring2009.html
  - There is a colloquium today

Physics Department
The University of Texas at Arlington

COLLOQUIUM

Isolated Early-Type Galaxies in the Sloan Digital Sky Survey

Dr. Pamela M. Marcum
TCU Department of Physics & Astronomy

4:00 pm Wednesday, February 4, 2009
Room 101 SH

Abstract

A favored paradigm for the formation of elliptical galaxies, which generally reside in overdense environments such as those of galaxy groups or clusters, involves the initial merging of multiple disk galaxies. As part of an ongoing broad-scoped study aimed at probing extreme galactic environments, we have identified a rare set of significantly isolated elliptical galaxies in the Sloan Digital Sky Survey (SDSS). In contrast to group and cluster members, which experience continual harassment throughout their lives, the solitary nature of these SDSS galaxies makes them excellent objects for the study of secular galaxy evolution over cosmic time. Their isolation also simplifies the range of possible formation scenarios: such a galaxy is either the "fossil remnant" of a merged former galaxy group, or is a bulge-dominated system originating from initial formation processes, the latter of which would challenge contemporary theories of elliptical galaxy formation. Our optical broadband imaging and spectroscopy analysis show a surprisingly large number of galaxies in our study to have young stellar populations and luminosities inconsistent with a merged-group origin.

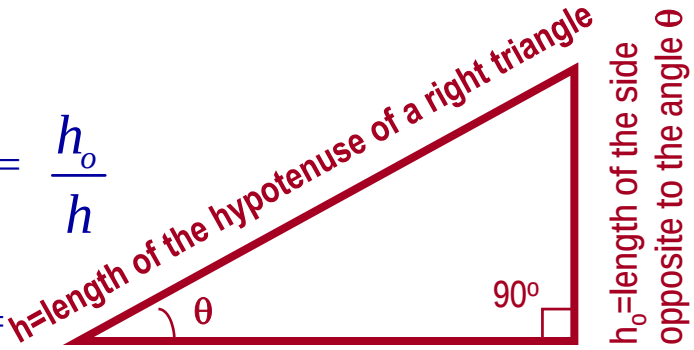
Refreshments will be served in the Physics Library at 3:30 pm

Trigonometry Reminders

- Definitions of sinθ, cosθ and tanθ

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

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



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

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

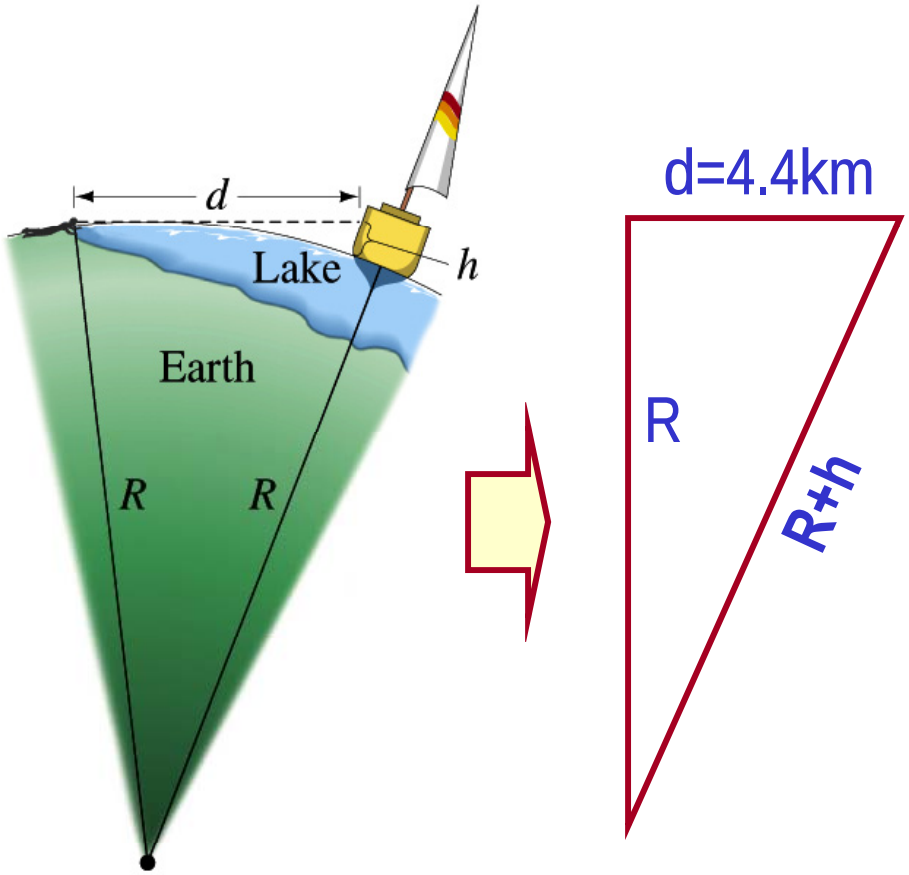
Pythagorian theorem: For right triangles

