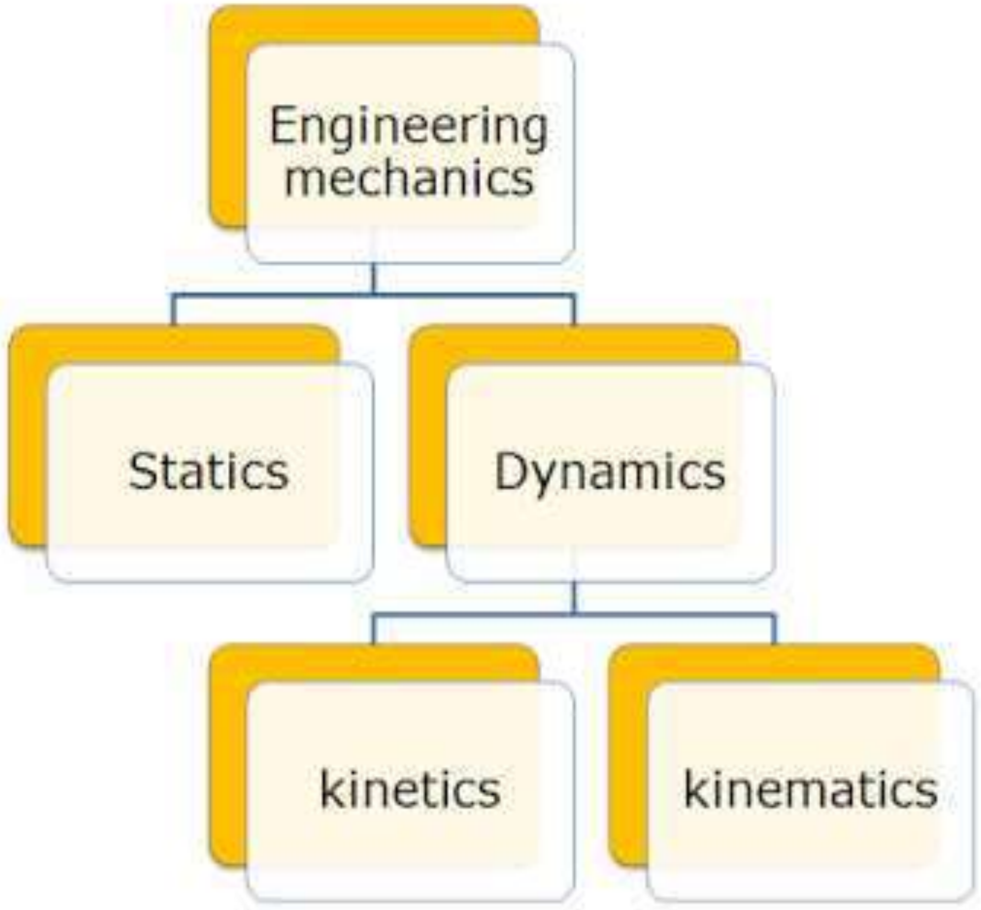
Unit - I - Simple and Compound Stresses

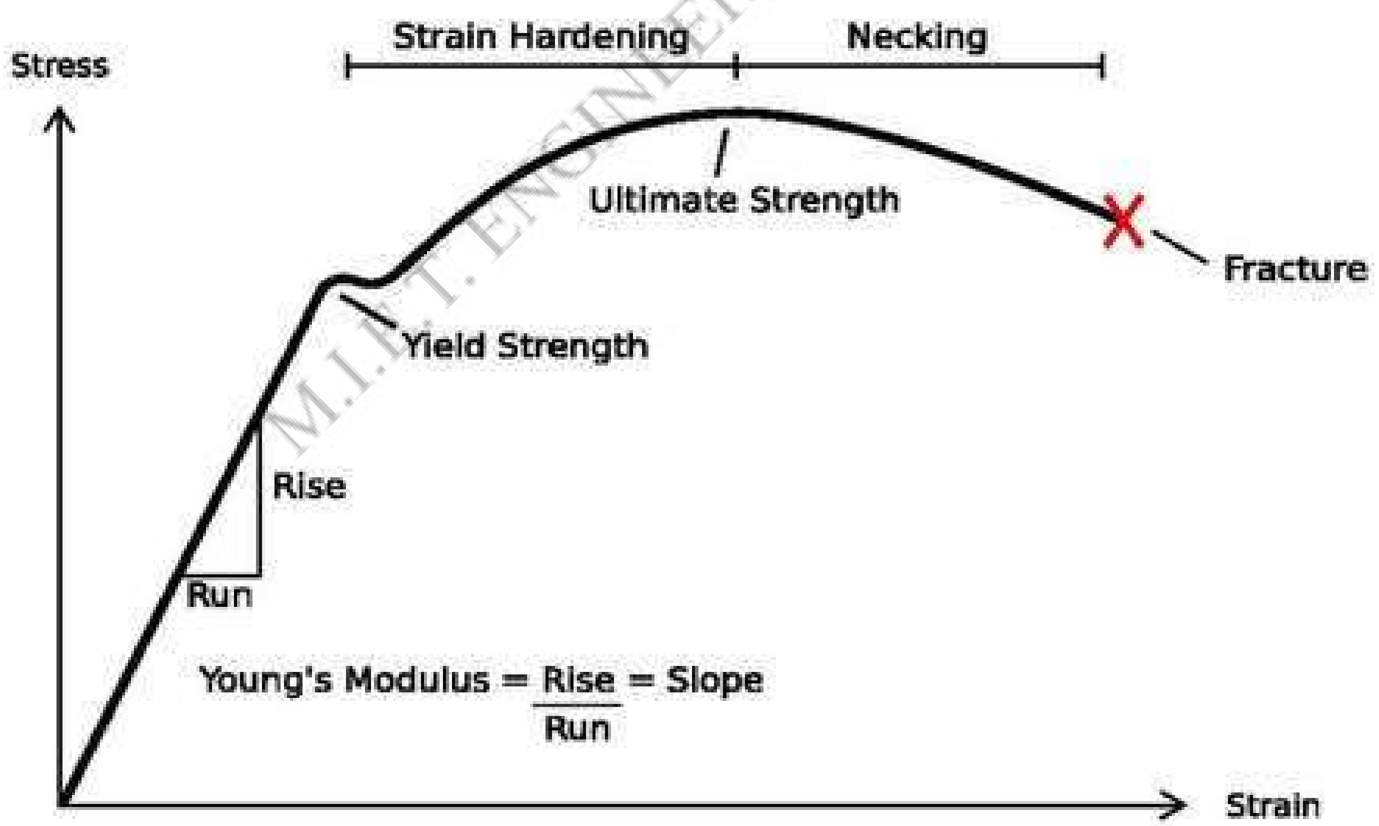
1. Stress and Strain at a Point
2. Tension , Compression and Shear Stress
3. Hooke's Law
4. Relationship among elastic Constants
5. Stress-Strain Diagram for Mild Steel , TOR Steel, Concrete.
6. Ultimate Stress, Yield Stress, Factor of Safety, Thermal Stresses
7. Determination of Principal Stresses and Principal Planes
8. Mohr's Circle of Stresses
9. Volumetric strain



Ultimate stresses

Ultimate stress refers to **the maximum stress that a given material can withstand under an applied force**

The **maximum stress** it withstands before fracturing is its **ultimate strength**



Thermal stresses

- Thermal stresses are the stresses induced in a body due to change in temperature.
- The corresponding strain is called thermal strain.
- Thermal stresses are setup in a body, when the temperature of the body is raised or lowered and the body is not allowed to expand or contract freely.
- Thermal stress is stress created **by any change in temperature to a material**. Temperature gradients, thermal expansion or contraction and thermal shocks are things that can lead to thermal stress. This type of stress is highly dependent on the thermal expansion coefficient which varies from material to material.

Types of Deformation

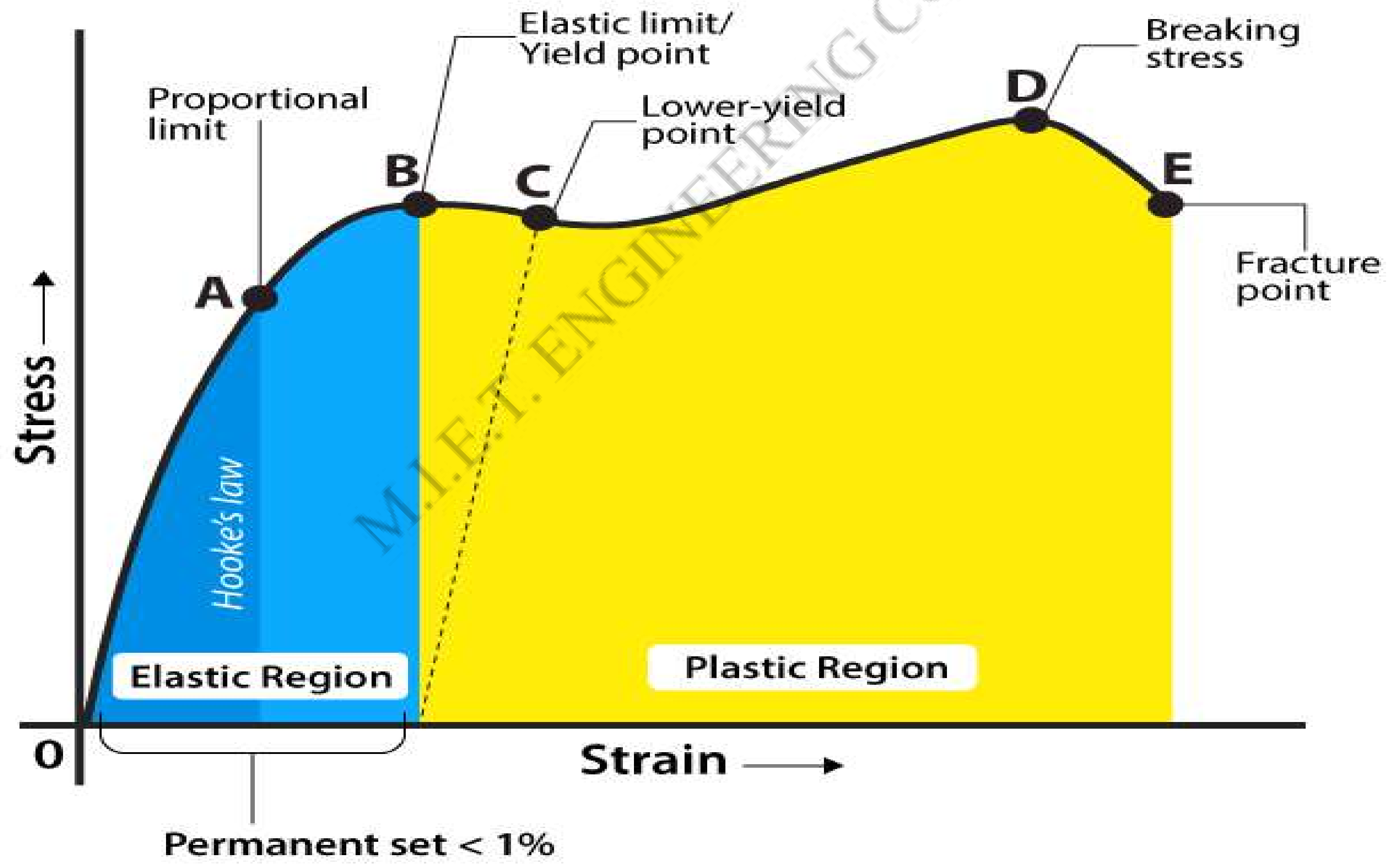
There are two different types of deformation: elastic and plastic.

