KINEMATICS

FISIKA DASAR 1

Kinematics: Description of Motion

Relative Velocity

Multi-body Kinematics Problems

Adopted from MIT Course

Introduction

Description of Motion

$$x = x(t) \qquad x = c$$

All measurements require an origin, a coordinate system, and units

Next complication is ***"reference frame"***, the term used to describe the motion of observer Constant velocity is **OK**, accelerated observer is **not**

Basic definitions:

- **Position** *Distance versus displacement*
- **Velocity - change of position** *Speed is the magnitude of velocity*
- **Acceleration - change of velocity**

Adopted from MIT Course

Relative Velocity

Kinematic

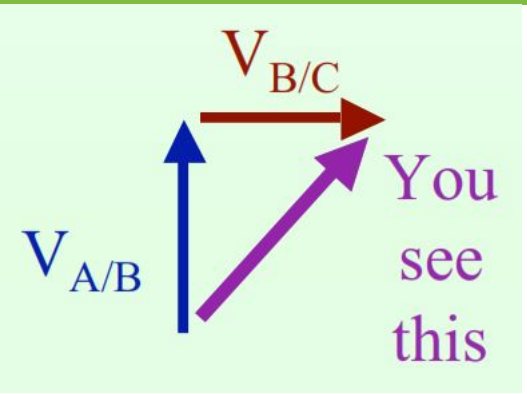
Basic Concept

- Observer B sees a moving object A, and
- Observer B is moving relative to observer C, so
- What does observer C see for the motion of the object?

Notation: use “wrt” to indicate “with respect to”

$$\vec{V}_{A\,wrt\,C} = \vec{V}_{A\,wrt\,B} + \vec{V}_{B\,wrt\,C}$$

Example: A=ball, B=me, C=you



Adopted from MIT Course

Kinematics Concepts

Posisi Sesaat	$x = x(t)$
Kecepatan Sesaat	$v = \frac{dx}{dt}$
Kecepatan rata-rata	$v_{rata-rata} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$
Percepatan	$a = \frac{dv}{dt} = \frac{d}{dt}\frac{dx}{dt} = \frac{d^2x}{dt^2}$
Percepatan rata-rata	$a_{rata-rata} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$

Example

Example

Posisi sebuah objek dilukiskan oleh:

$$x(t) = 4t^2 + 2t + 4$$

Hitung:

a. Kecepatan pada t=1detik

b. Kecepatan rata-rata pada 5 detik pertama

c. Percepatan sesaat

Answer:

a. $v = 8t + 2$, pada *t=1detik* ***maka*** $v = 10m/s$

b. $x(5) = 100 + 10 + 4 = 114m$

$x(0) = 4m$

$$v_{rata-rata} = \frac{x(5) - x(0)}{5 - 0} = \frac{114 - 4}{5} = 22{,}5m/s$$

c. $a = \frac{dv}{dt} = 8m/s^2$

Key Kinematics Concepts

- Change=slope=derivative

$$v_x = \frac{dx}{dt} \qquad a_x = \frac{dv_x}{dt} = \frac{d^2x}{dt^2}$$

velocity is the slope of position vs t, acceleration is the slope of velocity vs t and the curvature of position vs t

- Even in simple 1D motion, you must understand the vector nature of these quantities
- Initial conditions
- All formulas have assumptions

One Important Special Case

Constant Acceleration $=a$

$$x = x_o + v_o t + \frac{1}{2} a t^2$$

$$v = v_o + at$$

Initial conditions

Physics

Adopted from MIT Course

Example

Example 1

A car is moving straight at a **constant velocity** of 4m/s. The starting position is 10m to the reference, then the car runs for 2 seconds. Calculate:

a. Current car position
b. Distance

Answer:

a. $x_0 = 10m$ $\quad x = vt + x_0$

$v = 4m/s \quad = 4.2 + 10$

$t = 2s \quad = 18m$

b. $\Delta x = vt$

$= 4.2$

$= 8\ m$

Example

Example 2

A particle moving with an initial velocity of 20m/s is slowed by a deceleration of $2\mathrm{m}/s^2$ for 4 seconds, if the initial position of the particle is 5m. Calculate:

a. Particle position and distance
b. Particle velocity at 4 seconds

Answer:

a. $x = x_0 + v_0 t + \frac{1}{2} a t^2$

$= 5 + 20t + \frac{1}{2}(-2)t^2$

$= 5 + 20t + t^2$

$\boldsymbol{x(4) = 5 + 20(4) + (4)^2 = 69m}$

$\boldsymbol{\Delta x = x - x_0 = 69 - 5 = 64m}$

b. $v = v_0 + at$

$= 20 + (-2)4$

$= 12m/s$

Multi-body Kinematics Problems

- Need to use consistent coordinate system and origin for all objects
- Need to think carefully about directions (signs!)
- Need to think carefully about initial conditions, especially when things "start" at different times
- Write separate equations for each object
- Read problem carefully to understand the
- specific constraint to use to solve

SUMMARY

1. Kinematics provides a language to describe motion
2. Basic relationship between position, velocity, acceleration (change=slope=derivative)
3. Study special cases (like constant acceleration) but understand the assumptions that go into all Formulas
4. Position, velocity, and acceleration are ALL vectors and need to be manipulated using either arrows (qualitative) or components (quantitative)
5. Directions (or signs in 1D) of position, velocity, and acceleration can all be different

Adopted from MIT Course

THANK YOU