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

Do Ex. 3 and 4 yourselves…

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

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

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

$$= 6500km$$

Dimension and Dimensional Analysis

- An extremely useful concept in solving physical problems
- Good to write physical laws in mathematical expressions
- No matter what units are used the base quantities are the same
  - *Length* (distance) is length whether meter or inch is used to express the size: Usually denoted as *[L]*
  - The same is true for *Mass ([M])* and *Time ([T])*
  - One can say "Dimension of Length, Mass or Time"
  - Dimensions are used as algebraic quantities: Can perform two algebraic operations; multiplication or division

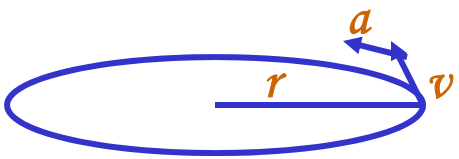
Dimension and Dimensional Analysis

- One can use dimensions only to check the validity of one's expression: Dimensional analysis
  - Eg: Speed $[v] = [L]/[T]=[L][T^{-1}]$
    - *Distance (L) traveled by a car running at the speed V in time T*
    - $L = V*T = [L/T]*[T]=[L]$
- More general expression of dimensional analysis is using exponents: eg. $[v]=[L^n T^m] =[L]\{T^{-1}]$ *where n = 1 and m = -1*

Examples

- Show that the expression $[v] = [at]$ is dimensionally correct
  - Speed: $[v]$ =L/T
  - Acceleration: $[a]$ =L/T^2
  - Thus, $[at]$ = (L/T^2)xT=LT$^{(-2+1)}$ =LT^{-1} =L/T= $[v]$

•Suppose the acceleration a of a circularly moving particle with speed v and radius r is proportional to r^n and v^m. What are n and m?



$$a = kr^n v^m$$

Dimensionless constant | Length | Speed

$$L^1T^{-2} = (L)^n \left(\frac{L}{T}\right)^m = L^{n+m}T^{-m}$$

$$-m = -2 \Rightarrow m = 2$$

$$n + m = n + 2 \equiv 1 \Rightarrow n = -1$$

$$a = kr^{-1}v^2 = \frac{v^2}{r}$$

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: $v_x \equiv \frac{x_f - x_i}{t_f - t_i} = \frac{\Delta x}{\Delta t} \equiv \frac{\text{Displacement}}{\text{Elapsed Time}}$

