CHAPTER 1

Introductory Concepts

1.1 INTRODUCTION

Engineering Mechanics is the basic engineering discipline which reads with the bodies at motion or rest under the action of various forces. The scope of the subject starts from fundamental calculation methods of creating engineering design for under dynamic, atmospheric, temperature forces etc. The names of the scientists associated with the subject are Archemedes, Galilio, Newton, Einstein, Varignon, Euler, D Alembert etc and their contributions are discussed in the different chapters.

1.2 CLASSIFICATION OF ENGINEERING MECHANICS

Depending upon the nature of body under study engineering mechanics is divided into mechanics of rigid bodies which deals with rigid bodies and mechanics of fluids which deals with deformable bodies like fluid or gas (Fig,1.1).

Mechanics of Rigid bodies is classified into statics which deals with bodies at rest and dynamics which deals with bodies at motion.

Dynamics is further classified into Kinematics which deals with the motion of the body in term of its velocity, acceleration displacement maximum height reached without considering the forces that are responsible for its motion. The second one is Kinetics which deals with the motion of the body with the forces responsible.

In case of mechanics of deformable bodies the internal stresses are to be studied which are responsible for the deformation of the body.

1.3 BASIC TERMINOLOGY

Space, time mass and force all the important terms associated with mechanics in addition to length, displacement, velocity and acceleration.

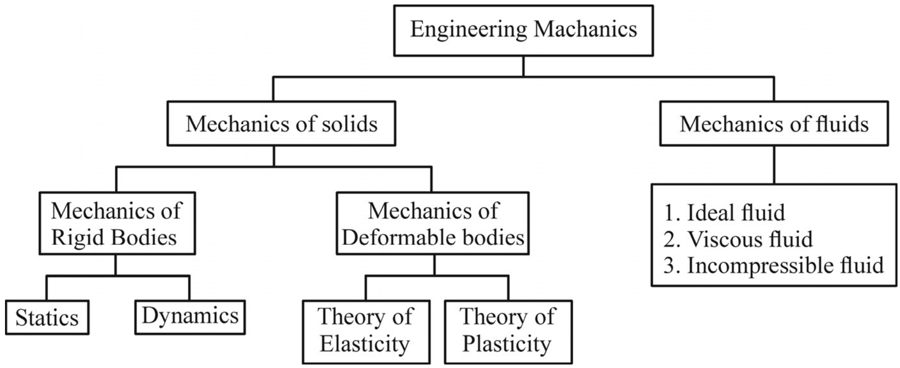

Fig.1.1

1.4 LAWS OF MECHANICS

The subject is developed on the following fundamental laws.

1. Newton's first law of motion
2. Newton's second law of motion
3. Newton's third law of motion
4. Newton's law of gravitation
5. Law of transmissibility of forces
6. Parallelogram law of force
7. Varignon's theorem
8. Polygon law of force
9. Lamis theorem

1.4.1 NEWTON'S FIRST LAWS OF MOTION

It states that unless external forces are applied a body which is at rest or in motion would continue to do so. The concept of inertia is developed from this law.

1.4.2 NEWTON'S SECOND LAW OF MOTION

According to this, the rate of change of momentum of a body is directly proportional of the applied force and body moves in the direction of force. From this the force is defined. The units of force in SI system is Newton

$$F = ma$$

1.4.3 NEWTON'S THIRD LAW OF MOTION

To every action there is equal and opposite reaction. This means that the forces of action and reaction between two bodies are equal in magnitude but opposite in direction.

1.4.4 NEWTON'S LAW OF GRAVITATION

According to this law, everybody attracts other body. The attractive force between two bodies is directly proportional to the mass of the bodies and inversely proportional to the square of the distance between them.

If two bodies of mass m_1 and m_2 are considered which are separated by a distance r, then the attractive force F is given by

$$F = G \frac{m_1 m_2}{r^2}$$

Where G is called universal gravitational constant.

1.4.5 LAW OF TRANSMISSIBILITY OF FORCE

According to this law, the state of rest or motion of the body is not changed if a force acting on it is replaced by another of equal magnitude and direction but acting at any other point on the body.

1.4.6 PARALLELOGRAM LAW OF FORCES

This law enables us to determine the single force called resultant which can replace two forces acting on a point with the source effect caused by two forces. A states that if two forces acting simultaneously on a body at a point are represented in magnitude and direction by two adjacent sides of parallelogram, their resultant is represented in magnitude and direction by the diagonal of the parallelogram which passes through the point of intersection of the two sides representing the forces.

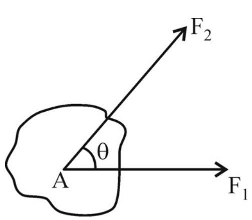

Fig.1.2(a)

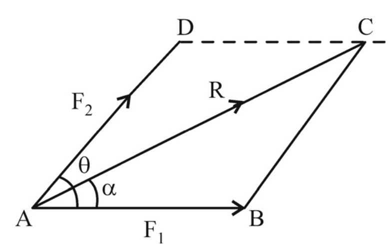

Fig.1.2(b)

As shown in Fig.1.2(a) at a point at in the body two forces F_1 and F_2 are acting R which is diagonal of the parallelogram ABCD constructed in such a way that AB represents magnitude and direction of F_1 and AD represents magnitude and direction of F_2 as shown in Fig.1.2(b).

Mathematically we can prove that $R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$

where θ is the angle between F_1 and F_2.

The direction of resultant R is given by α as shown in Fig.1.1(b) can be proved to be

$$\tan\alpha = \frac{F_1\sin\theta}{F_1 + F_2\cos\theta}$$

1.4.7 VARIGNAN'S THEOREM

It states that the moment of a force about any point is equal to the sum of moments of the components of that force about the same point.

1.4.8 POLYGON LAW OF FORCE

It states that a number of explorer forces are acting at a point such that they can be represented in magnitude and direction by sides of polygon taken in order, their resultant is represented in both magnitude and direction by the closing side of the polygon taken in the opposite order.

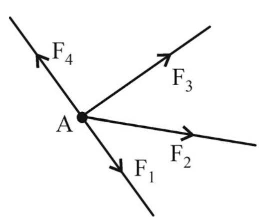

Fig.1.3(a)

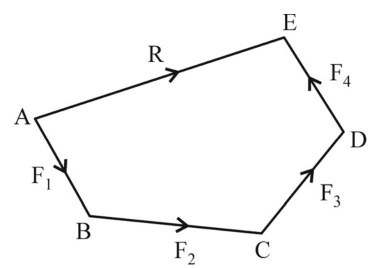

Fig.1.3(b)

As shown in Fig.1.3(a) four forces F_1, F_2, F_3 and F_4 are acting on point A. As shown in Fig.1.3(b) if all these forces are represented by sides of polygon both in magnitude and direction. The closing side AE gives the direction and magnitude of resultant R. Triangular Law of force which is widely used in mechanics is divided from polygon law of force.

1.4.9 LAMI'S THEOREM

If three concurrent forces P, Q and R acting on a body and keeping it in equilibrium then each force is proportional to the sine of the angle between other two forces.

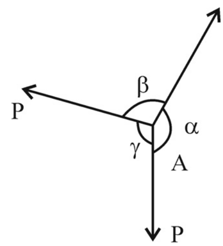

Fig.1.4

As showing in Fig.1.4 three forces P, Q and R acting on a point A. The angle between the forces is given in the Fig.1.4.

According to Lami's theorem

P α sin α, Q α sin β and R α sin γ

∴ We can write $$\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma} = \text{constant}$$