Course Code: ESC106A
Course Title: Construction Materials and Engineering Mechanics

Lecture No. 5:
Engineering Mechanics

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Lecture Intended Learning Outcomes

At the end of this lecture, students will be able to:

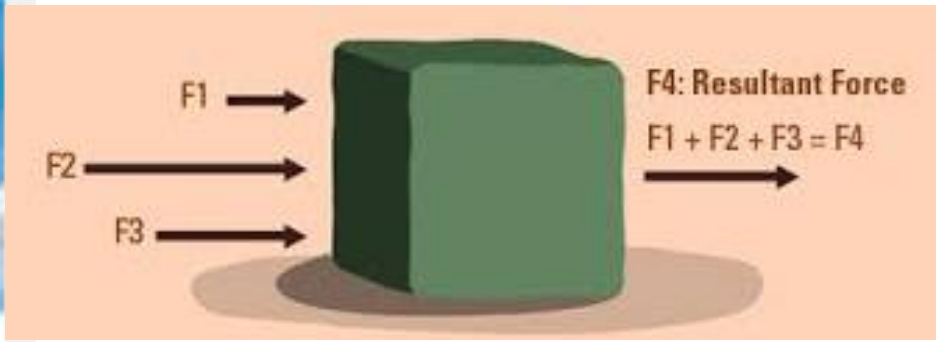
- Define Engineering Mechanics
- Describe the basic idealizations of Mechanics such as rigid body, continuum, particle and point force
- Explain the concepts of Mechanics
- Differentiate the different branches of Mechanics

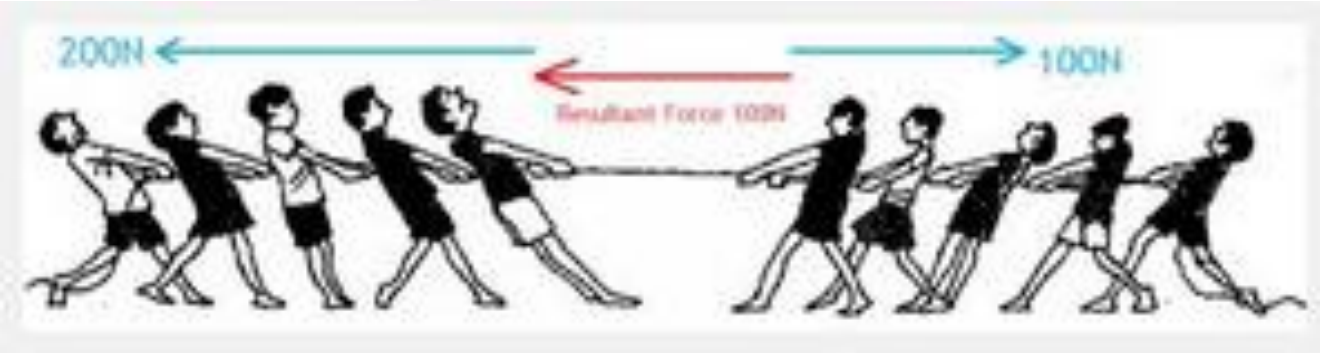
Contents

Engineering Mechanics

Branches of mechanics and its importance: Engineering Design, Mechanics in engineering, Introduction to SI units , Basic idealisations - Particle, Continuum, Rigid body and Point force with examples, principles of mechanics with examples

Welcome to the Fascinating World of Mechanics





What is Mechanics?

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.

What is Mechanics?

