BASIC CONCEPTS OF ENGINEERING MECHANICS

MECHANICS

It's a branch of science, which deals with the action of forces on bodies at rest or in motion.

ENGINEERING MECHANICS

It deals with the principles of mechanics as applied to the problems in engineering.

BASIC CONCEPTS

1. **Matter**: Anything which has mass and requires space to occupy is called matter.
2. **Mass**: It is a measure of quality of matter contained by the body.
   SI unit: Kg.
3. **Volume**: It is a measure of space occupied by the body.
   Unit: m^3
   Note: Liter → Unit of volume
   1000 liters = 1 m^3
   TMS – Thousand million cubic feet.
   → 10^9 ft^3
   → 1000^9 ft x 10000 ft x 1000 ft
4. **State of rest and motion**: State of rest and state of motion are relative and depend on the frame of reference. A body is said to be in a state of rest w.r.t. a frame of reference if the position of the body w.r.t. that frame of reference is not changing with time. A body is laid to be in a state of motion w.r.t. a frame of reference if the position of the body w.r.t. that frame of reference is changing with time.
5. **Scalar and Vector Quantities**: Quantities which require only magnitude to represent them are called scalar quantities.
   Eg: Mass, Time interval.
   Quantitites which require both magnitude and direction to represent them are called vector quantities.
   Eg: Force, Velocity, etc.

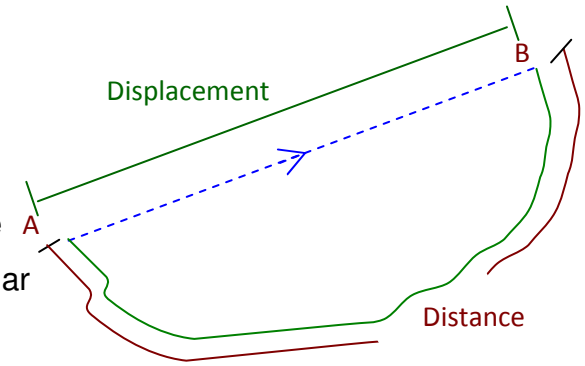
6. **Displacement and distance travelled**: The total linear movement made by a body to change its position from one point to another is called distance travelled by the body. It is a scalar quantity.

   Unit: Meter (m)

   mm – Millimeter → 10^{-3}m

   km – Kilo Meter → 10^{3}m

   The total linear movement made by a body to change its position from one point to another moving along a particular direction is called displacement.



   Displacement is a vector quantity.

   Unit: Meter (m).

7. **Speed and Velocity:** The distance travelled in a unit time is speed.

   Unit: m/s → ms^{-1}

   The displacement in unit time is called velocity.

   Unit: m/s → ms^{-1}

8. **Uniform motion and non-uniform motion:** If the velocity of the moving body remains constant then the motion is said to be uniform. If the velocity is changing with time, the motion is laid to be non-uniform.

9. **Acceleration and retardation:** The time rate of change of velocity is called acceleration.

   If the velocity is increasing with time then acceleration is positive. If the velocity is decreasing with time then acceleration is negative. Negative acceleration is called retardation or deceleration.

   Unit: m/s^2 → ms^{-2}

10. **Momentum**: It is the capacity of a moving body to impart motion to other bodies. Momentum of a moving body is given by the product of mass and velocity of the moving body.

    Momentum = Mass X Velocity

    Unit: kg m/s or kg ms^{-1}.

11. **Newton's I Law of Motion**: "Everybody continues to be in its state of rest or uniform motion unless compelled by an external agency".

12. **Inertia:** It is the inherent property of a body by virtue of which it can retain its state of rest or uniform motion unless compelled by an external agency.
13. **Force:** It is an external agency, which overcomes or tends to overcome the inertia of a body. It is a vector quantity.
14. **Elements of a force**: There are four elements:
    a. Magnitude
    b. Direction
    c. Line of action
    d. Point of action or application
15. **Newton's II Law of motion**: "The rate of change of moment of a body is directly proportional to the magnitude of the force applied and takes place in the direction of the force applied".