- **Elastic deformation** will automatically reverse itself when external forces are removed. Imagine a rubber band - no matter how you stretch it, once you let go of one end it will 'snap' back to its original shape.

- **Plastic deformation** is a permanent deformation. To reverse it, an additional external force needs to be applied to return the object to its original shape. When you squeeze the middle of a plastic bottle, it compresses and stays deformed even when you let go. You'd have to add pressure to the inside or squeeze the opposite direction to return it to normal.

Yield Stress

Yield stress, marking the transition from elastic to plastic behaviour, is **the minimum stress at which a solid will undergo permanent deformation or plastic flow** without a significant increase in the load or external force.



Factor of Safety

It is defined as the ratio of Ultimate stress to the Working or Permissible Stress.

Mathematically it is written as

$$\text{Factor of Safety} = \frac{Ultimate\ Stress}{Permissible\ Stress}$$

$$\text{Factors of safety} = \frac{\text{Ultimate strength}}{\text{Working stress}} \quad \text{for brittle materials}$$

$$= \frac{\text{Yield strength}}{\text{Working stress}} \quad \text{for ductile materials}$$

References

- Strength of Materials by Dr.R.K.Bansal
- https://nptel.ac.in/courses/112/107/112107146/
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Thank You

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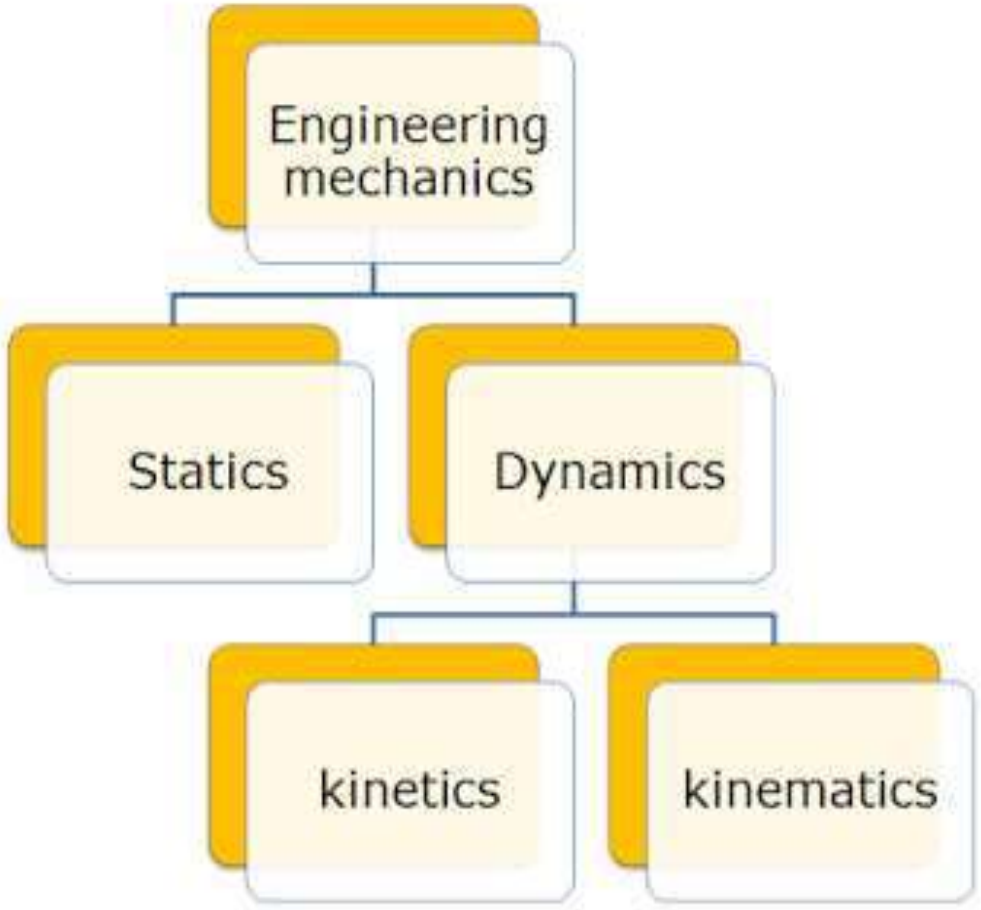


What is Stress?

Stress is defined as the force experienced by the object which causes a change in the object.

The stress formula is the divided product of the force by the cross-section area

$$\sigma = F/A$$

σ= refers to the amount of stress on the object

F= refers to the force that is acting on the object.

A = refers to the cross-sectional area

The unit of Stress is N/m^2

Types of Stress

- Compression
- Tension
- Shear
- Bending
- Torsion
- Fatigue

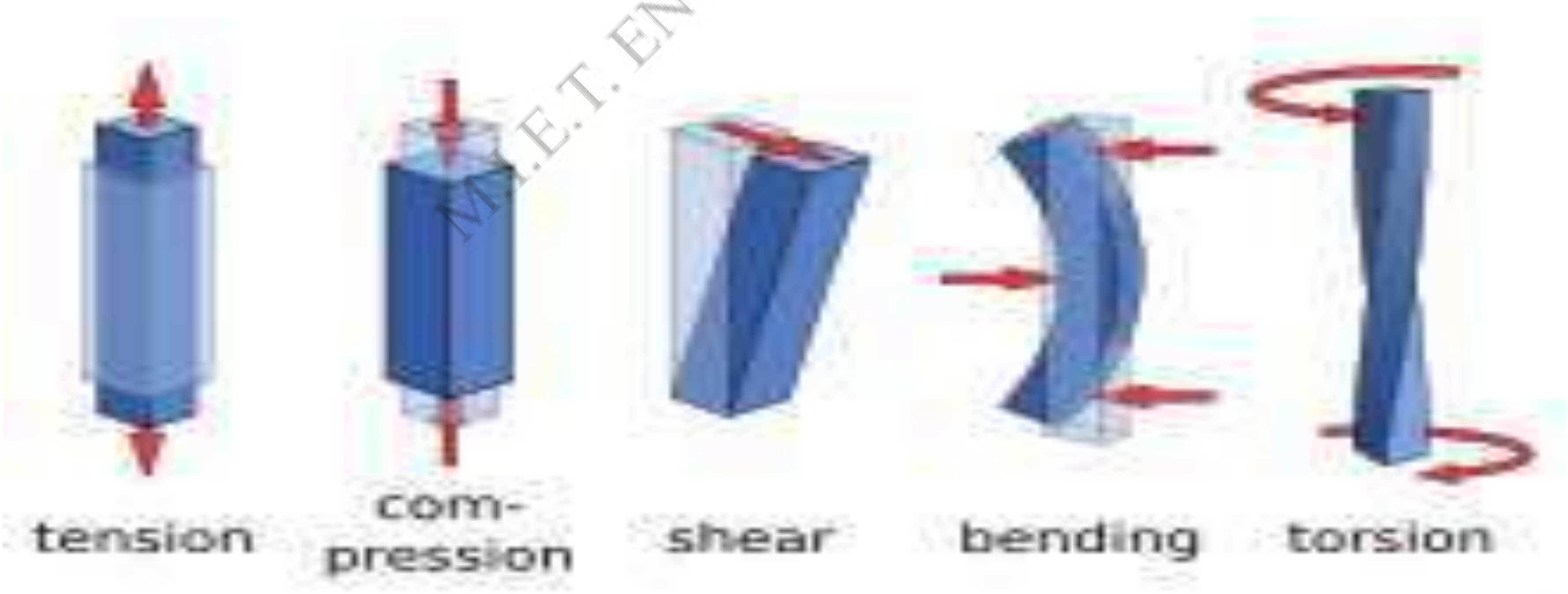
Compression

Compression stress is the result of axially-loaded forces pointing towards the center of an object.

There are two major issues with compression stress:

Compression forces can cause an object to shorten, or they can cause an object to buckle.

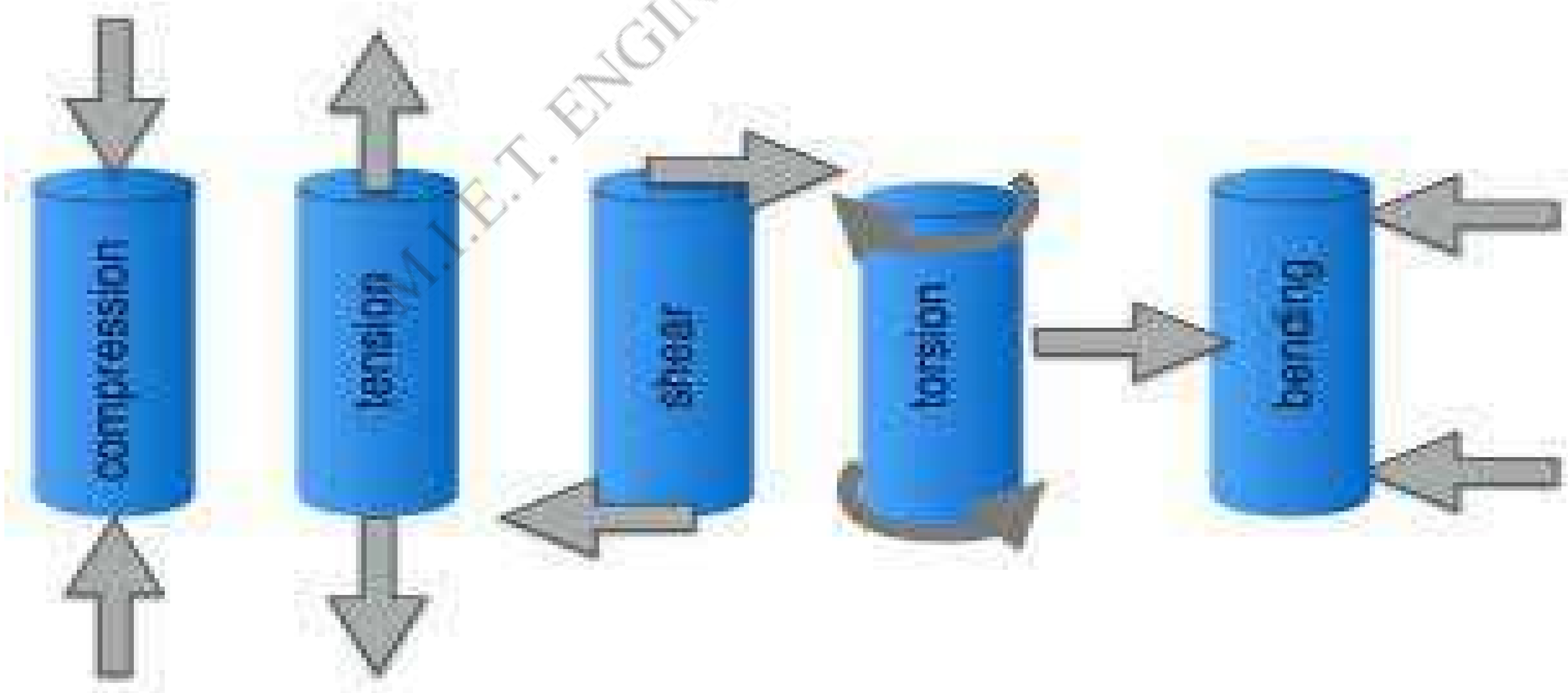
When an object buckles, it bends in such a way that it can no longer hold the load, even though structurally speaking, the object can hold more stress than is applied to it.