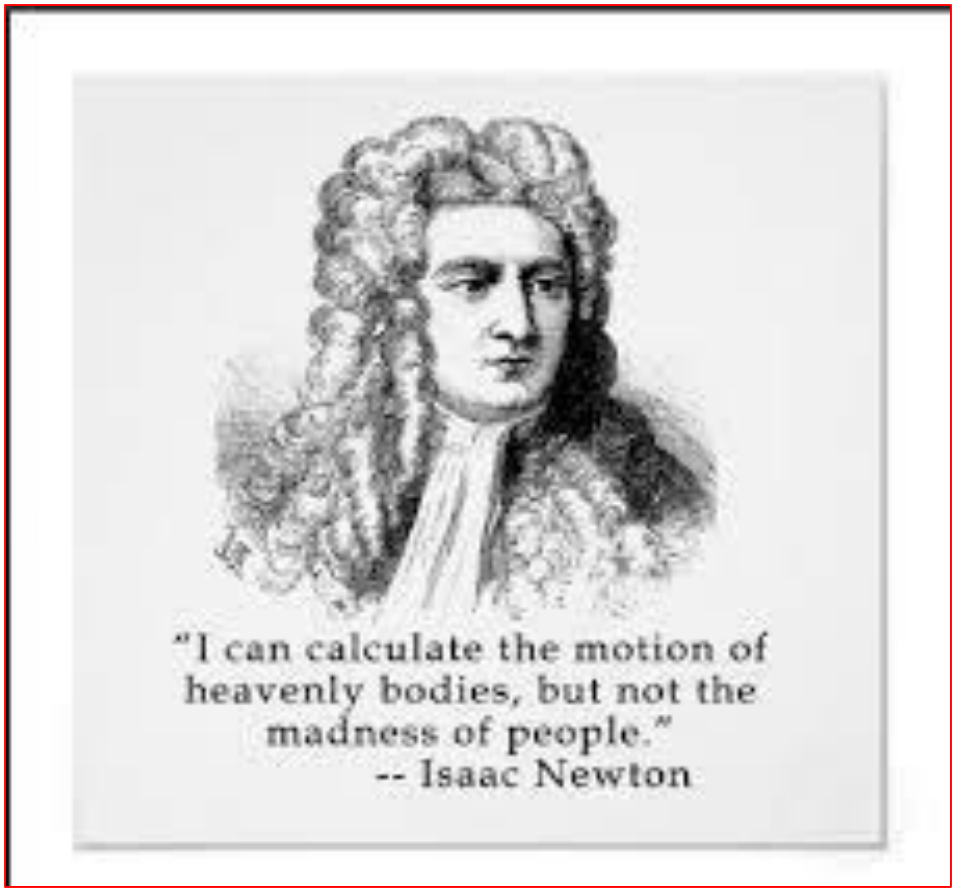
Engineering Mechanics is the Mechanics tailored entirely for ENGINEERS

It is also called NEWTONIAN MECHANICS

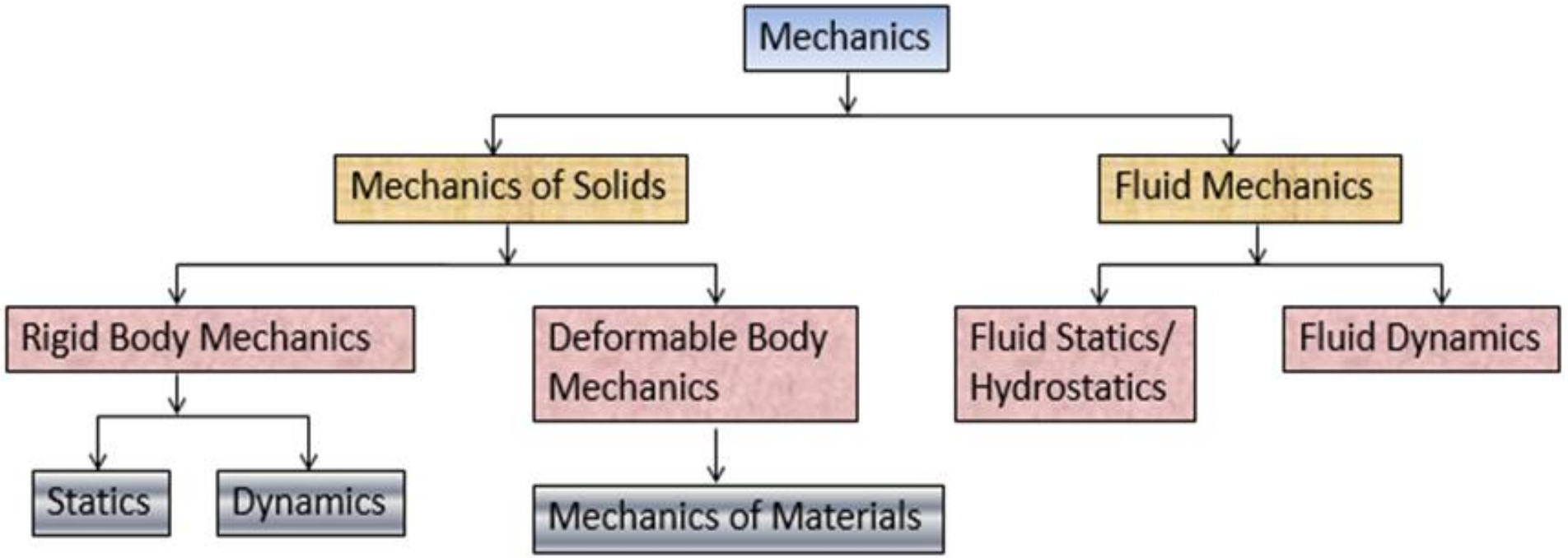
Important Developments in the History of Mechanics