Explanation:

Initial momentum = mu

Final momentum = mv

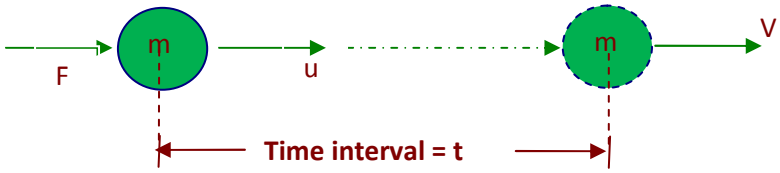
Change in momentum over a time interval 't' = mv – mu

Rate of change of momentum = $\frac{mv-mu}{t}$

According to Newton's II law,

$F \alpha \frac{mv-mu}{t}$

$F \alpha m\left(\frac{v-u}{t}\right)$



$F \alpha ma$

$F = K ma$

In SI, unit force is defined as that force which acts on a body of unit mass producing unit acceleration.

i.e., F = 1 when m = 1 and a = 1

then 1 = k . 1 . 1

$\therefore$ k = 1

F = ma

Unit of force: newton (N) is the unit of force. One newton is that force which acts on a body of mass 1 kg producing an acceleration of 1 m/s^2.

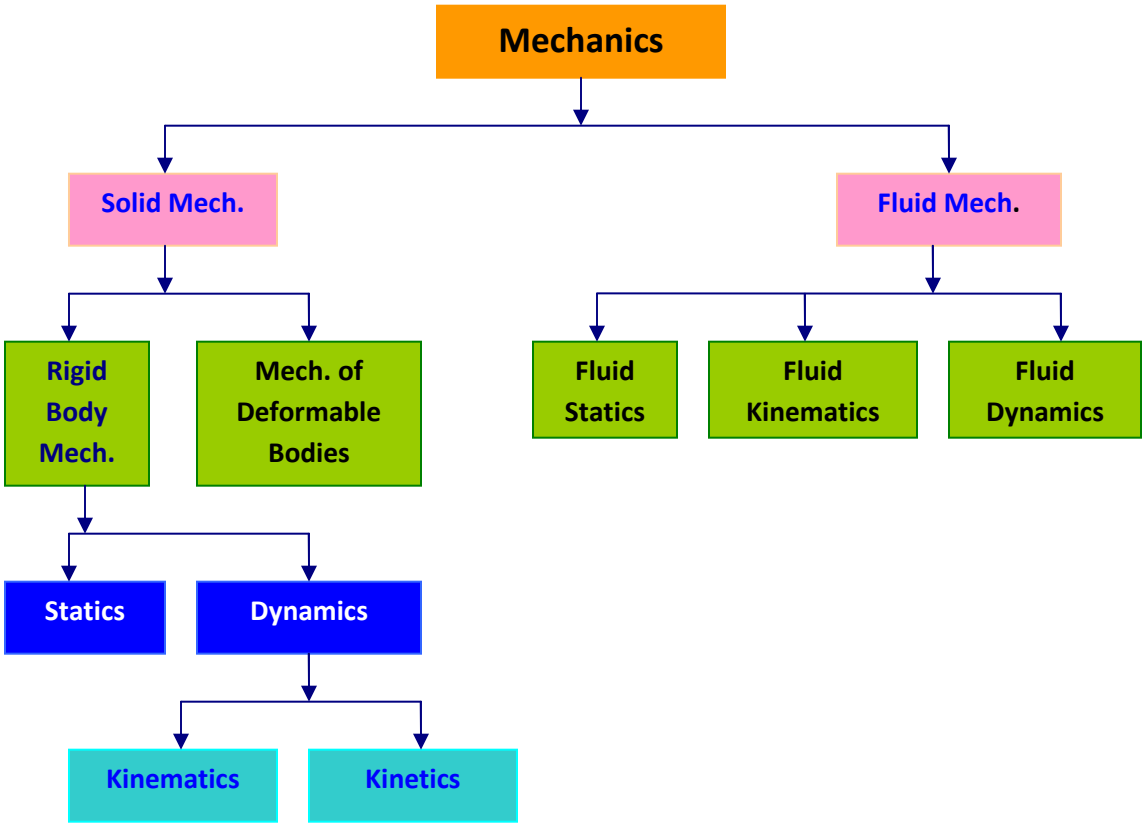
kN – Kilo newton – 10^3N

MN – Mega newton – 10^6N

GN – Giga newton – 10^9N

16. **Newton's III law of motion**: "For every action there is equal and opposite reaction".

17. **Branches of Mechanics:**



Statics: Statics deals with the action of forces on bodies at rest or in equilibrium.

Dynamics: Dynamics deals with the action of forces on bodies in motion.

Kinematics: It deals with the study of geometry of motion without considering the cause of motion.

Kinetics: Kinetics deals with a study of motion considering the course of motion.

18. **Rigid body**: The concept of rigid body is purely theoretical or imaginary. A rigid body is said to undergo, no deformation under the action of any external agency such as force and moments.

    In other words relative positions of the modules of a rigid body are fixed in space.