Tension

Tension stress is caused when axially-loaded forces are pulling away from an object's center, and perpendicular to the object's surface. Tension stress can cause lengthening of an object.

It is the force applied per unit area which results in the increase in length (or area) of a body. Objects under tensile stress become thinner and longer.

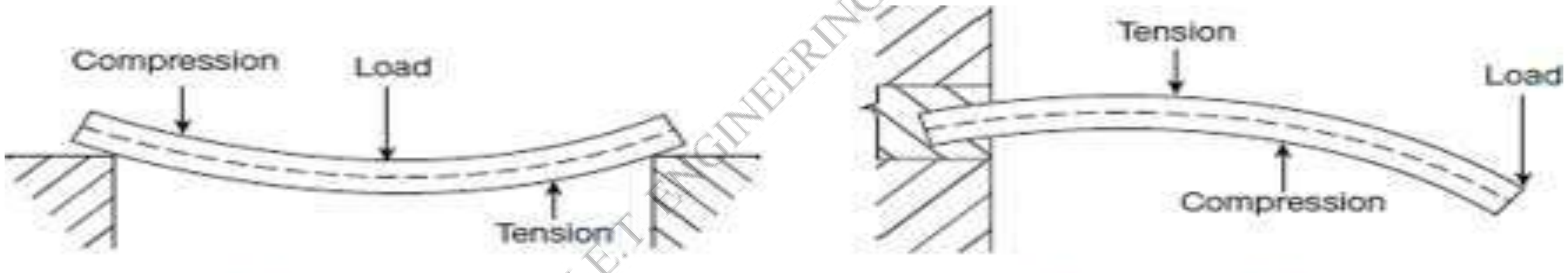


Shear Stress

Shear stress is caused when the forces applied to an object are parallel to the object's cross-section. This stress can cause the object to deform and, in some cases, pull apart. As the object deforms, it changes. The shape of the object can change, which can affect how the object withstands other forces.

Bending stress

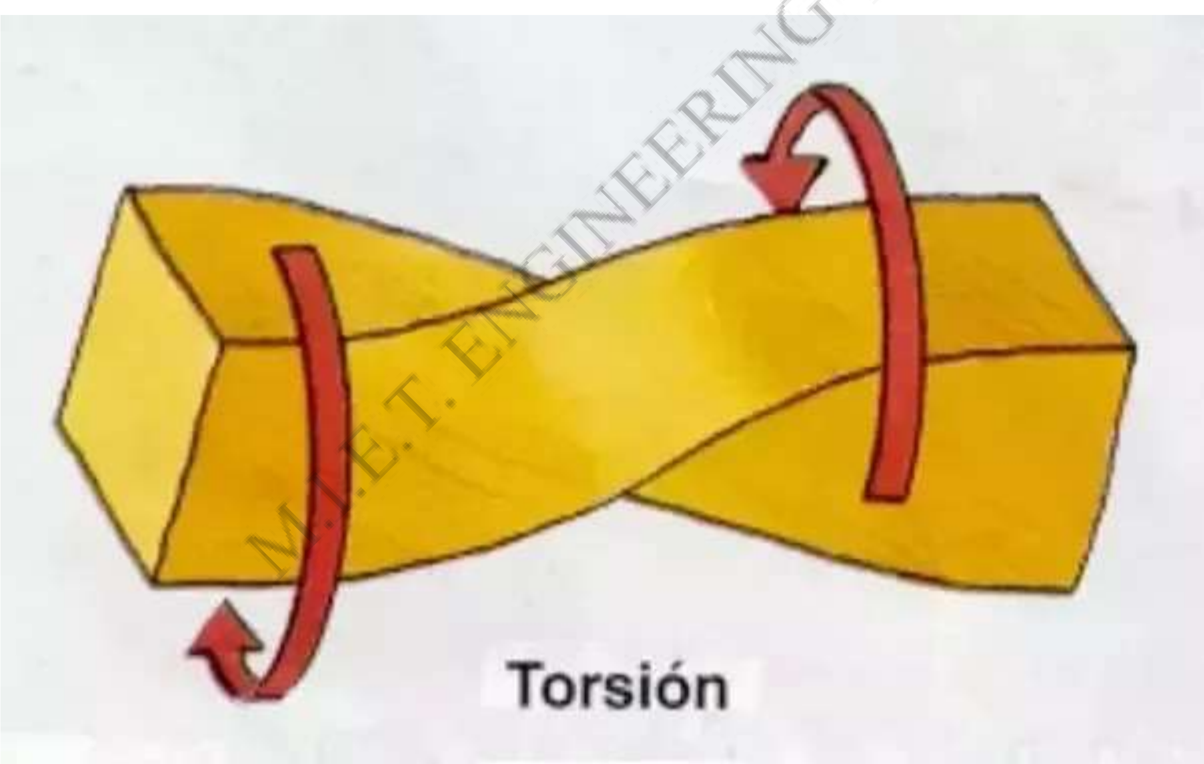
Bending stress is the normal stress that an object encounters when it is subjected to a large load at a particular point that causes the object to bend and become fatigued.



(a) Simply supported beam (b) Cantilever beam

Torsion

the field of solid mechanics, **Torsion** is the twisting of an object due to an applied torque. Torsion is expressed in either the Pascal (Pa), an SI unit for newtons per square metre.

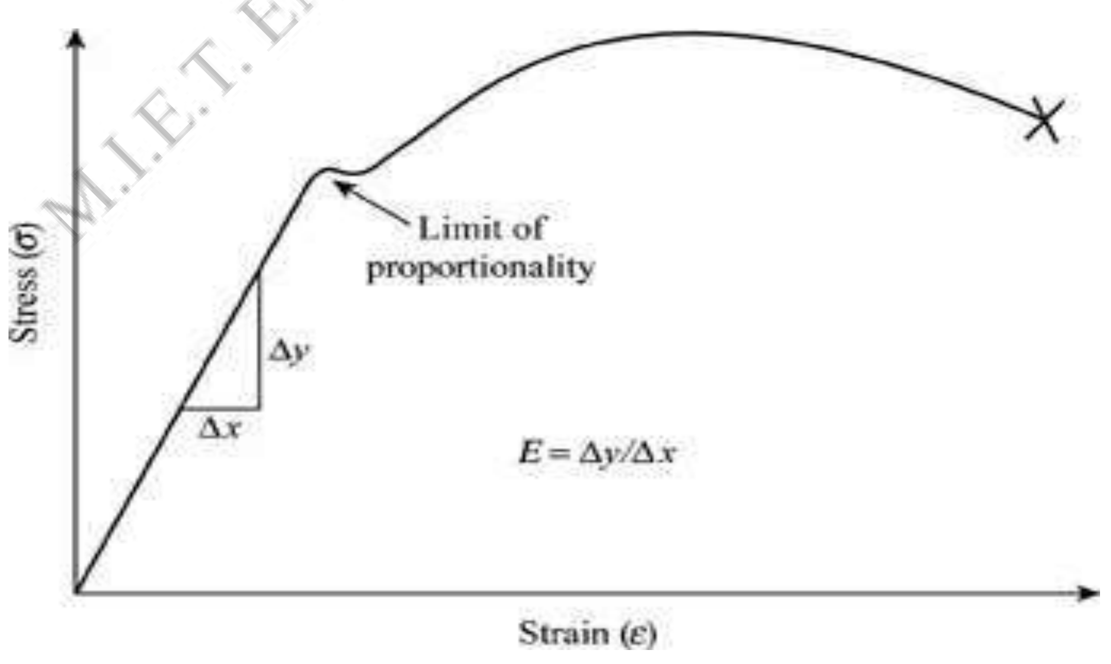


Fatigue

Fatigue is defined as a **process of progressive localized plastic deformation occurring in a material subjected to cyclic stresses and strains** at high stress concentration locations that may culminate in cracks or complete fracture after a sufficient number of fluctuations.

What is Hooke's Law?

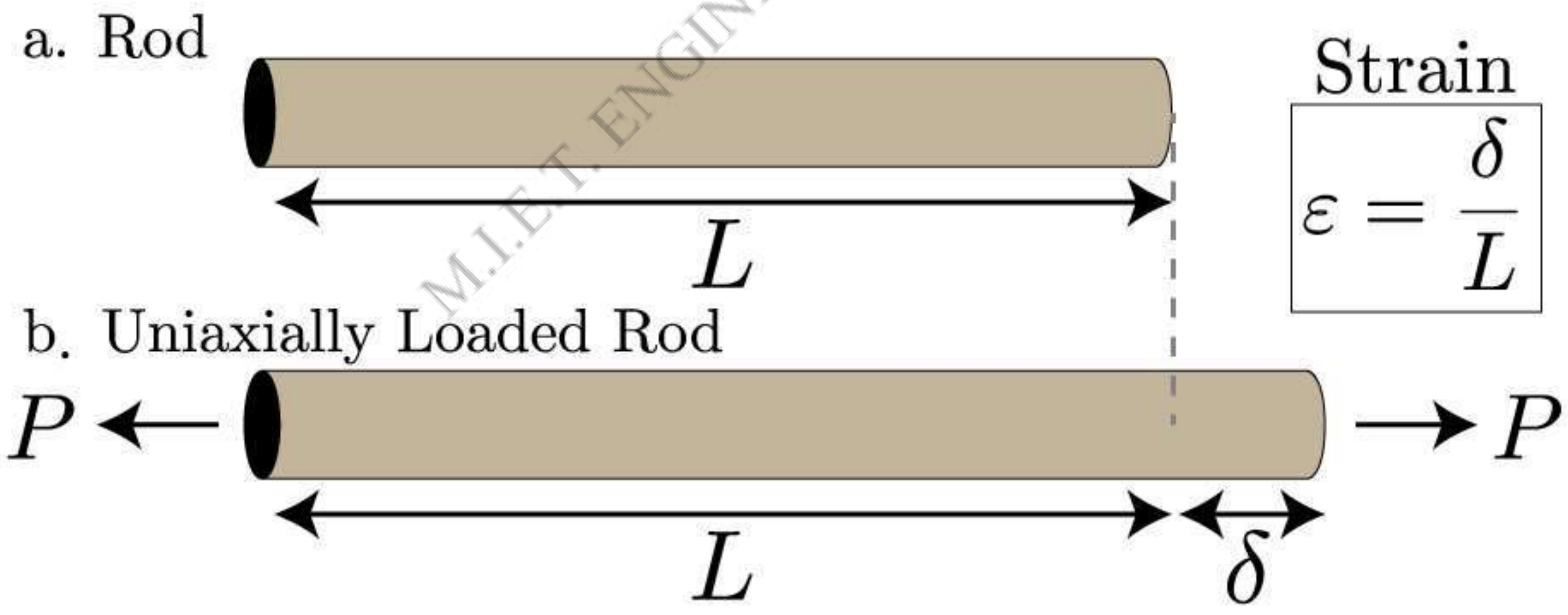
- Hooke's law states that when a material is loaded within elastic limit, the stress is proportional to the strain produced by the stress.
- This means the ratio of stress to the corresponding strain is a constant within the elastic limit.
- This constant is known as Modulus of Elasticity or Modulus of Rigidity.