400 BC	Archytus of Tarentum - Theory of Pulleys
287-212 BC	Archimedes - Lever equilibrium, buoyancy principle
1452-1519	Leonardo da Vinci - Equilibrium, concept of moments
1473-1543	Copernicus - Proposed that the earth revolves around the sun
1548-1620	Stevinus - Inclined planes, parallelogram law for addition of forces
1564-1642	Stevinus, Galileo - Virtual work principles
1564-1642	Galileo - Dynamics of pendulums, falling bodies
1629-1695	Huygens - Accurate measurement of the acceleration due to gravity
1642-1727	Newton - Law of universal gravitation, laws of motion
1654-1722	Varignon - Work with moment and force relationships
1667-1748	Bernoulli - Application of virtual work to equilibrium
1707-1793	Euler - Rigid body systems, moments of inertia
1717-1783	D'Alembert - Concept of inertia force
1736-1813	Lagrange - Formalized generalized equations of motion
1792-1843	Coriolis - Work with moving frames of reference
1858-1947	Planck - Quantum mechanics
1879-1955	Einstein - Theory of relativity

Father of Engineering Mechanics



Divisions of Mechanics



Some applications in which Mechanics plays an important role

- This robot must be designed to grip objects with appropriate force and carry out the motions assigned to it.

Cont..

Besides the aesthetic demands, this bridge must be designed to safely withstand all the forces on it, including its own weight, traffic, wind, changes in temperature, and possibly even seismic disturbances (earthquakes)

Cont..

- As part of procedures to correct deformities in bones or to lengthen them, an external fixator is used to apply forces to the bones.

Cont..

- Disk drives for data storage are complex mechanical systems, in which high magnetic forces are used to swivel the arm carrying the recording head rapidly into position to read or write data.

Cont..

- Earthquakes result from large forces that build up between sliding tectonic plates that eventually slide past one another

Fundamental Concepts and their units

International System of units (SI) are adopted

- Length (L)
  - Unit is meter (m)
- Time (t)
  - Unit is seconds (s)
- Mass (m)
  - Unit is kilograms (kg)
- Force (F)
  - Unit is Newton (N)
  - 1 Newton is equal to a force required to give 1 kilogram of mass an acceleration of $1m/s^2$ ($1N = kg\text{-}m/s^2$)

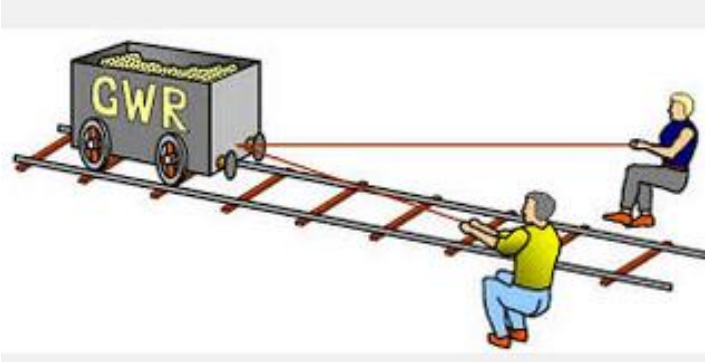
Mass

- Mass is a measure of a quantity of matter that is used to compare the action of one body with that of another.

