Chapter 2: Homework
(Due Jan 28th)

- Problems 6, 8, 14, 30, 40, 54
- Turn in to your recitation TA during your recitation on January 28, 2005
- For further instructions please read your course outline
Chapter 2: Kinematics

- Motion is described in terms of position (x), displacement \( r \), velocity \( v \), and acceleration \( a \).
- In one-dimensional motion, motion can be either forward or backward with reference to the origin.
- An x or y label indicates the positive end of the axis.
- Convention:
  - Positive end of an x-axis is towards the right side of the origin and positive end of y-axis is up.
  - All the signs for x, \( r \), \( v \), and \( a \) are based on the above notation.
Sign convention

- **Slowing down**
  - $v_x > 0$, $a_x > 0$
  - $v_x < 0$, $a_x < 0$
  - $v_y > 0$, $a_y > 0$
  - $v_y < 0$, $a_y < 0$

- **Speeding up**
  - $v_x > 0$, $a_x > 0$
  - $v_x < 0$, $a_x < 0$
  - $v_y > 0$, $a_y > 0$
  - $v_y < 0$, $a_y < 0$
Motion Analysis through Graphs

- Position and time form the basis for describing the motion of a particle.
- Position-time graph or position graph is generated by plotting time on x-axis and position on y-axis.
- Although (x, y) axes are considered, the problem we are solving is still a one-dimensional problem.
- Note: Time is to be plotted **always** on x-axis.
- The position-time graph (or position graph) shows a continuous curve whose slope will give the velocity/speed of the particle.
Analyze the position graph

(a)

What type of motion is described by this graph?

Uniform ? OR Non-uniform ?

Note the change in direction and magnitude (distance/displacement with reference to Origin) with time.
Uniform and Non-uniform Motion

- If a particle covers equal displacements in any successive equal intervals of time, then the particle is in uniform motion.
- The graph between position and time will be a straight line whose slope will be a constant.
- If a particle covers unequal displacements in equal intervals of time then, the particle is said to be in non-uniform motion.
- The position-time graph of non-uniform motion is a curve with varying slope.
Uniform/Non-uniform Motion

Uniform motion

The displacements between successive frames are the same. Dots are equally spaced. \( v_x \) is constant.

Nonuniform motion

The displacements between successive frames are not the same. Dots are not equally spaced. \( v_x \) is not constant.

Position graph is a straight line. The slope of the line is \( v_{avg} \).

Position graph is curved.

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Velocity from the position graph

- From Chapter I, the average velocity

- That is, the average velocity is the slope of the position-time graph

- An object’s motion is said to be uniform if and only if its velocity \((v_x \text{ or } v_y)\) is constant throughout the position-time graph

- There is no need to specify the suffix “avg” for velocity that does not change throughout the graph
Relationship between velocity and displacement

For uniform motion:

\[ v_s \propto \frac{\Delta s}{\Delta t} \]

The slope of the line is \( v_s = \frac{\Delta s}{\Delta t} \).
Example (Uniform Motion)

- Bob is moving east of C at 60mph and Susan is moving west of P at 40mph. Where would they meet?
- Draw position-time graph for this problem?
Instantaneous Velocity

- Instantaneous velocity is the velocity measured that instant of time?
- What is its use?

Mathematically,

Mathematically this means: as $\Delta t$ gets smaller and smaller, the average velocity reaches a constant value – the limit – and no longer changes.

This limit is called the derivative of $s$ with respect to $t$.

The instantaneous velocity at time $t$ is the slope of the line that is tangent to the position-time graph at time $t$. 
**Instantaneous Velocity (contd.)**

(a) The slope between 2 and 3 is \( v_{mp} \).

(b) The slope between c and d is a better approximation to the velocity at \( \times \).

(c) The velocity at \( \times \) is the slope as \( \Delta t \to 0 \).

(d) The velocity at \( \times \) is the slope of the line tangent to the curve at \( \times \).

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Calculus of Motion: Derivatives

- If the position of a particle is a function of $t$ (time in sec) then what would be its velocity?
  Example: $s = 2t^2$
    - Find velocity using the definition
    - Find velocity from calculus
    - Compare your results

- Derivative of position represents "instantaneous" velocity

- For a function $u = ct^n$ its derivative is $nct^{n-1}$