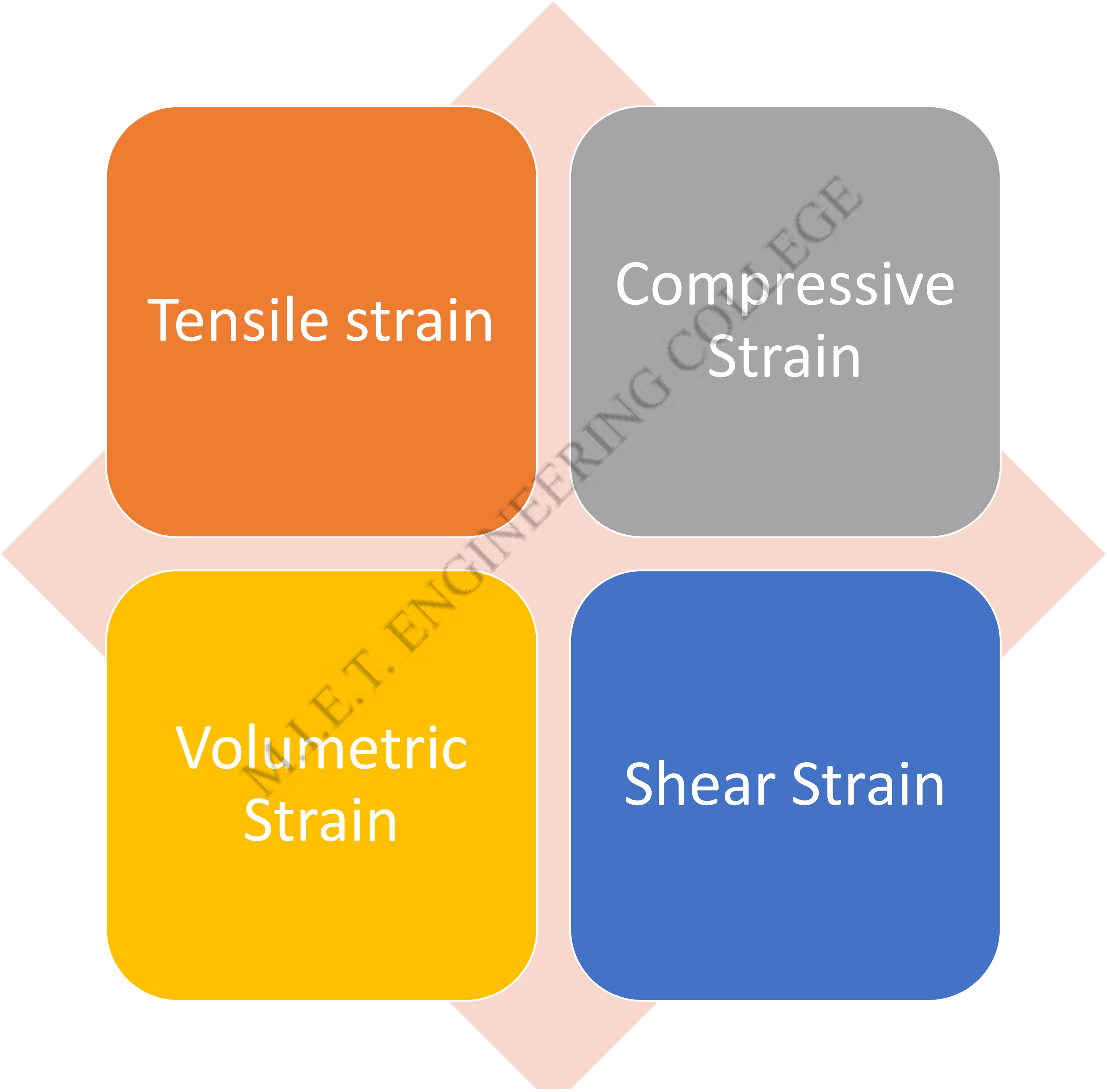
What is Strain?

When a body is subjected to some external force, there is some change in the dimension of the body. The ratio of change of dimension of the body to the original dimension is known as Strain

Strain is Dimensionless .



Types of Strain



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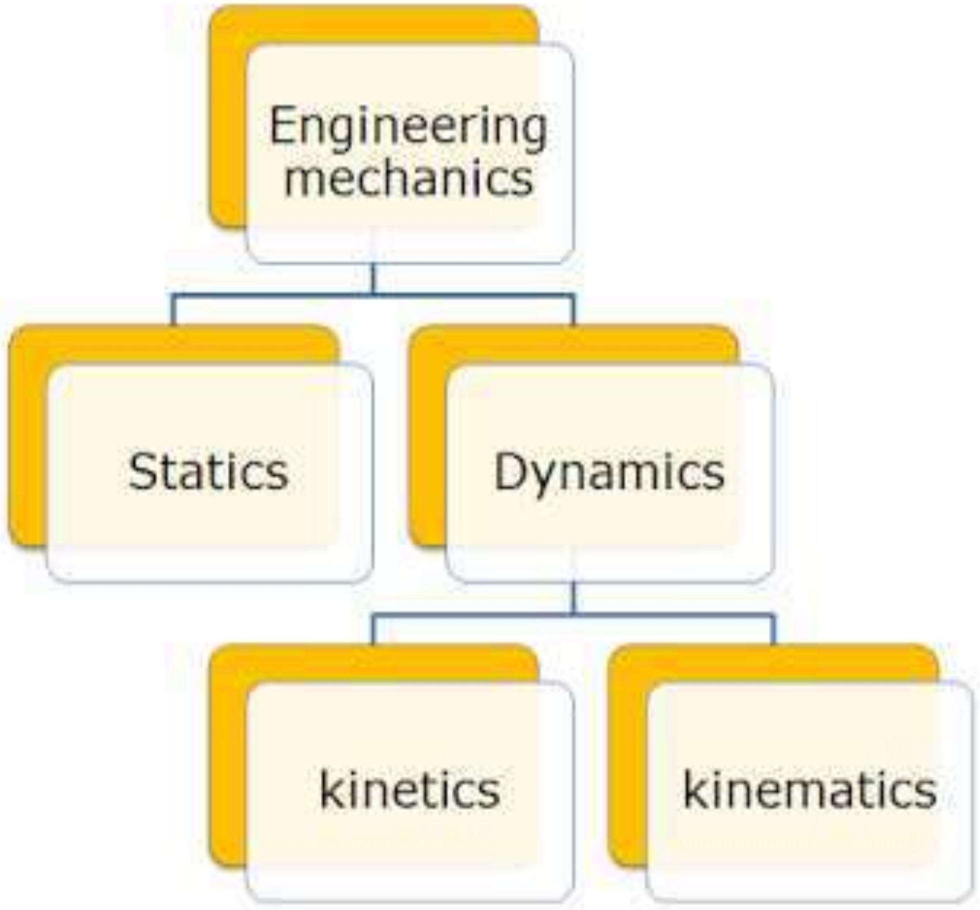
10. Compound Bars



Principal stresses and Principal Planes

The planes which have no shear stress, are known as Principal Planes.

Hence, Principal planes are the planes of Zero shear stress.

These planes carry only Normal stresses.

The Normal Stresses acting on a principal plane are Known as Principal stresses.

Methods of Determining Stresses on Oblique Section

Analytical Method

Graphical Method

Mohr Circle

Mohr’s Circle is the Graphical method of finding Normal, Tangential and resultant stresses on an oblique plane.

important points must be noted for graphical analysis by Mohr's circle:

Yield Stress

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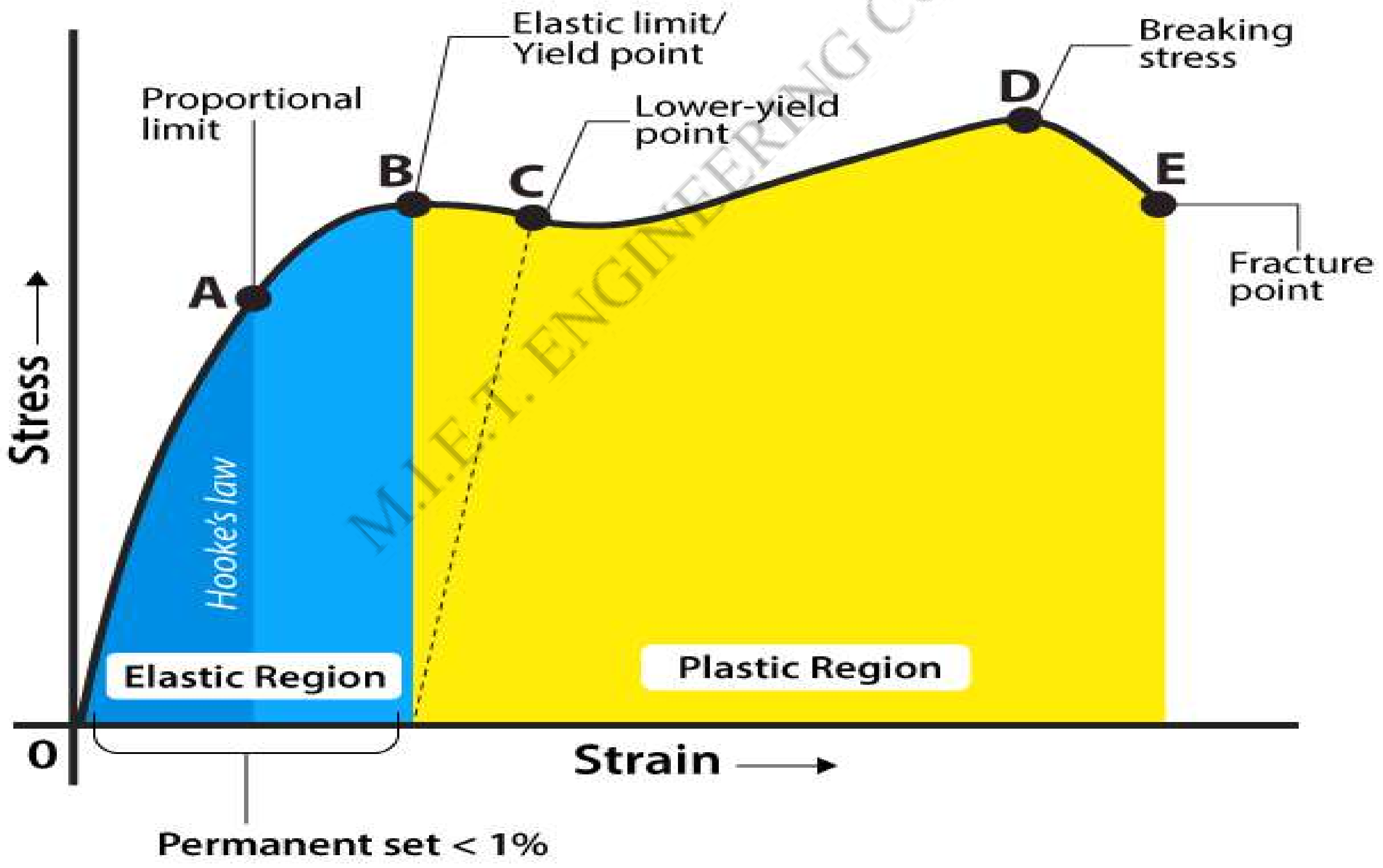