- This property manifests itself as a gravitational attraction between two bodies and provides a measure of the resistance of matter to a change in velocity.

Force

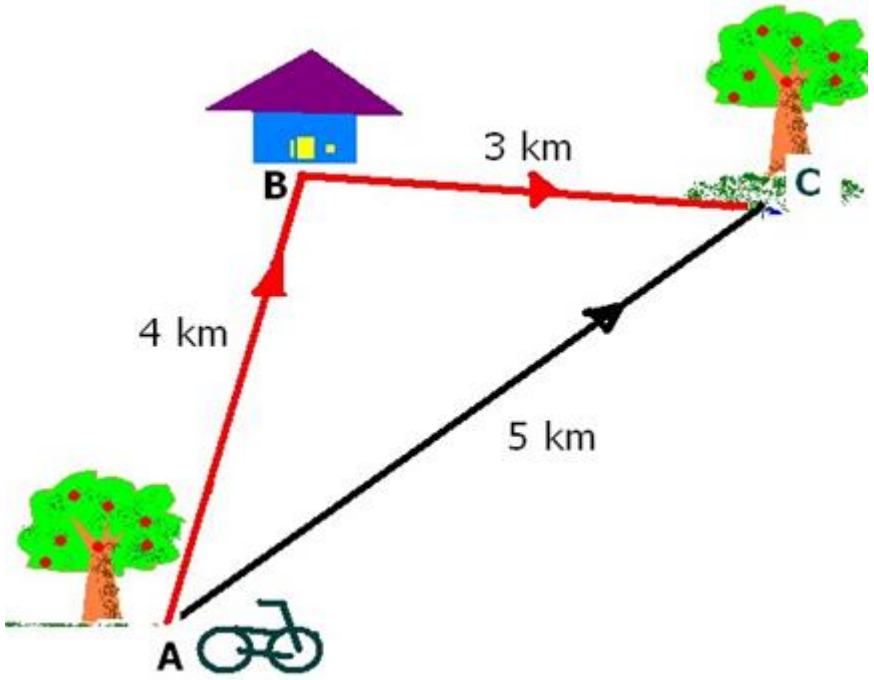
- In general, *force* is considered as a “push” or “pull” exerted by one body on another.
- This interaction can occur when there is direct contact between the bodies, such as a person pushing on a wall, or it can occur through a distance when the bodies are physically separated.
- Examples of the latter type include gravitational, electrical, and magnetic forces.
- In any case, a force is completely characterized by its magnitude, direction, and point of application.



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)



Basic Idealizations

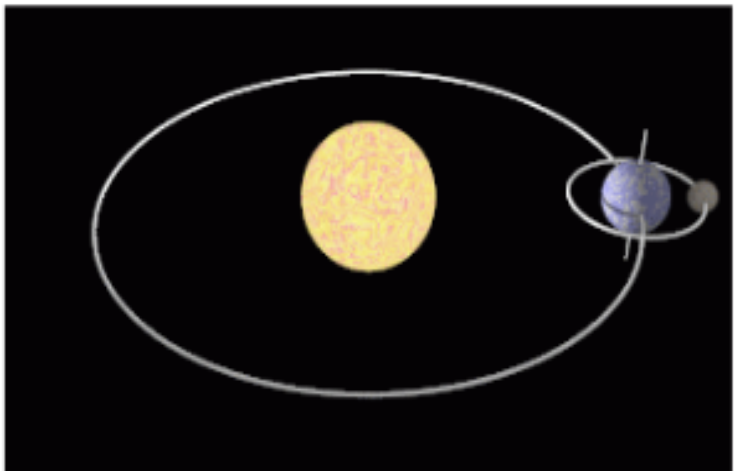
Three Important Idealizations

- Particle
  - This idealization helps as the geometry of the body will not be involved
- Rigid Body
  - 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
  - When the effect of a loading is assumed to act at a point on a body, it is a concentrated force

