Chapter 1. Introduction

Last class...

Math Review: Powers and exponents
Prefixes for units
Conversion of units
Dimensional analysis

Today...

Chapter 2. Motion in 1-dimension

Position and displacement
Speed and velocity
Motion with a constant velocity
Acceleration

Chapter 2. Motion in 1-dimension

Why do we study motion?

A lot of things move!
Simplest kind of motions
⇒ Motion along a straight line
(i.e., 1-dimensional motion)
Position

What is motion?

Change of position over time

How to represent position along a straight line:

define: \( x = 0 \) some position (Origin)
positive direction for \( x \)
length unit, e.g., meter

Position of ball: \( x = +3 \) m

Displacement

Displacement: Change in position

\[ x_2 = -2 \text{ m} \quad x_1 = +3 \text{ m} \]

\[ \text{(Displacement)} = \Delta x = x_2 - x_1 \]

\[ \Delta x = -2\text{m}-(+3\text{m}) = -5 \text{ m} \]

+ or - sign represents direction
Length unit, e.g., meter
**Average velocity, \( v_{\text{avg}} \)**

(Average velocity between time \( t_1 \) and \( t_2 \)) = \( v_{\text{avg}} \)

\[
\frac{x(t_2) - x(t_1)}{t_2 - t_1} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t} = \text{Displacement} \quad \text{Time change}
\]

Unit: [Length]/[Time], e.g., m/s

**Average speed, \( s_{\text{avg}} \)**

(Average speed between time \( t_1 \) and \( t_2 \)) = \( s_{\text{avg}} \)

\[
\left( \frac{\text{Total distance}}{\text{Time change}} \right) = \frac{\Delta s}{\Delta t}
\]

Distance does not care about direction, unlike displacement

Distance & \( s_{\text{avg}} \) : always positive, no direction

In general, Distance = Displacement

Average speed = Average velocity
Example:
Displacement, distance, average velocity, average speed

\[ X=0 \text{ km} \quad x = 50 \text{ km} \]
\[ t = 0 \text{ min} \]

Example:
Displacement, distance, average velocity, average speed

\[ X=0 \text{ km} \quad x = 50 \text{ km} \]
\[ t = 50 \text{ min} \]
Example:
Displacement, distance, average velocity, average speed

\[ \begin{align*}
X &= 0 \text{ km} \\
x &= 50 \text{ km} \\
t &= 50 \text{ min}
\end{align*} \]

Example:
Displacement, distance, average velocity, average speed

Between \( t_1 = 0 \) and \( t_2 = 100 \text{ min} \),
find displacement, distance, average velocity, average speed

\[ \begin{align*}
X &= 20 \text{ km} \\
x &= 50 \text{ km} \\
t &= 100 \text{ min}
\end{align*} \]
Math review: Slope of a line

Graphical interpretation of average velocity

(Average velocity between time $t_1$ and $t_2$) $v_{avg} = \frac{\text{(Displacement)}}{\text{(Time change)}}$

$= \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}$

→Slope of the green line joining $(t_1, x_1)$, $(t_2, x_2)$ in $x$ vs. $t$ plot
**Instantaneous velocity, or velocity**

Instantaneous velocity, or simply, velocity

\[
\text{Instantaneous velocity} = \text{Average velocity between } t \text{ and } t + \Delta t, \\
\text{where } \Delta t \text{ is tiny (or, } \Delta t \to 0 \text{ limit)}
\]

- Slope of tangential line at \( t \) for \( x \) vs. \( t \) curve
- How fast at a given time \( t \)

![Graph showing motion with constant velocity](image)

**Motion with a constant velocity, \( v \)**

\( x(t) \) vs. \( t \):  
\[
v = v_{\text{avg}} = \frac{x(t) - x_0}{t - 0} \Rightarrow x(t) - x_0 = v \cdot t \Rightarrow x = x_0 + v \cdot t
\]

**Instantaneous Speed, or Speed**

(Instantaneous Speed) = (magnitude of instantaneous velocity)
iClicker Quiz

Average velocity between 20 s and 30 s is

(a) positive
(b) zero
(c) negative

iClicker Quiz

Instantaneous velocity at 30 s is

(a) positive
(b) zero
(c) negative
**iClicker Quiz**

Velocity at 10 s is

(a) positive
(b) zero
(c) negative

**Motivation to study acceleration**

Velocity changes!
Average acceleration

(Average acceleration between time $t_1$ and $t_2$) = $a_{avg}$

\[
\frac{v(t_2) - v(t_1)}{t_2 - t_1} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t} = \frac{(Velocity \ change)}{(Time \ change)}
\]

Unit: $(m/s)/s=m/s^2$

$[a_{avg}]=L/T^2$

→Slope of the line joining $(t_1, v_1)$, $(t_2, v_2)$ in v vs. t plot

Instantaneous acceleration

Instantaneous acceleration, or simply, acceleration

= Average acceleration between t and $t+\Delta t$, where $\Delta t$ is tiny (or, $\Delta t \to 0$ limit)

→Slope of tangential line at t for v vs. t curve

Slope = $a = \frac{\Delta v}{\Delta t}$

Instantaneous acceleration

[velocity (m/s)]

time (s)
iClicker Quiz: The acceleration between 0 s and 2 s is ______
(a) Positive  (b) zero  (c) negative  (d) Not enough information
\[ v_2 = -20 \text{ m/s} \quad v_1 = -10 \text{ m/s} \]
\[ t_2 = 2 \text{ s} \quad t_1 = 0 \text{ s} \]

Example: Find average acceleration between 0 s and 2 s.

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**Announcement**

HW #1: Introduction (Due 1 pm central time, 9/14, Monday).

HW #2: Motion in 1-d (Due 11 pm central time, 9/16, Wednesday).

If you have a difficulty with HW website, contact me.

Paper Quiz on Monday, Sep. 14th.