Physics 207, Lecture 3, Sept. 13

Agenda

- Chapter 2, Chapter 3.1, 3.2
  - ❖ Velocity, Speed (Instantaneous and Average)
  - ❖ Acceleration (Instantaneous and Average)
  - ❖ One-Dimensional Motion with Constant Acceleration
  - ❖ Free-fall and Motion on an Incline
  - ❖ Coordinate systems

Assignment: Finish reading Ch. 3, begin Chapter 4 (4.1 and 4.2)

- WebAssign Problem Set 1 due Tuesday next week (start now)

Speed and Velocity
Changes in position *vs* Changes in time

- Average velocity = Net distance covered (displacement) per total time

$$\bar{v}(\text{average velocity}) = \frac{\Delta x(\text{total displacement})}{\Delta t(\text{total time})}$$

- Speed is just the magnitude of velocity (aka a **scalar**).
  - ❖ Total distance ("path") traveled per total time spent.

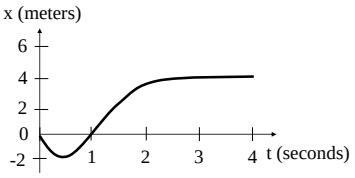
Active Figure 1 http://www.phy.ntnu.edu.tw/ntnujava/main.php?t=282

- Instantaneous velocity, velocity at a given instant
- Slope of the position curve

$$v(\text{velocity}) = \lim_{\Delta t \to 0} \frac{\Delta x(\text{displacement})}{\Delta t(\text{time})} = \frac{dx}{dt}$$

Active Figure 2 http://www.phy.ntnu.edu.tw/ntnujava/main.php?t=230

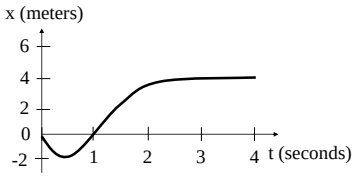
Lecture 3, Exercise *1*
Average Velocity



What is the average velocity over the first 4 seconds ?

A) -2 m/s B) 4 m/s C) 1 m/s D) not enough information to decide.

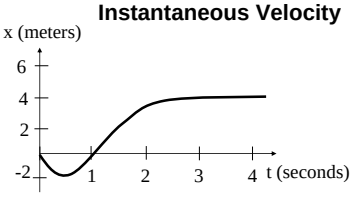
Lecture 3, Exercise *2*
Average Speed



What is the average speed over the first 4 seconds ?

A) 1.0 m/s B) 1.5 m/s C) 2.0 m/s D) not enough information to decide.

Lecture 3, *Exercise 3*
Instantaneous Velocity



What is the instantaneous velocity at the fourth second ?

A) 4 m/s B) 0 m/s C) 1 m/s D) not enough information to decide.

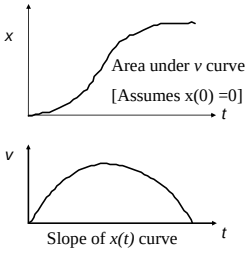
Recap

- If the position x is known as a function of time, then we can find both velocity v

$$x = x(t)$$

$$v = \frac{dx}{dt}$$

$$x - x(0) = \int_{t_0}^{t_1} dt \; v(t)$$



Examples of speed

	Speed (m/s)
Speed of light	3×10^{8}
Electrons in a TV tube	10^{7}
Comets	10^{6}
Planet orbital speeds	10^{5}
Satellite orbital speeds	10^{4}
Mach 3	10^{3}
Car	10^{0}
Walking	1
Centipede	10^{-2}
Motor proteins	10^{-6}
Molecular diffusion in liquids	10^{-7}

Acceleration
Changes in velocity *vs* Changes in time

- Average acceleration = Net change in velocity (v_{final} - $v_{initial}$) per total time

$$\bar{a}(\text{average acceleration}) = \frac{\Delta v(\text{change in velocity})}{\Delta t(\text{total time})}$$

Active Figure 1 http://www.phy.ntnu.edu.tw/ntnujava/main.php?t=282

- Instantaneous acceleration, acceleration at a given instant
- Slope of the velocity curve

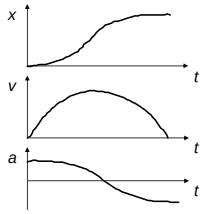
$$a(\text{accel.}) = \lim_{\Delta t \to 0} \frac{\Delta v(\text{net change in } v)}{\Delta t(\text{time})} = \frac{dv}{dt}$$

Active Figure 2 http://www.phy.ntnu.edu.tw/ntnujava/main.php?t=230

Again

- If the position x is known as a function of time, then we can find both velocity v and acceleration a as a function of time!