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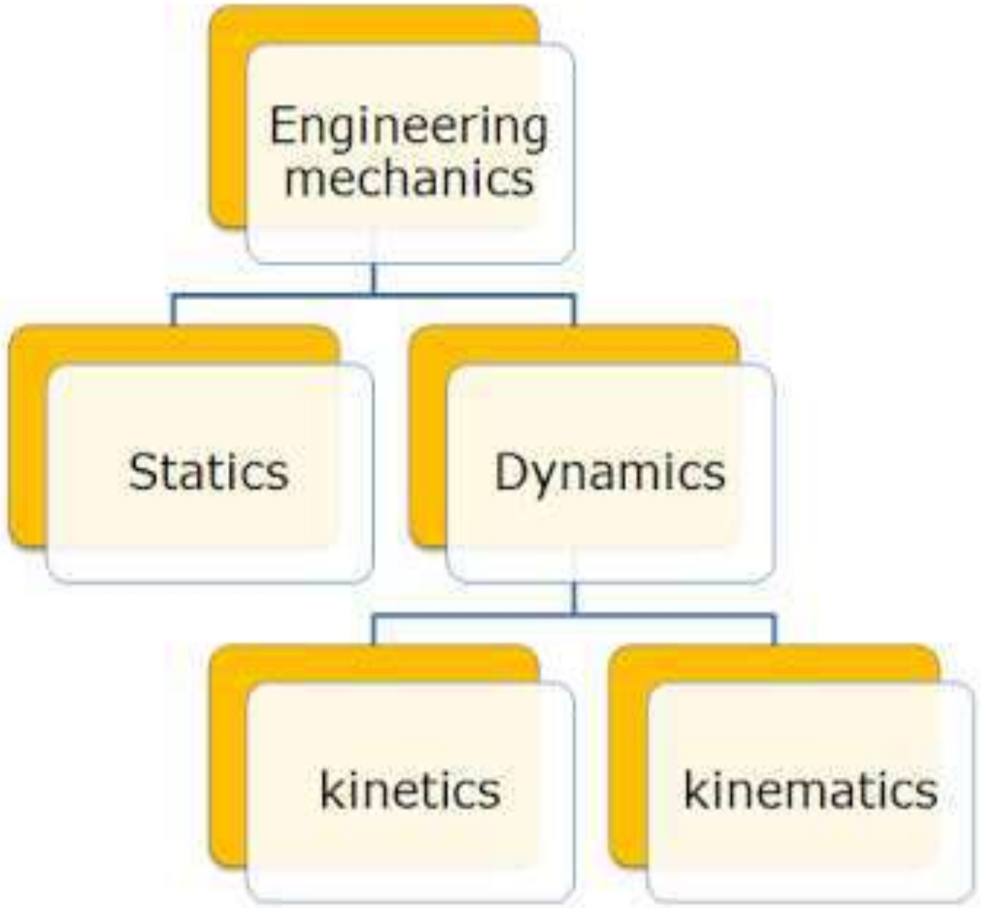
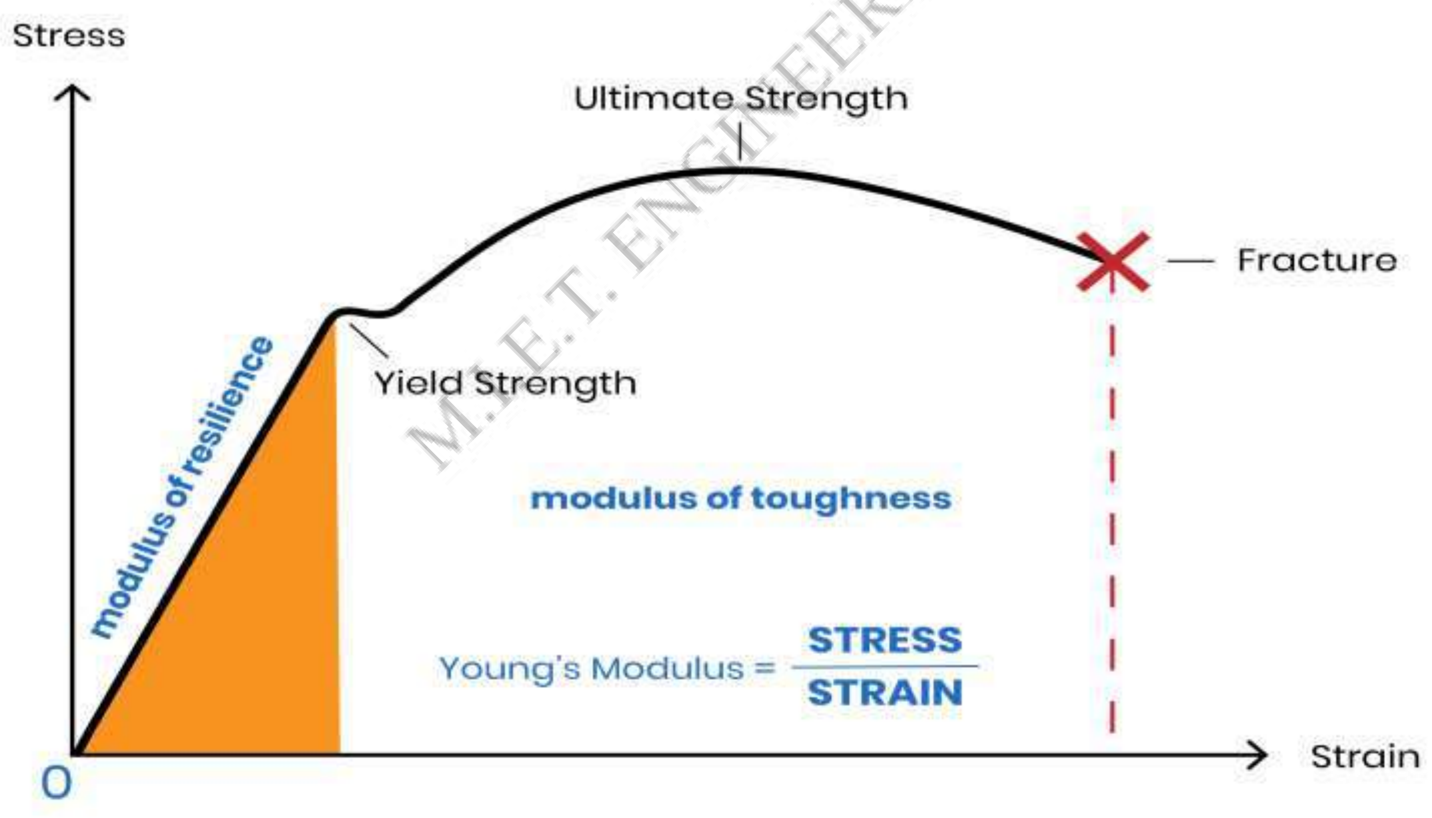


What are Elastic Constants?

Elastic constants are **the parameters expressing the relation between the stress and the strain on the materials within the stress range** that the materials exhibit elastic behaviour.



Types of Elastic Constants

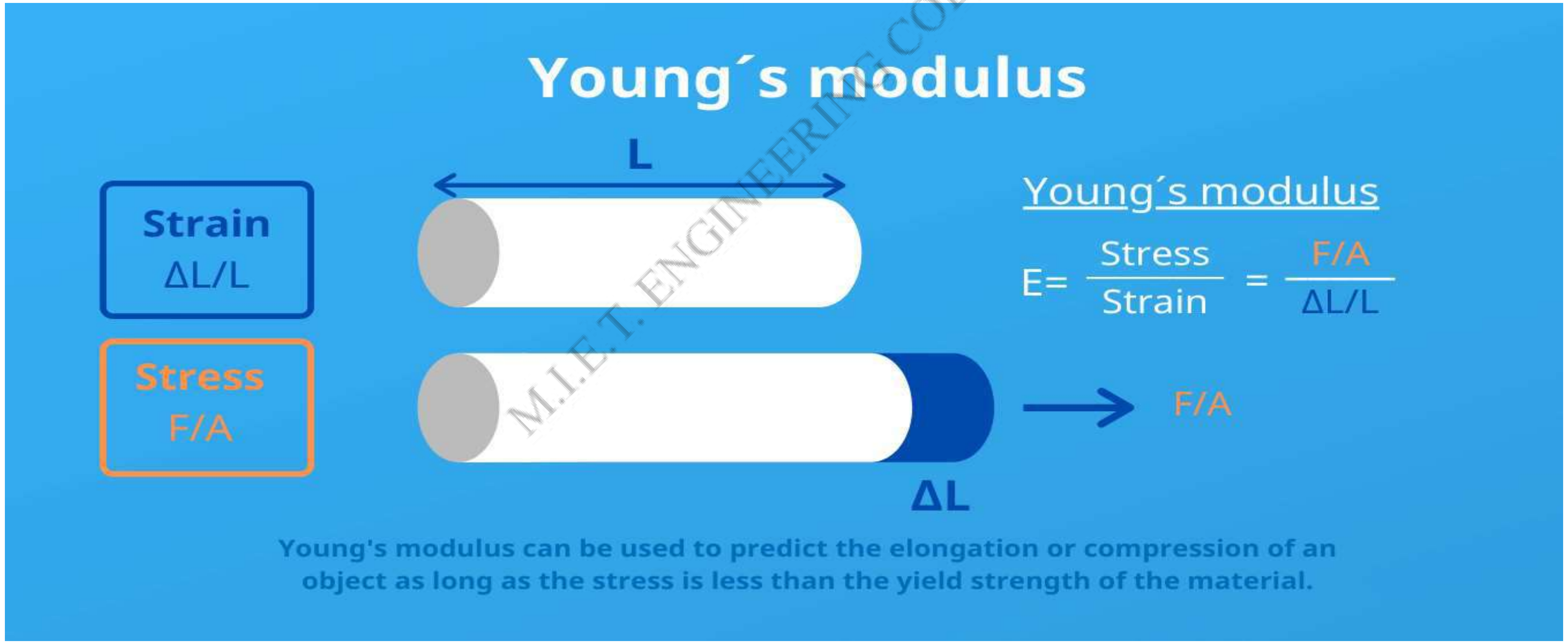
- Young's modulus.
- Bulk modulus.
- Rigidity modulus.
- Poisson's ratio.

