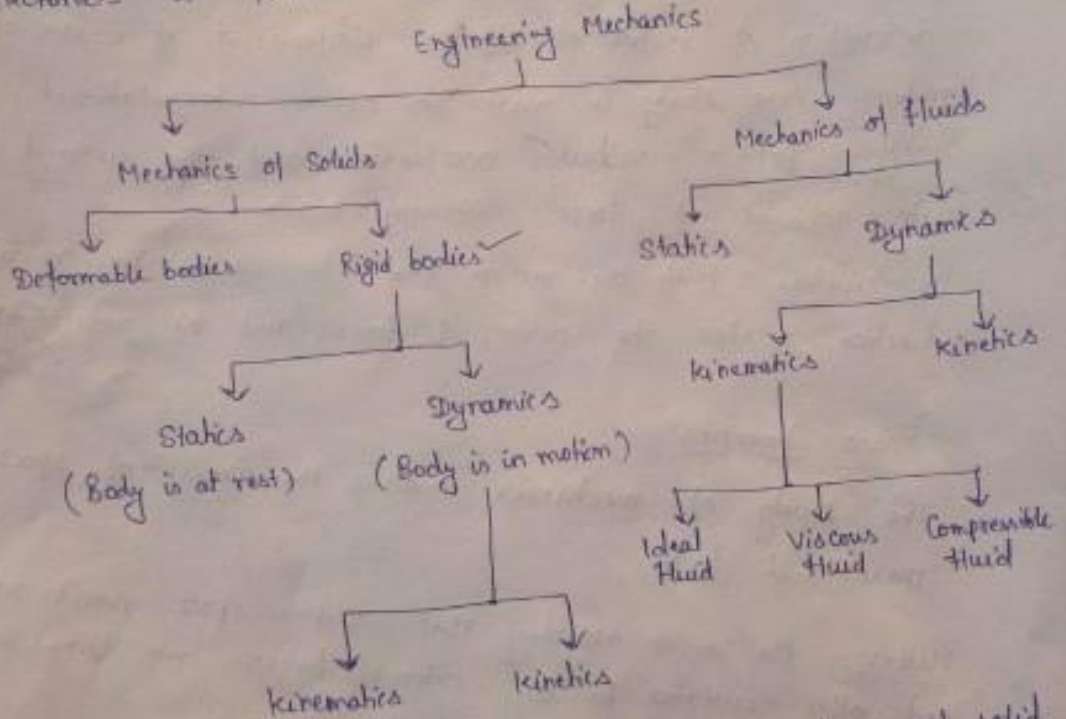
Engineering Mechanics

Definition :— It is the science which deals with the physical state of rest or motion of bodies under the action of forces.

Depending upon the nature of body involved, Engineering mechanics is further divided into



Mechanics of solids & mechanics of fluids :— Mechanics of solid is the study of solids at rest or in motion, whereas mechanics of fluid deals with the study of liquids and gases at rest or in motion.

Deformable bodies and rigid bodies :— The deformable bodies deform when acted upon by forces where as no deformation occurs in rigid body. The rigid body may change its position or orientation under the action of applied force

However the relative position of the particles constituting the rigid body remains unchanged

Statics and dynamics :- Statics deals with forces in terms of their distribution and effect on a body in equilibrium i.e at absolute or relative rest.
Dynamics deals with the study of bodies in motion.

Kinematics and kinetics :- Kinematics is concerned with the description of motion of objects independent of cause of motion. Here study is made of motion inter relationship among position, velocity, acceleration and time without taking into account of force causing motion.
In kinetics, both the motion and its causes are considered. kinetics relates the action of forces and the resulting motion.

Basic Concepts :-
The study of mechanics involves the concepts of space, time mass and force.

Matter :- Matter is anything that occupies space, possess mass and offer resistance to any external forces. Iron, stone, wood and air represent matter.
Matter is made up of atoms and molecules. But the real picture of matter as atoms and molecules is too complex to deal with. We assume that the matter is continuously distributed. Such a description of matter is called a continuum

Particle :- It is defined as an object whose mass is concentrated at a point. This assumption is made when the size of a body is negligible and is irrelevant to the description of the motion of the body.

(i) Concept of space – to fix the position of a point.
(frame of reference and co-ordinate system)

(ii) Concept of time :- to relate the sequence of events
(starting & stopping of the motion of a body)

(iii) Concept of mass – to distinguish b/w behaviour of two bodies under the action of an identical force.

