

Classical Mechanics

- Motion of a particle
- Position vs. time
 - ⇒ Velocity *
 - ⇒ Acceleration
- ↳ Translation / Rotation

Ideal Particle

- classical physics concept
- Point-like object - No size
 - ↳ Except Rotations
- Mass $\neq 0$
- Real Particles: size, charge, spin

Newtonian Mechanics

3-Dimensional Space
Euclidean Geometry: $\Delta = 180^\circ$ } Observations
Experiments.

Time

Absolute: clock rates independent of position or velocity.

Euclidean Geometry } Classical/Newtonian
+ Absolute Time } Mechanics

Principia Mathematica
(1687)

Laws of Motion
+ Gravity

Measurements

Length: meters }
Time: seconds } SI
Mass: kg }

Kinematics

- describes geometry of motion. How?
position $\xrightarrow{\text{time}}$ velocity $\xrightarrow{\text{time}}$ acceleration
- dynamics: Forces
- Why?

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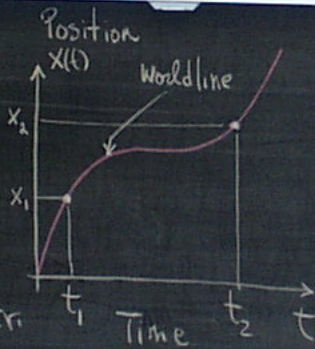
Time

Absolute: clock rates independent of position or velocity.

Position: Moving Particle

- Curve: 1-coordinate
- Surface: 2-coordinates
- Volume: 3-coordinates

Position vs Time: Complete Descr.



Speed

Average Speed = $\frac{\text{distance travelled } [L]}{\text{time taken } [T]}$

$$s = \frac{d}{t} > 0 \text{ (Always)}$$

m/s
ft/s

Speeds:

| | |
|---------|---------------------------------------|
| Light | 3×10^8 m/s |
| Sound | 300 |
| Person | 12 |
| Glacier | 10^{-6} Continent: 10 ⁻⁸ |

Motion and Speed are relative.
Depend on Reference Frame



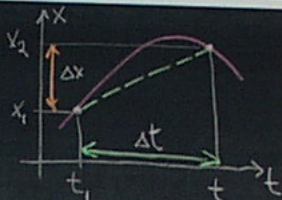
Average Velocity

- 1-Dimension; St. line Motion
- If $x = f(t)$ changes \Rightarrow particle moves.

\Rightarrow velocity

$$\text{Av Velocity } \bar{v}_{\text{av}} = \bar{v} = \frac{\text{displacement}}{\text{change in time}} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}$$

= Slope of line connecting (x_1, t_1) and (x_2, t_2)



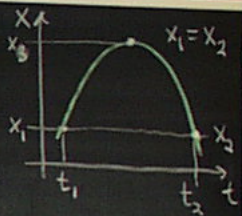
$\bar{v} > 0$ + x-axis
 $\bar{v} < 0$ - x-axis

Average Speed: $\frac{\text{distance trav.}}{\text{time}}$

Average Velocity: $\frac{\text{displacement}}{\text{time}}$

$$\bar{s}_{12} = \frac{2(x_2 - x_1)}{t_2 - t_1} \neq 0$$

$$\bar{v}_{12} = \frac{x_2 - x_1}{t_2 - t_1} \equiv 0 !!!$$



Instantaneous Velocity

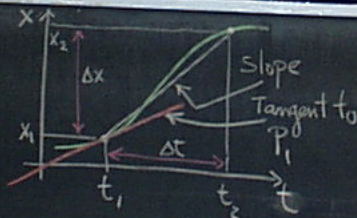
\bar{P}_1, \bar{P}_2 Slope = $\bar{v}_{\text{av}}(t_1, t_2)$

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

What is velocity exactly at P_1 ?

Reduce Δx and Δt

Inst. Velocity \equiv Velocity limit as $\Delta t \rightarrow 0$!



$$v(t) = \lim_{\Delta t \rightarrow 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

velocity = time derivative
of the position function
= first derivative wrt.

Invariant to coord. system
if no relative motion.