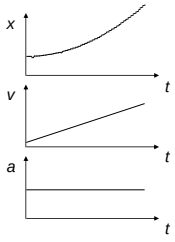
$$x = x(t)$$
$$v = \frac{dx}{dt}$$
$$a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$$



And given a constant acceleration we can integrate to get explicit v and a

$$x = x(t)$$
$$v = \frac{dx}{dt}$$
$$a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$$

$$x = x_0 + v_0 t + \frac{1}{2}at^2$$
$$v = v_0 + at$$
$$a = const$$



Rearranging terms gives two other relationships

- For constant acceleration:

$$x = x_0 + v_0 t + \frac{1}{2}at^2$$
$$v = v_0 + at$$
$$a = const$$

- From which we can show (caveat: **constant acceleration**):

$$v^2 - v_0^2 = 2a(x - x_0)$$
$$\bar{v}_{avg} = \frac{1}{2}(v_0 + v)$$

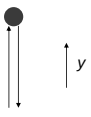
Lecture 3, *Exercise 5*
Motion in One Dimension

- When throwing a ball straight up, which of the following is true about its velocity v and its acceleration a at the highest point in its path?

A) Both $v = 0$ and $a = 0$.

B) $v \neq 0$, but $a = 0$.

C) $v = 0$, but $a \neq 0$.



Free Fall

- When any object is let go it falls toward the ground !! The force that causes the objects to fall is called gravity.
- This acceleration caused by gravity is typically written as "little" ***g***
- Any object, be it a baseball or an elephant, experiences the same acceleration (***g***) when it is dropped, thrown, spit, or hurled, i.e. ***g*** is a constant.

Gravity facts:

- *g* does not depend on the nature of the material!
  - ❖Galileo (1564-1642) figured this out without fancy clocks & rulers!
- demo - feather & penny in vacuum
- Nominally, $g = 9.81\ m/s^2$
  - ❖At the equator $g = 9.78\ m/s^2$
  - ❖At the North pole $g = 9.83\ m/s^2$
- More on gravity in a few lectures!

Context Rich Problem: (Exercise 6)

- **On a bright sunny day you are walking around the campus watching one of the many construction sites. To lift a bunch of bricks from a central area, they have brought in a helicopter. As the pilot is leaving, she accidentally releases the bricks when they are 1000 m above the ground. The worker below is getting ready to walk away in 10 seconds. (Let g = 10 m/s²)**

Does the worker live?

(Criteria for living…..they move before the brick strike the ground)

Problem Solution Method:

Five Steps:

1) **Focus the Problem**
   - **draw a picture – what are we asking for?**
2) **Describe the physics**
   - **what physics ideas are applicable**
   - **what are the relevant variables known and unknown**
3) **Plan the solution**
   - **what are the relevant physics equations**
4) **Execute the plan**
   - **solve in terms of variables**
   - **solve in terms of numbers**
5) **Evaluate the answer**
   - **are the dimensions and units correct?**
   - **do the numbers make sense?**

Tips:

- **Read !**
  - ❖Before you start work on a problem, read the problem statement thoroughly. Make sure you understand what information is given, what is asked for, and the meaning of all the terms used in stating the problem.
- **Watch your units (dimensional analysis) !**
  - ❖Always check the units of your answer, and carry the units along with your numbers during the calculation.
- **Participate in your discussion sections !**

Recap of today's lecture

- ❖Displacement, Velocity, Speed (Text: 2.1-2)
- ❖Acceleration (Text: 2.3)
- ❖Kinematics with constant acceleration (Text: 2.5)
- ❖Free Fall (Text: 2.6)
- ❖Problem solving (Chapter 2)

- Assignment: Finish reading Ch. 3, begin Chapter 4 (4.1 and 4.2)
- WebAssign Problem Set 1 due Tuesday next week (start now)