Lecture 1

Mechanics : is a branch of the physical sciences that is concerned with the state of rest or motion of bodies that are subjected to the action of forces .

In general , this subject can be subdivided into three branches : **rigid-body mechanics**, **deformation-body mechanics**, and **fluid mechanics**.
We will study rigid-body mechanics since it is a basic requirement for the study of the mechanics of deformable bodies and the mechanics of fluid . Furthermore, rigid-body mechanics is essential for the design and analysis of many types of structural members and mechanical components .
Rigid-body mechanics is divided into two areas : statics and dynamics. Statics deals with the equilibrium of bodies , that is , those are either at rest or move with a constant velocity ; whereas dynamics is concerned with the accelerated motion of bodies.

Basic Quantities :

The following four quantities are used throughout mechanics.
Length :is used to locate the position of appoint in space and thereby describe the size of physical system .
Time : is conceived as a succession of events .
Mass : is a measure of a quantity of matter that is used to compare the action of one body with that of another .
Force : is considered as a " push " or " pull" exerted by one body on another . This interaction can occur when there is direct contact between the bodies, such as a person pushing on a wall , or it can occur through a distance when the bodies are physically separated.

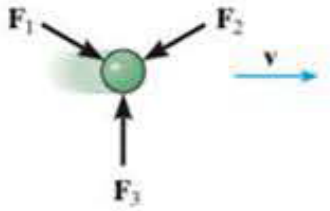
Idealizations :

Models or idealizations are used mechanics in order to simplify application of the theory . Here we will consider three important idealizations :
Particle : a particle has a mass , but a size that can be neglected. When a body is idealized as a particle. The principles of mechanics reduce to a rather simplified from since the geometry of the body will not be involved in the analysis of the problem .
Rigid Body : a rigid body can be considered as a combination of a large number of particles in which all the particles remain at a fixed distance from one another , both before and after applying a load .
Concentrated Force : a concentrated force represents the effect of a loading which is assumed to act at a point on a body. We can represent a load by a concentrated force .

Newton's Three Laws of Motion :

Engineering mechanics is formulated on the basis of Newton's three laws of motion. The validity of which is based on experimental observation . These laws apply to the motion of particle as measured from a nonaccelerating reference frame. They may be briefly stated as follows :

First Law : A particle originally at rest , or moving in a straight line with constant velocity, tends to remain in this state provided the particle is not subjected to an unbalanced force.



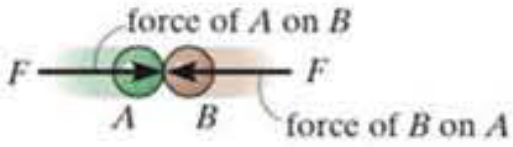
Equilibrium

Second Law : A particle acted upon by an unbalanced force **F** experiences an acceleration **a** that has the same direction as the force and a magnitude that is directly proportional to the force . If **F** is applied to a particle of mass **m ,** this law may be expressed mathematically as :

$$\mathbf{F} = m\mathbf{a}$$

Accelerated motion

Third Law : the mutual forces of action and reaction between two particles are equal, opposite , and collinear .



Action – reaction

Units of Measurement :

SI Units : the International System of units , is a modern version of the metric system which has received worldwide recognition. The **SI** system defines length in meters **(m)**. time in seconds **(s)**, and mass in kilograms **(kg)**. The unit of force, called a newton **(N)** , is derived from **F = ma**. Thus, **1** Newton is equal to a force required to give **1** kilogram of mass an acceleration of **1 m/s^2** (**N = kg.m/s^2**) .

If the weight of a body located at the " standard location" is to be determined in Newton. Here measurements give **g = 9.806 m/s^2** :

$$W = mg \quad (g = 9.806\ m/s^2)$$

U.S. Customary : in the U.S. Customary system of units (**FPS**) length is measured in feet (ft), time in second (s), and force in pounds (Ib) . The unit of mass, called a slug, is derived from **F = ma** .

TABLE 1–1 Systems of Units

Name	Length	Time	Mass	Force
International System of Units SI	meter m	second s	kilogram kg	newton* N $\left(\frac{kg \cdot m}{s^2}\right)$
U.S. Customary FPS	foot ft	second s	slug* $\left(\frac{lb \cdot s^2}{ft}\right)$	pound lb

*Derived unit.

TABLE 1–2 Conversion Factors

Quantity	Unit of Measurement (FPS)	Equals	Unit of Measurement (SI)
Force	lb		4.448 N
Mass	slug		14.59 kg
Length	ft		0.304 8 m

Example :

Convert 2 km/h to m/s How many ft/s is this ?

Solution:

Since 1km = 1000 m and 1h = 3600 s , the factors of conversion are arranged in the following order, so that a cancellation of the units can be applied :

$$2\ \text{km/h} = \frac{2\ \text{km}}{1\ \text{h}}\left(\frac{1000\ \text{m}}{1\ \text{km}}\right)\left(\frac{1\ \text{h}}{3600\ \text{s}}\right)$$

$$= \frac{2000\ \text{m}}{3600\ \text{s}} = 0.556\ \text{m/s} \qquad \textit{Ans.}$$

From Table 1–2. 1 ft = 0.3048 m. Thus.

$$0.556\ \text{m/s} = \left(\frac{0.556\ \text{m}}{\text{s}}\right)\left(\frac{1\ \text{ft}}{0.3048\ \text{m}}\right)$$

$$= 1.82\ \text{ft/s} \qquad \textit{Ans.}$$

Example :

Convert the quantities 300 lb · s and 52 slug/ft^3 to appropriate SI units.

Solution :

$$1\text{b} = 4.448\ 2\ \text{N}.$$

$$300\ \text{lb}\cdot\text{s} = 300\ \text{lb}\cdot\text{s}\left(\frac{4.448\ \text{N}}{1\ \text{lb}}\right)$$

$$= 1334.5\ \text{N}\cdot\text{s} = 1.33\ \text{kN}\cdot\text{s} \qquad \textit{Ans.}$$

Since 1 slug = 14.593 8 kg and 1 ft = 0.304 8 m. then

$$52\ \text{slug/ft}^3 = \frac{52\ \text{slug}}{1\ \text{ft}^3}\left(\frac{14.59\ \text{kg}}{1\ \text{slug}}\right)\left(\frac{1\ \text{ft}}{0.304\ 8\ \text{m}}\right)^3$$

$$= 26.8(10^3)\ \text{kg/m}^3$$

$$= 26.8\ \text{Mg/m}^3 \qquad \textit{Ans.}$$