(iv) Concept of force – to change the state of rest or of uniform motion of a body.

Reference frame :- The Earth surface is usually employed as a reference frame. also called inertial frame
A truly inertial frame is one which moves at constant velocity.

Scalar & Vector Quantities :-

Fundamental Principles :-

1. Newton's Three Laws of Motion
2. Newton's Law of Gravitation
3. Parallelogram law for the addition of force.
4. Sine Law & Cosine Law
5. Lami's Theorem
6. Principle of transmissibility

1(a) Newton's First Law :- Everybody continues in a state of rest or of uniform motion in a straight line unless it is compelled to change that state by a force imposed on the body. (Define force). Gives the concept of inertia.

1(b) Newton's Second Law :- The rate of change of linear momentum is directly proportional to the impressed force and its take place in the direction of the straight line in which the force is impressed.

$$\boxed{F = ma}$$

1(c) Newton's Third Law :- To every action, there is equal and opposite reaction. which means, that the forces of action and reaction b/w two bodies are equal in magnitude but opposite in direction.

2. Newton's Law of Gravitation :- Two particles are attracted towards each other along the line connecting them with a force whose magnitude is proportional to the product of their masses and inversely proportional to the square of the distance b/w them.

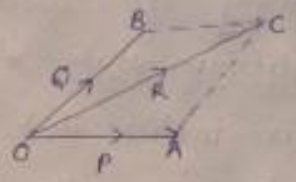
$$F \propto m_1 m_2 \qquad F \propto \frac{1}{r^2}$$

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

G = universal constant called constant of gravitation

r = is the distance b/w the particles

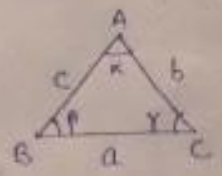
3. The Parallelogram Law :- if two forces P and Q acting at a point are represented in magnitude and direction by the two adjacent sides of a parallelogram, then the diagonal passing through their point of intersection represents the resultant both in magnitude and direction.



Parallelogram Law of Forces

4. Sine Law and Cosine Law :-

refer to ΔABC



Sine Law :-

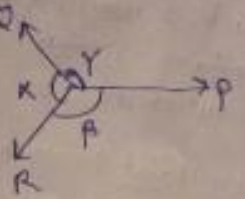
$$\frac{a}{\sin\alpha} = \frac{b}{\sin\beta} = \frac{c}{\sin\gamma}$$

as per Cosine Law :-

$$a^2 = b^2 + c^2 - 2bc\cos\alpha$$
$$b^2 = c^2 + a^2 - 2ca\cos\beta$$
$$c^2 = a^2 + b^2 - 2ab\cos\gamma$$

5. Lami's Theorem :- if three forces acting at a point are in equilibrium, then each force is proportional to the sine of the angle b/w the other two forces.

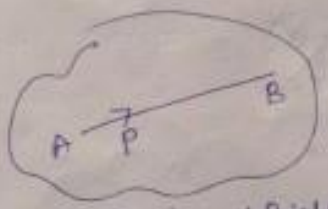
$$\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$$



6. Principle of transmissibility :-

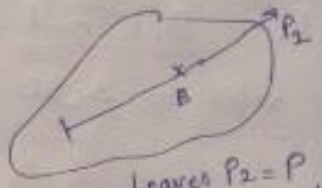
When the point of application of a force acting on a body is shifted to any other point on the line of action of the force without changing its direction, there occurs no change in the equilibrium state of the body.

This implies that a force acting at any point on a body may also be considered to any other point along its line of action without changing its effect on the body.



Force P acting at Point A
B is another point on the line of action of P

Apply two oppositely directed forces (P_1 and P_2) equal to and collinear with P.
P & P_1 cancel each other.



Leaves $P_2 = P$
This implies that a force acting at any Point on a body may also be considered to act at any other Point along its line of action.

Equilibrium, Resultant & Equilibrant :-

Equilibrium – When two or more than two forces act on a body in such a way that the body remains in the state of rest or of uniform motion, then the systems of forces is said to be in equilibrium.

Resultant :- When a body is acted upon by a system of forces, then vectorial sum of all the forces is known as resultant.

Equilibrant :- A number of forces may act on a body in such a manner that the body is not in equilibrium. The resultant of several forces may cause a change of state of rest or of uniform motion. A single force may have to be applied