Lecture 1: Course introduction
Motion in one dimension

- Semester preview
- Motion along a straight line
- Position and displacement
- Velocity and speed
- Acceleration as derivative of velocity with respect to time
- Interpret the sign of velocity and acceleration
What is physics?

Most fundamental of sciences

Behavior and structure of matter
Galaxy NGC 300, seven million lighters away, constellation Sculptor. Courtesy of NASA.
High energy proton collision in the LHC. © CERN
Why study physics?

• Required for major
• Find out how the world works
• Because it is FUN

Demonstrations
Topic overview

Mechanics
• Motion of macroscopic objects
• Forces, friction, circular motion
• Energy and momentum
• Motion of planets
• Rotational motion
• Oscillations and waves
• Fluids

Thermodynamics

Honda cog ad video
A few tools:

- SI system of units, unit conversions
- Scientific notation
- Prefixes: micro, milli, centi, kilo…
- Estimates

Please review on your own as needed.
See Ch. 1, Sec. 1.1-1.6
Basic math skills* required in this course

- Linear equations, systems of linear equations
- Quadratic equations
- Basic trigonometry: SOHCAHTOA, Pythagoras
- Calculus 1: derivatives/integrals

**Note:** Calc 1 is a prerequisite for this course. If you have not taken calc 1, you must talk to your recitation instructor!

*Special Homework # 1 will help you review

- Vectors (will be covered in lecture 3)
Kinematics: Describing Motion

Consider object as point mass → only translation

Things to know about a moving object:

Where is it?  →  Position

How fast is it moving and in which direction?  →  Velocity

How do speed and direction of motion change?  →  Acceleration
Position

• In reference to some coordinate system
• Numerical value $x$
• $x(t)$ is location of particle as a function of time
• Initial position: $x_0 = x(t_0)$ *

* Does not mean $x_0 = 0$
Showing position

With respect to a coordinate system:

$x$-axis with origin and a positive direction (arrow)

Mark position at certain times:

\[
X_3 \quad X_0 \quad X_2 \quad X_1
\]

\[
-2 \quad -1 \quad 0 \quad +1 \quad +2 \quad +3 \quad +4
\]
Position versus Time Graphs
Position versus Time Graphs
Displacement

Displacement = Change in position: *

\[ \Delta x = x_f - x_i \]

* Change (upper case delta \( \Delta \)) is the final value of a quantity minus the initial value.

\( \Delta x \) can be positive or negative \( \rightarrow \) direction

Displacement is not the same as distance traveled!
Speed and velocity

“I am currently going at 25 mph”
= instantaneous speed

Together with information about direction:
“I am currently going at 25 mph North on Pine Street”
= instantaneous velocity

“I drove the 60 miles in one hour”
= average speed, distance per time
Average velocity

\[
\text{average velocity } = \bar{v}_x = \frac{\text{displacement}}{\text{time interval}} = \frac{\Delta x}{\Delta t}
\]

unit: \( \frac{m}{s} \)

* The subscript \( x \) is very important!

\( \bar{v}_x > 0 \) : object moves in the positive x-direction

\( \bar{v}_x < 0 \) : object moves in the negative x-direction
Average velocity and $x$-$t$ graph

Average velocity between $t_1$ and $t_3$:

$$
\overline{v}_x = \overline{v}_{av-x} = \frac{x_3 - x_1}{t_3 - t_1}
$$

In this example:

$\overline{v}_x$ is negative.
Object moves to smaller value of $x$. 

slope is average velocity
Instantaneous velocity

Instantaneous velocity is defined as the limit:

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

The graph shows a curve in the x-t plane with points marked at various times: $t_1$, $t_2$, $t_3$, and $t_4$. The tangent at $t_2$ is highlighted, indicating the instantaneous velocity at that point. The slope at $t_2$ is also marked, illustrating how the velocity is changing at that instant.
\[ v_x = \frac{dx}{dt} \]

Speedometer shows absolute value of instantaneous velocity

\[ v = |v_x| = \text{speed} \]

always positive
Direction of velocity

\( v_x > 0 \): object moves in the positive \( x \)-direction

\( v_x < 0 \): object moves in the negative \( x \)-direction
Acceleration

Acceleration: how fast velocity changes, time rate of change of velocity

\[ a_x = \frac{dv_x}{dt} = \frac{d^2x}{dt^2} \]

Slope of \( v_x \) vs \( t \) graph

Unit: \( \frac{m/s}{s} = \frac{m}{s^2} \)

Acceleration produces change in velocity: \( dv_x = a_x dt \)
If \( a_x > 0 \) and thus \( dv_x = a_x dt > 0 \):

- if \( v_x > 0 \) speed up
- if \( v_x < 0 \) slow down
Signs of acceleration and velocity

If $a_x < 0$ and thus $d(v_x) = a_x dt < 0$:

if $v_x > 0$: slow down

if $v_x < 0$: speed up
Motion diagrams

http://phet.colorado.edu/en/simulation/moving-man

\[ x_0 = 0, \ v_{0x} = +4 \frac{m}{s}, \ a_x = -2 \ m/s^2 \]