Young’s Modulus

It is defined as the ratio of normal stress (σ) to the longitudinal strain (e).

It is also known as the Modulus of Elasticity.

It is Denoted by E.

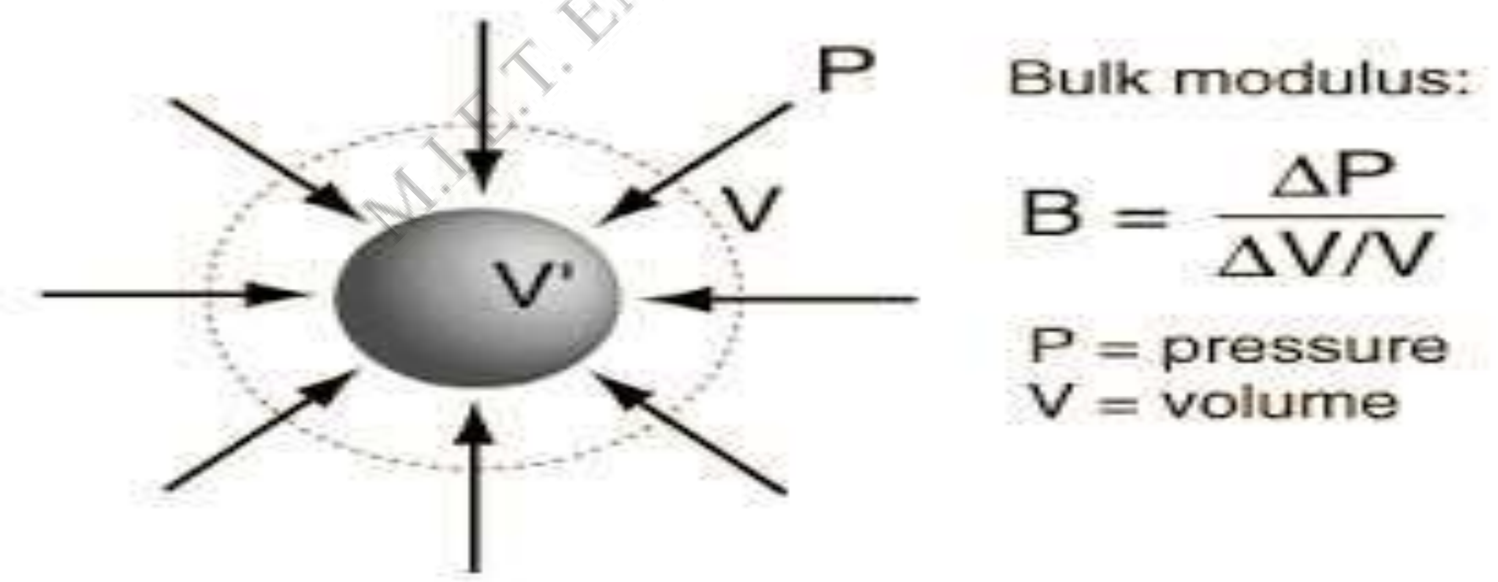


Bulk Modulus

The bulk modulus is **a measure of the ability of a substance to withstand changes in volume when under compression on all sides**. It is equal to the quotient of the applied pressure divided by the relative deformation.

It is also known as Volume Modulus of Elasticity . It is denoted by K.

K = Direct Stress / Volumetric strain



Rigidity Modulus

The **modulus of rigidity**, also known as shear modulus, is defined as a material property with a value equal to the shear stress divided by the shear strain.

It is the ratio between shear stress (τ) and shear strain (e_s). It is denoted by G or C

Formula

$$G = \frac{\tau}{\gamma} = \frac{\text{shear stress}}{\text{shear strain}}$$

G → Shear Modulus (Rigidity)

τ → shear stress

γ → shear strain

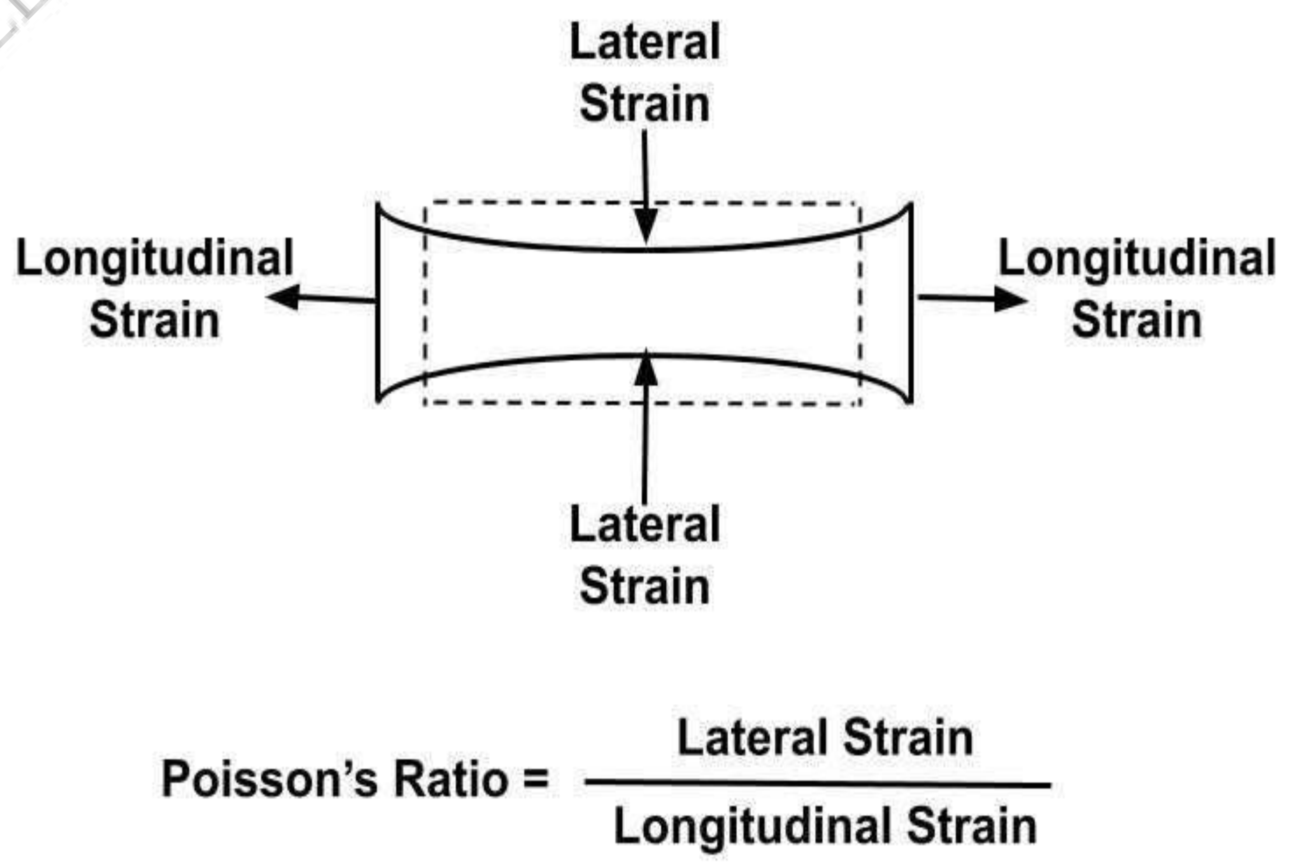
getcalc.com

Poisson's Ratio

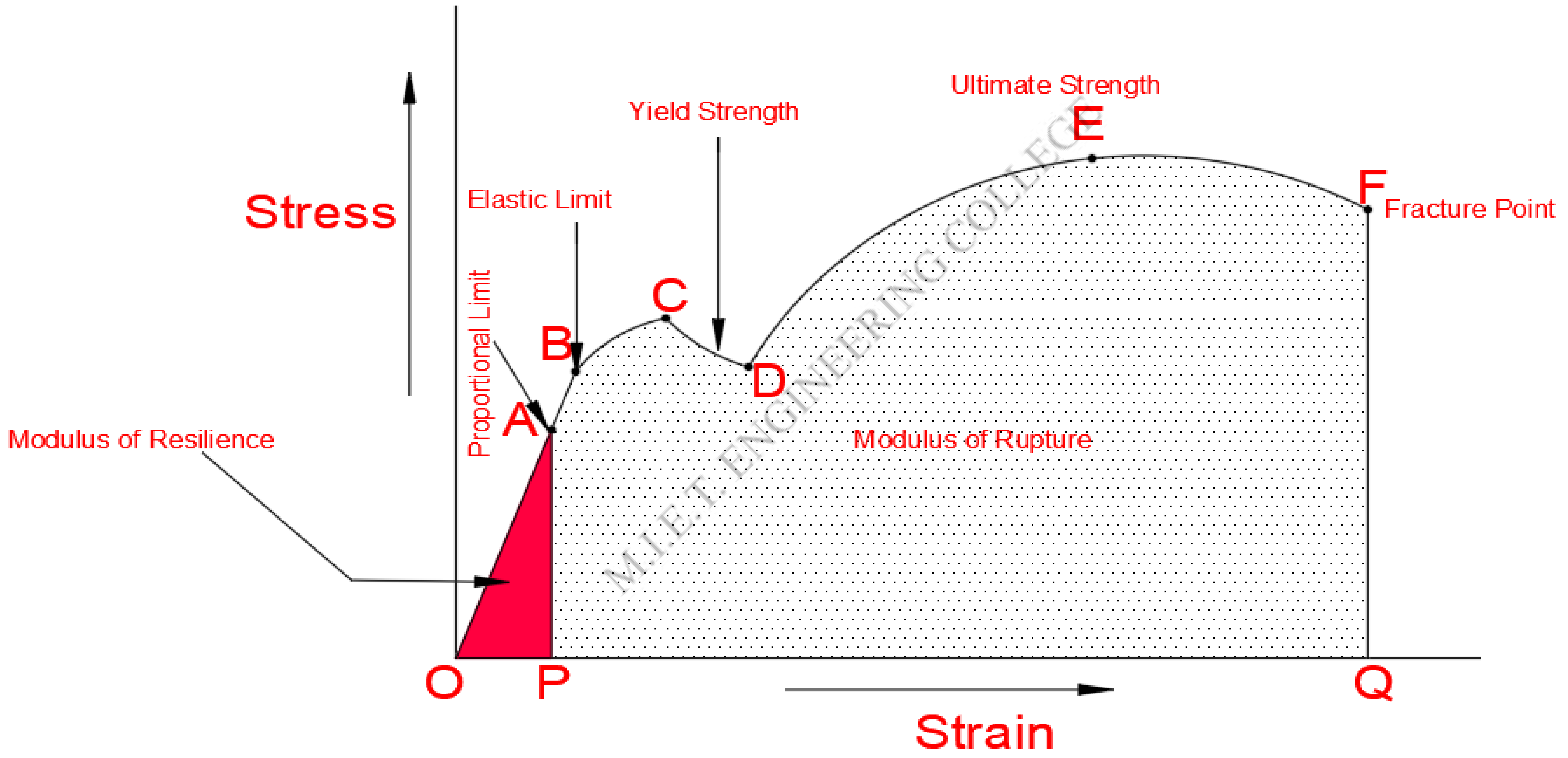
The ratio of lateral strain to the longitudinal strain is a constant for a given material, When the material is stressed within the elastic limit. This ratio is called Poisson's ratio.