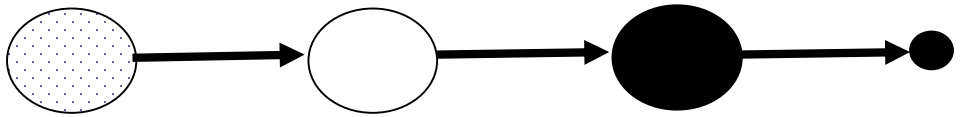
Basic Idealizations

Particle: A body with mass but with dimensions that can be neglected

- Size of earth is insignificant compared to the size of its orbit.
- Earth can be modeled as a particle when studying its orbital motion

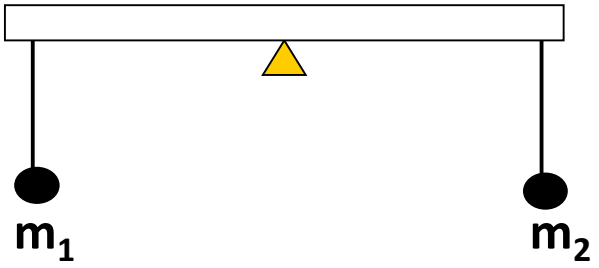


Basic Idealizations



Collection of Molecules | Continuum | Rigid body | Particle

Idealization of Steel ball



Rigid body

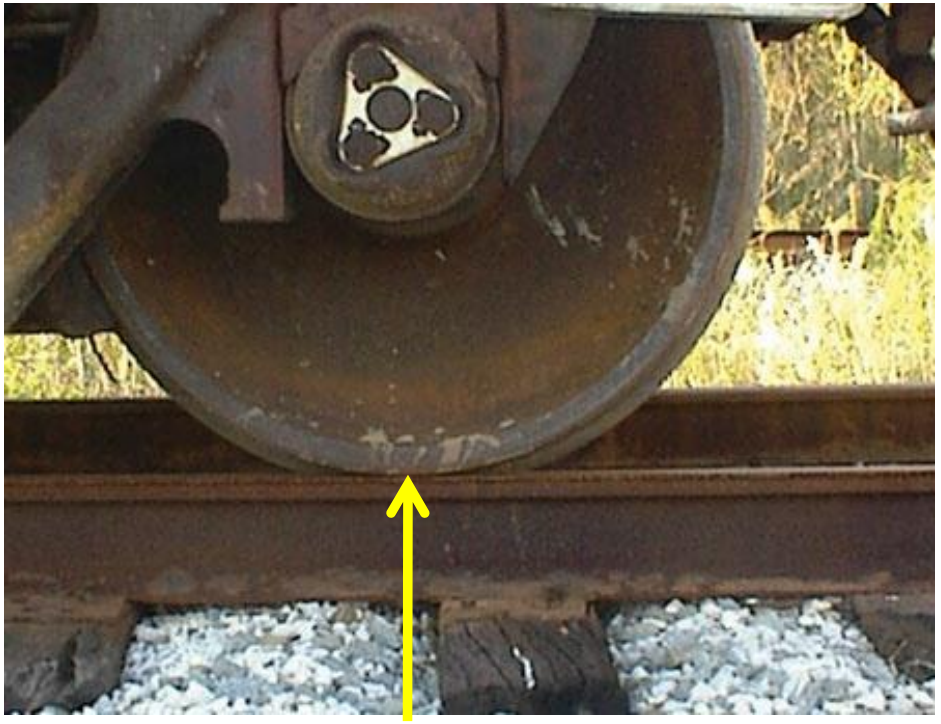
Concentrated Force

- The effect of a loading which is assumed to act at a point (CG) on a body. Provided the area over which the load is applied is very small compared to the overall size of the body

Ex: Contact Force between a wheel and ground.

Basic Idealizations

'A' is a hook in which 3 forces act. It can be considered as a particle



This rail wheel can be considered as a rigid body.
Force exerted between the wheel and rail is concentrated force

Summary

- Mechanics is the branch of science concerned with the behavior of physical bodies when subjected to forces or displacements, and the subsequent effects of the bodies on their environment

- The important divisions of Mechanics include statics, dynamics, kinematics and kinetics

- The basic idealizations or assumptions of Mechanics are body as a rigid body, continuum, particle and point force

- A force is an entity that changes the state of rest or uniform motion of a body