Chap 1

Introduction, Measurements, Estimation

1-5 Units, Standards and the SI Systems

The measurement of any quantity is made relative to a unit and this unit must be specified along with the numerical value of the quantity example I bought 1 Kg Sugar, we have three systems of units

1-6

System	Length	Mass	Time
SI (MKS)	meter (m)	kilogram (Kg)	second (S)
cgs	centimeter (cm)	gram (g)	second (S)
British	foot (ft)	slug	(S)

for the fundamental physical quantity which are length, Mass and time, we also have the electric current, temperature, amount of substance and Luminous intensity which have the following units Ampere (A), Kelvin (K), mole (mol) and Candela (cd) respectively.

- For the rest of the physical quantities we have derived units from these basic units like the unit of velocity is meter/second

- Converting Units : we can convert from one unit system to the other using a conversion factor, like (1in = 2.54cm) and so on.

- There is a prefix of the unit (see table 1-4)

1-8 : Dimensions and Dimensional Analysis

The fundamental physical quantities, Length, mass and time are called dimensions and they are abbreviated by [L], [M] and [T]

- The derived dimensions like for velocity $\left[\frac{L}{T}\right]$

- For each dimension there is a family of units for example, the dimension for displacement is Length [L] but we can use any of units in the three system of units like (meter, foot, kilometer mile and so on)

Dimensional Analysis

- Each physical equation must have the same dimension for both sides of it
- We can use Dimensional analysis to check if the equation is correct or not

For example: the displacement is given by $x = at$, where a is the acceleration and t is the time, then using dimensional analysis

$$[L] = \frac{[L]}{[T]^2}[T] = \frac{1}{[T]}$$

then this equation is not correct because both side of it ~~has~~ does not have the same dimension, So we can correct the equation by write it as

$$x = \frac{1}{2}at^2$$

$$[L] = \frac{1}{2}\frac{[L]}{[T]^2}[T]^2 = \frac{1}{2}[L]$$

the number $\frac{1}{2}$ is dimensionless

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Chap 2

Describing Motion : Kinematics in One Dimension

2-1 The study of the motion of an object and the related concepts of force and energy, momentum, form the field of mechanics. Mechanics customarily divided into two parts

(1) <u>Kinematics</u> : the study of the motion of objects regardless the cause of motion

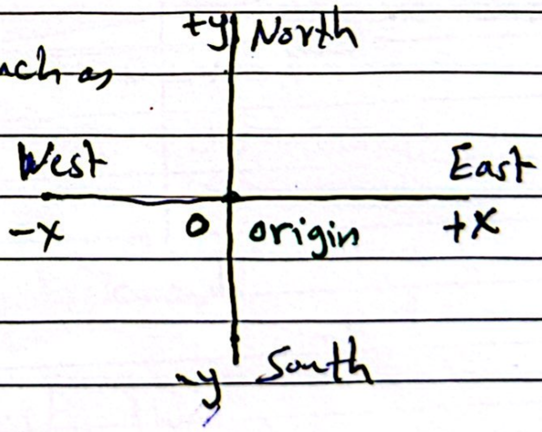
(2) <u>Dynamics</u> : the study of motion of objects with the cause of motion (force)

2-2 <u>Reference Frames and Displacement</u>

Any measurement of position, distance (Displacement), or speed (Velocity) must be made with respect to a referance frame or frame of referance

For example, if you are traveling on a train with a speed of 80 Km/h, suppose a person walks past you with a speed of 5 Km/h. This 5 Km/h is the speed of the person relative to the train frame of reference, but his speed is 85 Km/h relative to the ground.

- To specify the motion of an object we must specify a referance frame like Coordinates system such as



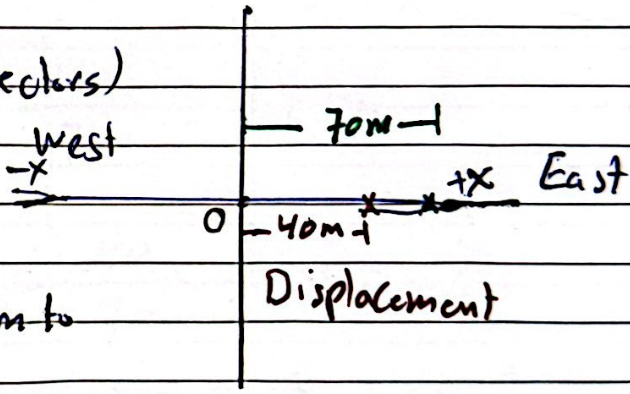
Cartesian Coordinates or xy coordinates or rectangular coordinate

2.3

For one Dimensional motion, the x-axis is chosen to describe the motion, then the position of an object at any moment is given by its x coordinate

- We need to make a distinction between distance and displacement, the distance is the actual total distance traveled by an object regardless of the direction but displacement is the difference between the initial and final positions (vectors)

For example



A person walkes 70 m to the east and then turns back and walkes 30 m to the west, then the total distance travelled is 100 m ~~and~~ but the displacement is 40 m from the starting point

Displacement is a vector quantity which must have both magnitude and direction

2-2 Average Velocity

$$\text{Average Speed} = \frac{\text{total distance travelled}}{\text{time elapsed}}$$

but

$$\text{Average Velocity} = \frac{\text{displacement}}{\text{time elapsed}} = \frac{x_f - x_i}{t_f - t_i} = \frac{\Delta x}{\Delta t}$$

In the previous example, the distance was 100m while the displacement was 40m, then if the time 70 second

$$\text{average speed} = \frac{100}{70} = 1.4\ m/s$$

while

$$\bar{v} = \text{average velocity} = \frac{40}{70} = 0.57\ m/s$$

(Ex 2-3): A car travels at a constant speed 50 Km/h for 100 Km. It then speeds up to 100 Km/h for another 100 Km. What is the car's average speed for the whole trip.

Solution :

The time for the first 100 Km is

$$t = \frac{\Delta X}{\bar{v}} = \frac{100\,Km}{50\,Km/h} = 2h$$

The time for the second 100 Km is

$$t = \frac{\Delta X}{\bar{v}} = \frac{100\,Km}{50\,Km/h} = 1\,h$$, then the average velocity (speed)

$$\bar{v} = \text{speed} = \frac{(100+100)\,Km}{(2+1)\,h} = 67\,Km/h$$

Note: Averaging the two speeds is not correct

$$\frac{50\,Km/h + 100\,Km/h}{2} = 75\,Km/h \text{ (wrong)}$$

2-3 : Instantaneous Velocity (v)

Instantaneous velocity is defined as the time rate of the displacement change.

$$v = v_{in} = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

- Uniform velocity means $\bar{v} = v_{in}$
- If the velocity is changing during the motion, then, the $\bar{v} \neq v_{in}$

$\boxed{2\text{-}4}$ Acceleration (a)

Average acceleration is defined as the change in velocity divided by the change in time

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$

The instantaneous acceleration (a) is the time rate of the change in velocity

$$a = a_{in} = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt}$$

Example 2-4

A car accelerates on a straight road in 5 s from rest to 75 km/h, what is the magnitude of its average acceleration

Solution

$$\bar{a} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{75\ km/h - 0\ km/hr}{5\ s}$$

$$= 15\ km/hr \cdot s$$

means the velocity increases by 15 km/h each second that is in first second $v = 15$ km/h in $t = 2$ s, $v = 30$ km/h and so on