Physics 101.

Lecture 2.

Monday, Jan. 6, 2003.

Topics covered: 1-D Kinematics

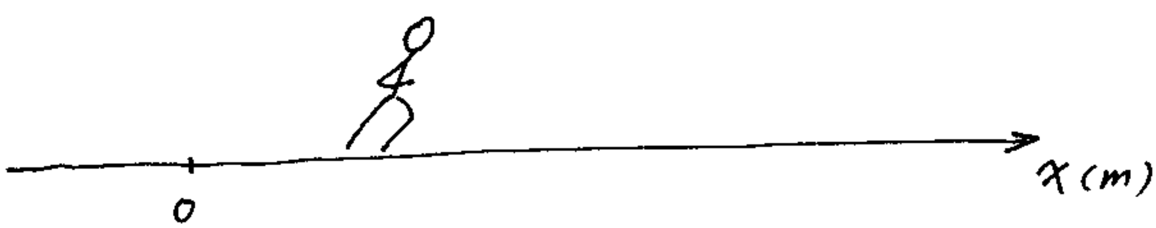
displacement and distance

velocity and speed.

Ref: Textbook. Ch.2.

1-D Kinematics

e.g.: A man running along a straight line



at time t_1, position x_1

" t_2, " x_2.

- displacement — change in position

$$\Delta x = x_f - x_i = x_2 - x_1$$ (can be positive or negative or zero)

$\Delta x > 0$ Towards (+) direction.

$\Delta x < 0$ Towards (−) direction.

- Distance — Length of travel.

$$d \text{ — always } \geq 0 .$$

- In general,

$$d \geq \Delta x .$$

$d = |\Delta x|$ only if the direction of motion does not change.

- Average Velocity over time interval $\Delta t = t_2 - t_1$:

$$v_{av} = \frac{\Delta x}{\Delta t} \quad (\text{can be } +/-)$$

- Average Speed

$$S_{av} = \frac{d}{\Delta t} \quad (\text{always } \geq 0)$$

again, $S_{av} \geq v_{av}$.

If the direction of Motion stays the same,

Then. $S_{av} = |v_{av}|$.

e.g. A round trip of an 100-m runner.

$x-t$ graph.

$$\begin{cases} t_1 = 0, & t_2 = 45, \\ x_1 = 0, & x_2 = 0. \end{cases}$$

Displacement: $\Delta x = x_2 - x_1 = 0$; Distance: $d = 220$ m.

Time interval: $\Delta t = t_2 - t_1 = 45$ (s).

Average velocity: $v_{av} = \dfrac{\Delta x}{\Delta t} = 0$

Average speed: $s_{av} = \dfrac{d}{\Delta t} = \dfrac{220\text{ m}}{45\text{ s}} = 4.89$ m/s

- Does the average velocity represent how fast the man is running?

  — NOT always.

  — Neither the average speed.

e.g.: A photo-Radar generated Speeding Ticket.

$v = 72\ km/h$.

speed limit $= 60\ km/h$.

On That day in 1996:

distance $= 10\ km$.

elapsed time $= 15\ min = 0.25\ h$.

average speed $= \dfrac{10\ km}{0.25\ h} = 40\ km/h$.

However, what the photo-radar measured was the **instantaneous velocity** — How fast at that instant when the picture was taken.

$$v \equiv \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

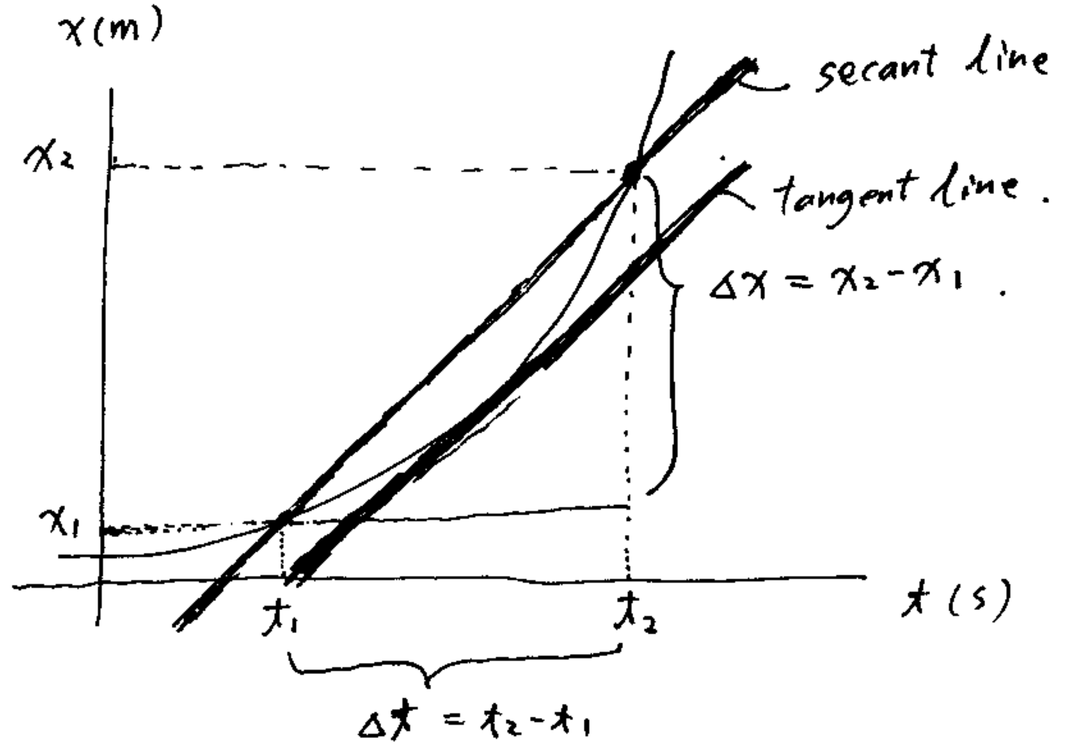
(Time-rate of change in x

$\dfrac{dx}{dt}$ — derivative of x with respect to t).

When Δt is small, $v \approx v_{av}$.

when v is constant, $v = v_{av}$.

- Meaning of v and v_{av} on x-t graph.



average velocity : $v_{av} = \frac{\Delta x}{\Delta t}$.

= slope of secant line .

instantaneous velocity. $v = \lim \frac{\Delta x}{\Delta t}$

= slope of tangent line .