It is denoted by μ.

μ = Lateral Strain/Longitudinal Strain



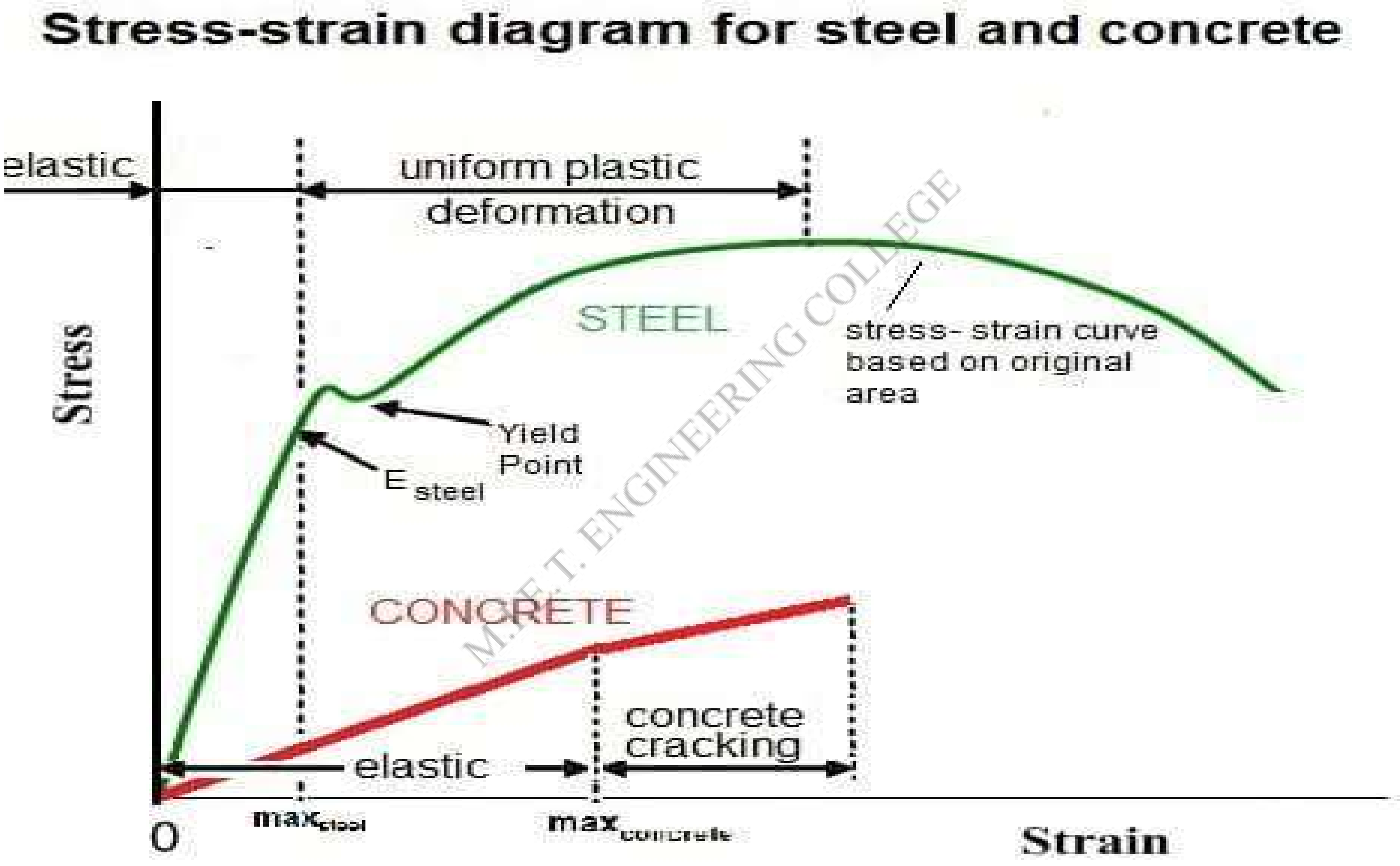
Stress- Strain Diagram for Mild steel



Stress-Strain Diagram of Mild Steel

1. If the stress is applied gradually to a mild steel rod, the strain also gradually increased that is represented in point 'A' In this stage when stress is removed from the rod the strain returns to '0'. Thus the '0' to 'A' points is called as **proportional limit**.
2. The increase of stress to the point 'B', the strain also increased proportionally it is called as **elastic limit** In this stage, if the applied stress is removed the strain returns to an original position that is rod gains to original shape.
3. The stress increased beyond the elastic limit, the material undergoes deformation. Which means the permanent extension occurs and the mild steel rod does not regain its original shape even after the stress is removed. This is expressed as 'C' to 'D' point in the graph which is called as **yield point**.
4. In Point 'C' at which maximum stress is required for a rod to undergo deformation is called as **upper yield point**
5. In point 'D' of which minimum stress is required for a rod to undergo deformation is called as **lower yield point**.
6. The increase of stress beyond this limit increases strain gradually to a point. This point is 'E' which is called as **ultimate stress** or ultimate strength point. Ultimate stress is the maximum stress the rod can withstand, thus this portion is called a strain hardening.
7. Further increase of stress beyond the ultimate stress, the localized reduction occurs in the cross sectional area of the rod which is the weakest point of the material. This is called as necking stage that means a **breaking point** stage. At this stage the mild steel rod breaks, thus the curve drops to the point 'F'.

Difference of Stress strain diagram of mild steel and concrete



What is difference between ductile and brittle material?

Ductile Material	Brittle Material
Solid materials that can undergo substantial plastic deformation prior to fracture are called ductile materials.	Solid materials that exhibit negligible plastic deformation are called brittle materials.
Percentage elongation of the ductile materials before fracture under tensile testing is higher.	Percentage elongation of the brittle materials before fracture under tensile testing is very less.
Ductile materials fail gradually by neck formation under the action of external tensile loading.	Brittle materials fail by sudden fracture (without any warning such as necking).
Energy absorbed by ductile materials before fracture under tensile testing is more.	Brittle materials absorb very small energy before fracture.
Various metal forming operations (such as rolling, forging, drawing, bending, etc.) can be performed on ductile materials.	Forming operations cannot be easily performed on brittle materials. For example, brittle material cannot be drawn into wire.
Ductile materials show longer life when subjected to fatigue loading.	Brittle materials fail faster when subjected to fatigue loading.
Examples of ductile material: •Mild steel •Aluminium •Copper •Rubber •Most plastics	Examples of brittle material: •Cast iron •Ceramics such as glass, cement, concrete, etc. •Stone •Ice

Problem

- A rod 150 cm long and diameter of 2 cm is subjected to an axial pull of 20kN. If the modulus of elasticity of the material of the rod is $2X10^5$ N/mm^2. Determine the stress, strain and elongation of rod.

References

- Strength of Materials by Dr.R.K.Bansal
- https://nptel.ac.in/courses/112/107/112107146/
- https://youtu.be/aQf6Q8t1FQE

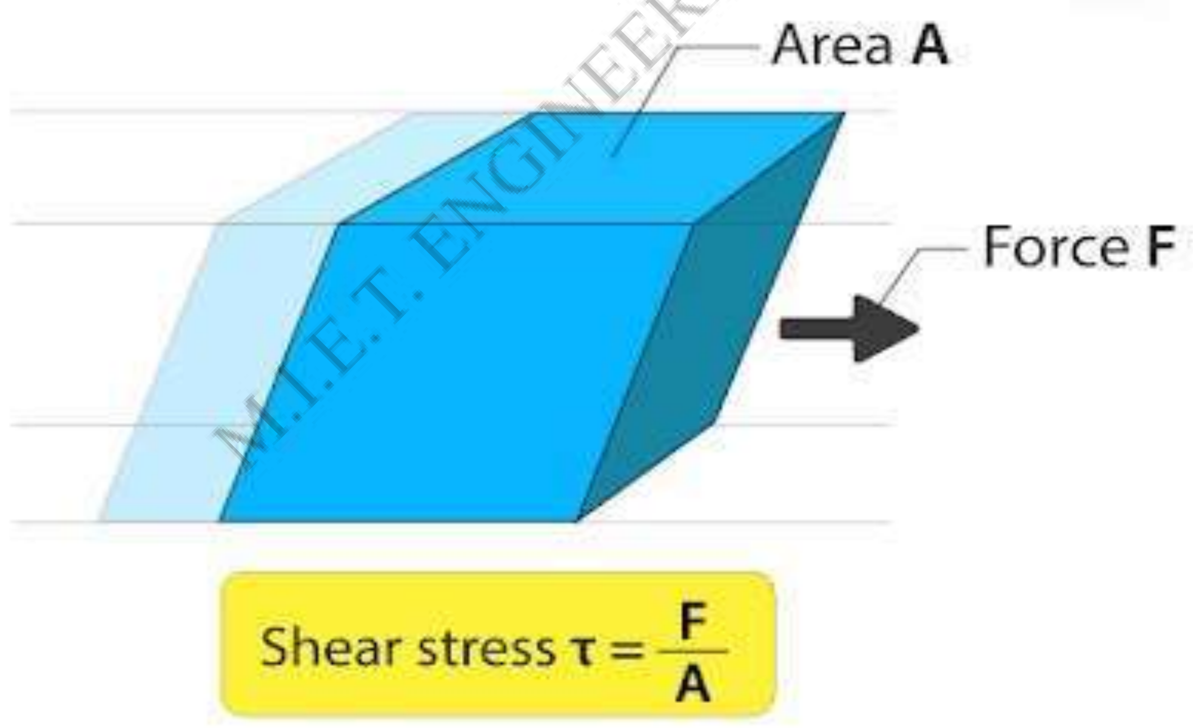
Unit - II -Bending of Beams

1. Beams and Bending
2. Types of loads, Supports
3. Shear force and bending moment diagrams for statically determinate beams with concentrated load, UDL, UVL
4. Theory of Simple Bending
5. Analysis of beams for stresses.
6. Stress Distribution at a C/S due to BM and Shear.

What is Shear Force?