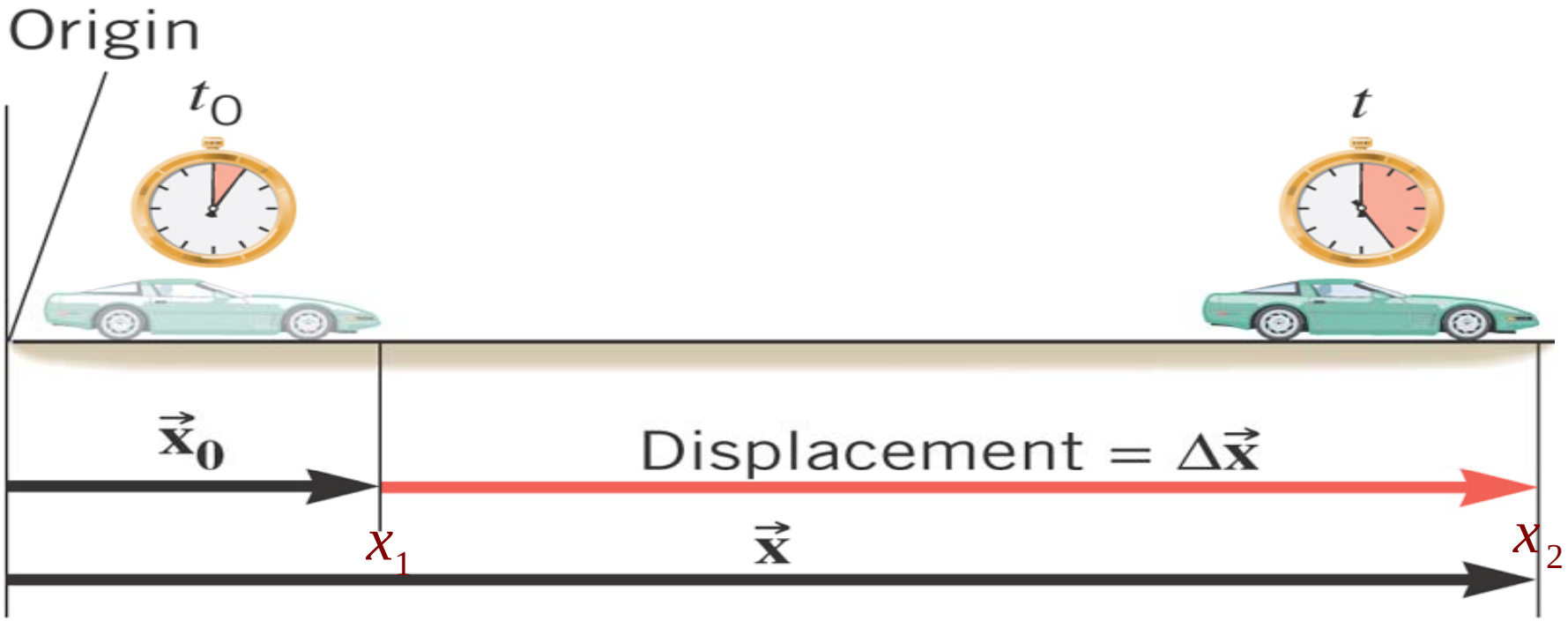
Unit? m/s A vector quantity

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? $\Delta x = x_2 - x_1$

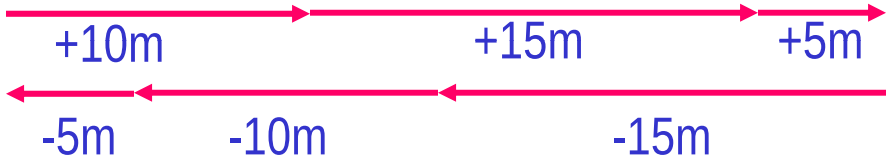
How much is the elapsed time? $\Delta t = t - t_0$

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

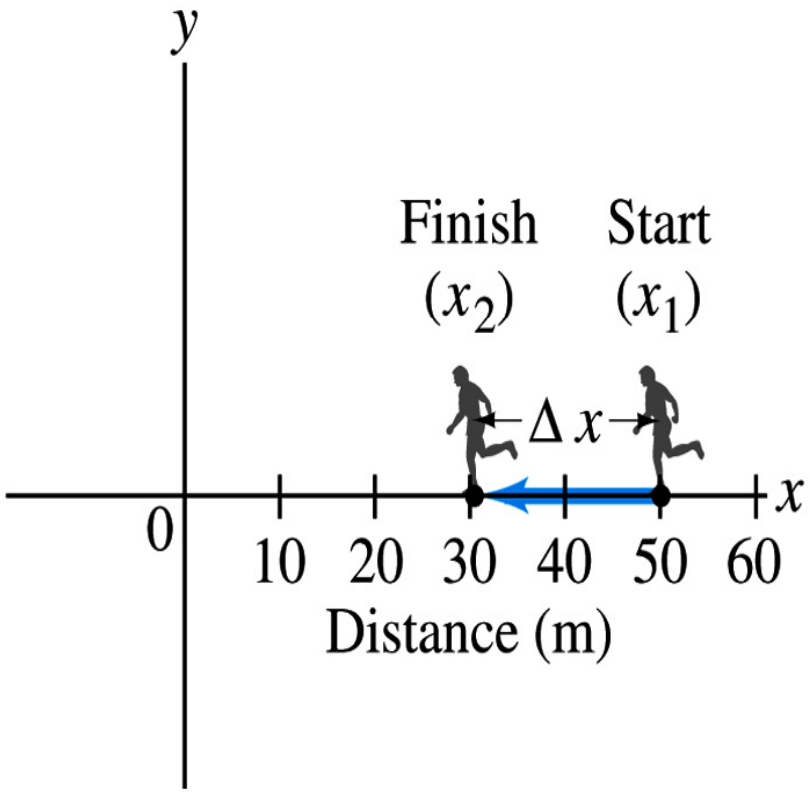
Average Velocity: $v_x \equiv \frac{x_f - x_i}{t_f - t_i} = \frac{\Delta x}{\Delta t} = \frac{0}{20} = 0(m/s)$

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

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

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:

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

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

Example 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?

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

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

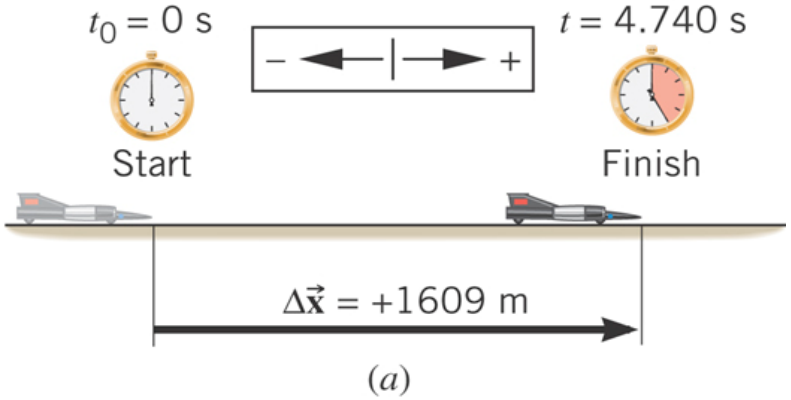
$$= (2.22 \text{ m/s})(5400 \text{ s}) = 12000 \text{ m}$$

Example 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.

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

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



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

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

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