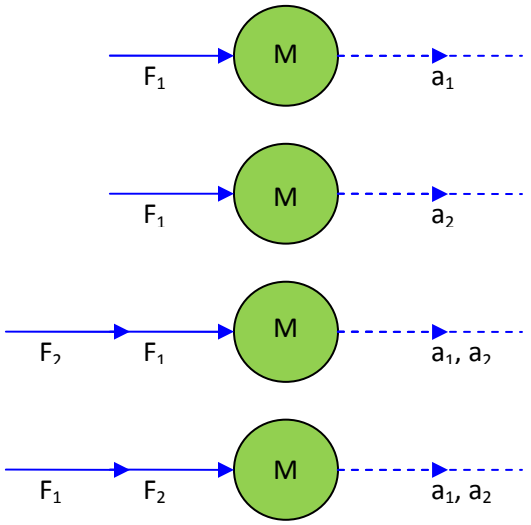
19. **Particle**: Concept of particle is purely theoretical or imaginary. A particle is said to have mass but requires no space to occupy. In other words, a particle is a point mass.

The concept of particle cannot be used if the shape and size of the body is influencing the motion.

Eg: i) Motion of a swimmer.

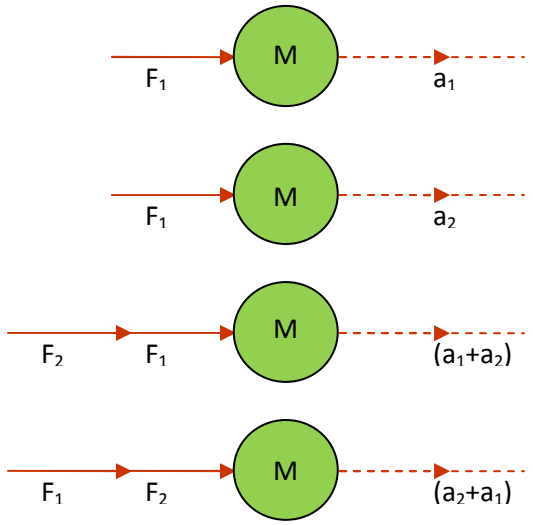
ii) Motion of a body along a curved path.

20. **Continuum**: The concept of continuum is purely theoretical or imaginary. Continuum is said to be made up of infinite number of molecules packed in such a way that, there is no gap between the molecules so that property functions remain same at all the points.
21. **Point force**: The concept of point force in purely theoretical or imaginary, here the force is assumed to be acting at a point or over infinity small area.
22. **Principle physical independence of forces**:



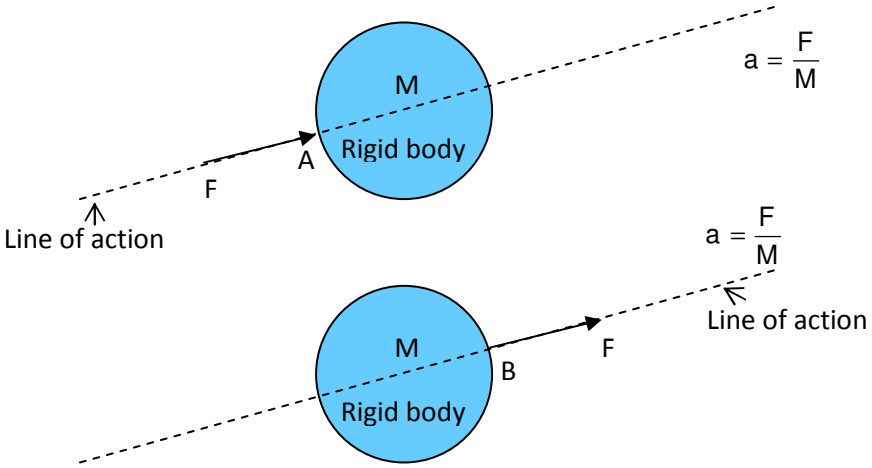
Action of forces on bodies are independent, in other words the action of forces on a body is not influenced by the action of any other force on the body.

23. **Principle of superposition of forces**:



Net effect of forces applied in any sequence on a body is given by the algebraic sum of effect of individual forces on the body.

24. Principle of transmissibility of forces:



The point of application of a force on a rigid body can be changed along the same line of action maintaining the same magnitude and direction without affecting the effect of the force on the body.

Limitation of principle of transmissibility: Principle of transmissibility can be used only for rigid bodies and cannot be used for deformable bodies.

25. Assumptions made in Engineering Mechanics

i) All bodies are rigid.

ii) Particle concept can be used wherever applicable.

iii) Principle of physical independence of forces is valid.

iv) Principle of superposition of forces is valid.

v) Principle of transmissibility of forces is valid.

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