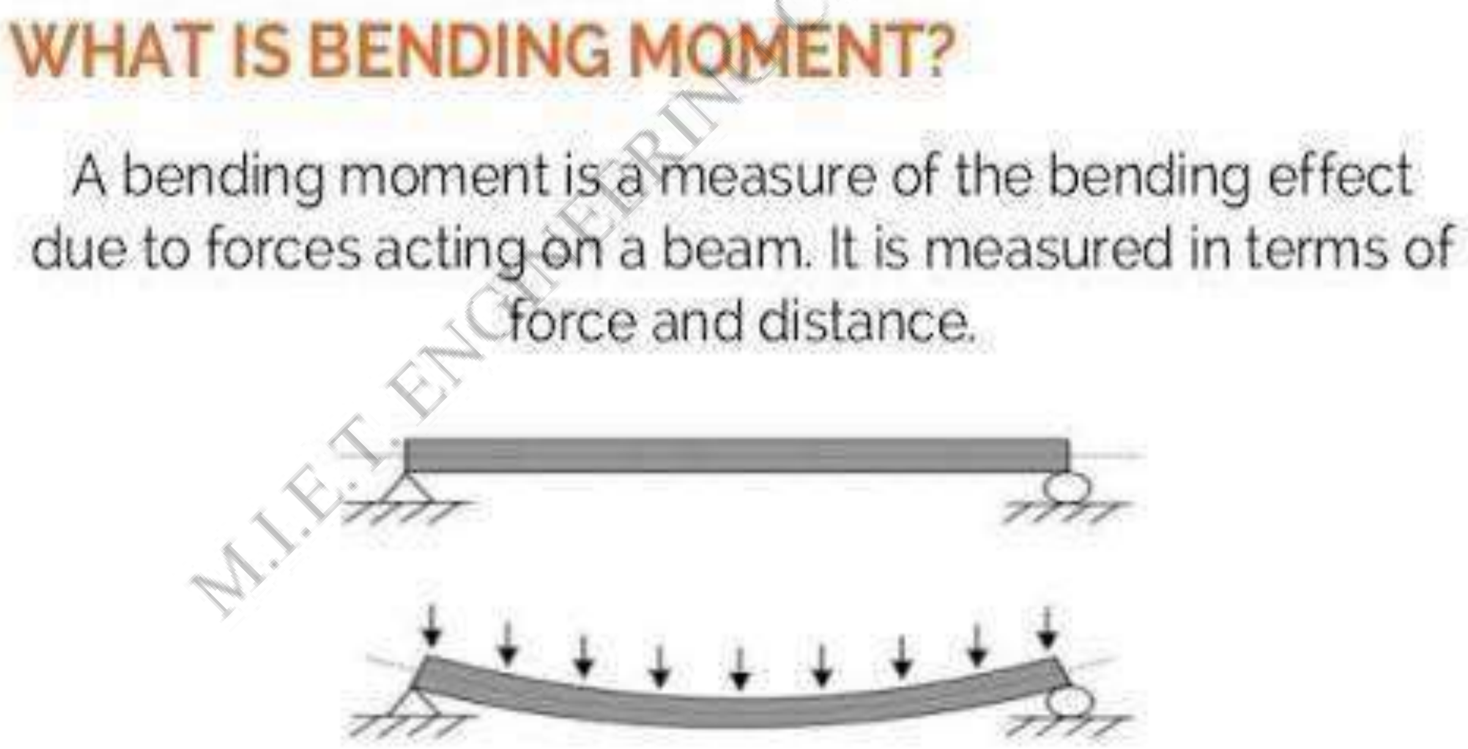
The algebraic sum of the vertical forces at any section of the beam to the right or left of the section is known as Shear Force.

https://youtu.be/C-FEVzI8oe8



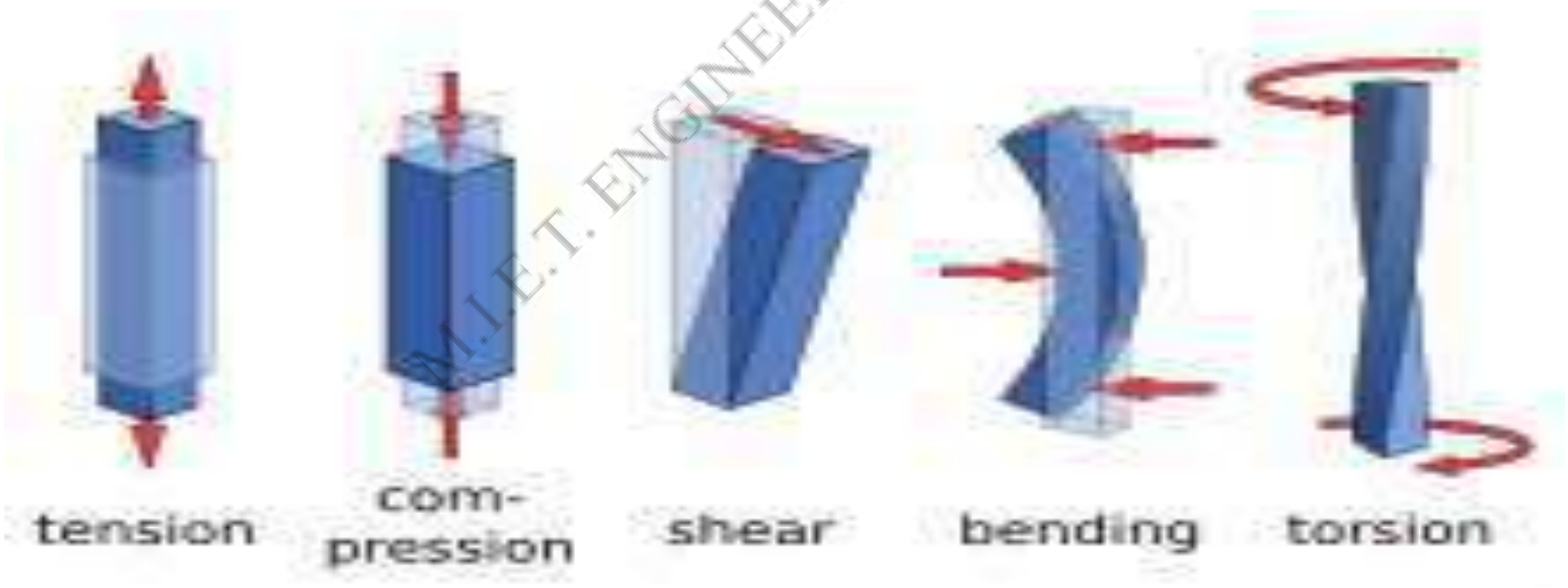
What is Bending Moment?

- The algebraic sum of the moments of all forces acting to the right or left of the section is known as Bending Moment.



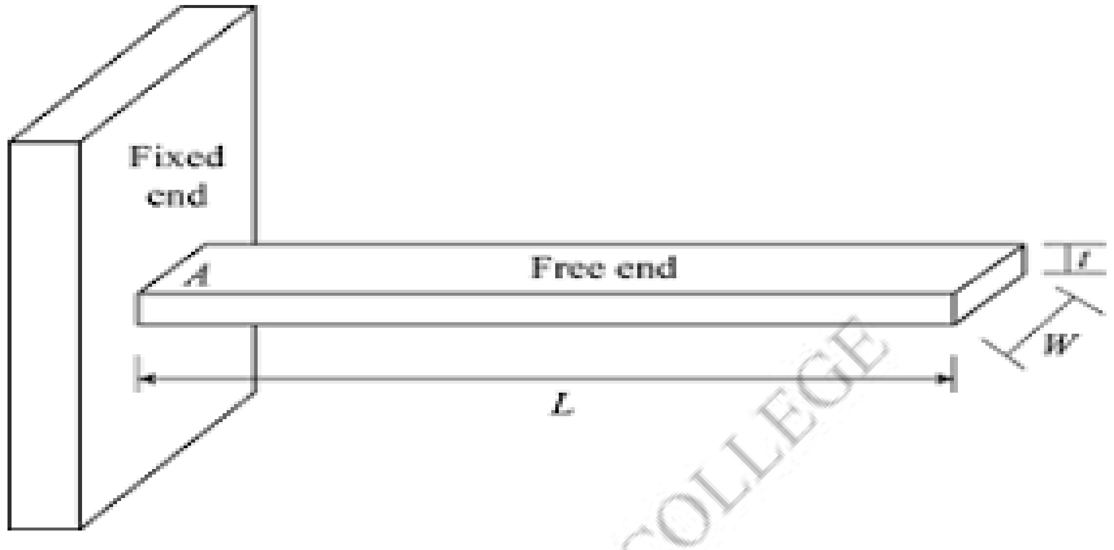
Shear force and Bending Moment Diagrams

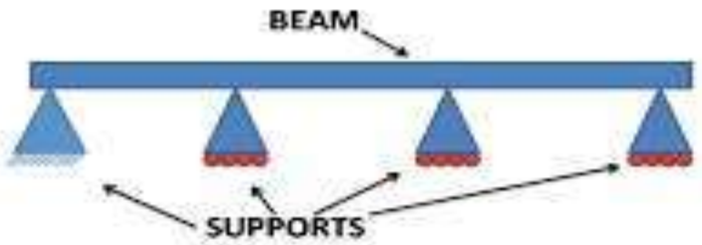
- A shear force diagram is the one which shows the variation of the shear force along the length of the beam.
- A Bending moment diagram is the one which shows the variation of the bending moment along the length of the beam.

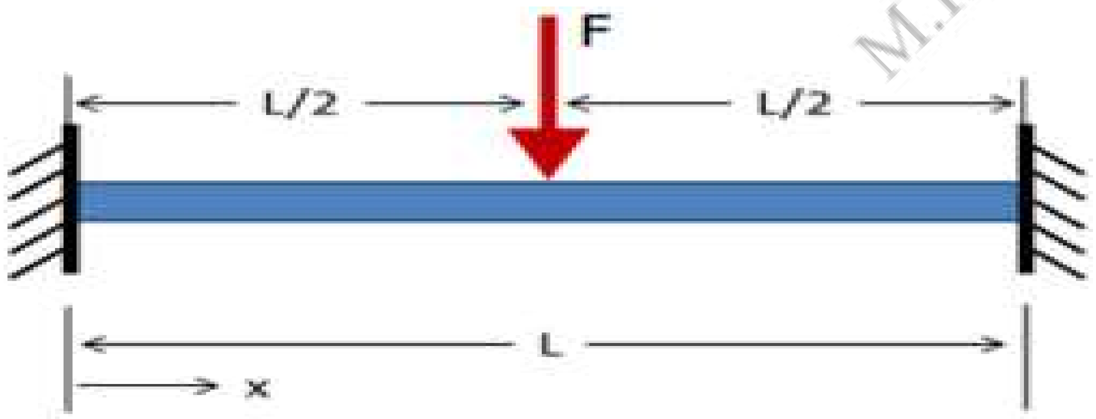


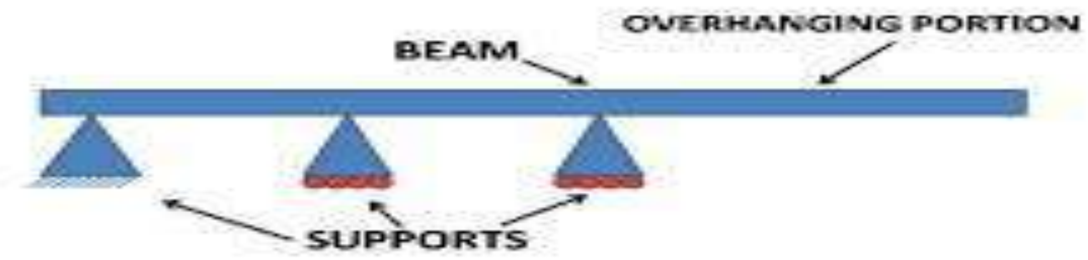
Types of Beams

1. Cantilever Beam
2. Simply Supported beam
3. Overhanging Beam
4. Fixed Beam.
5. Continuous Beams



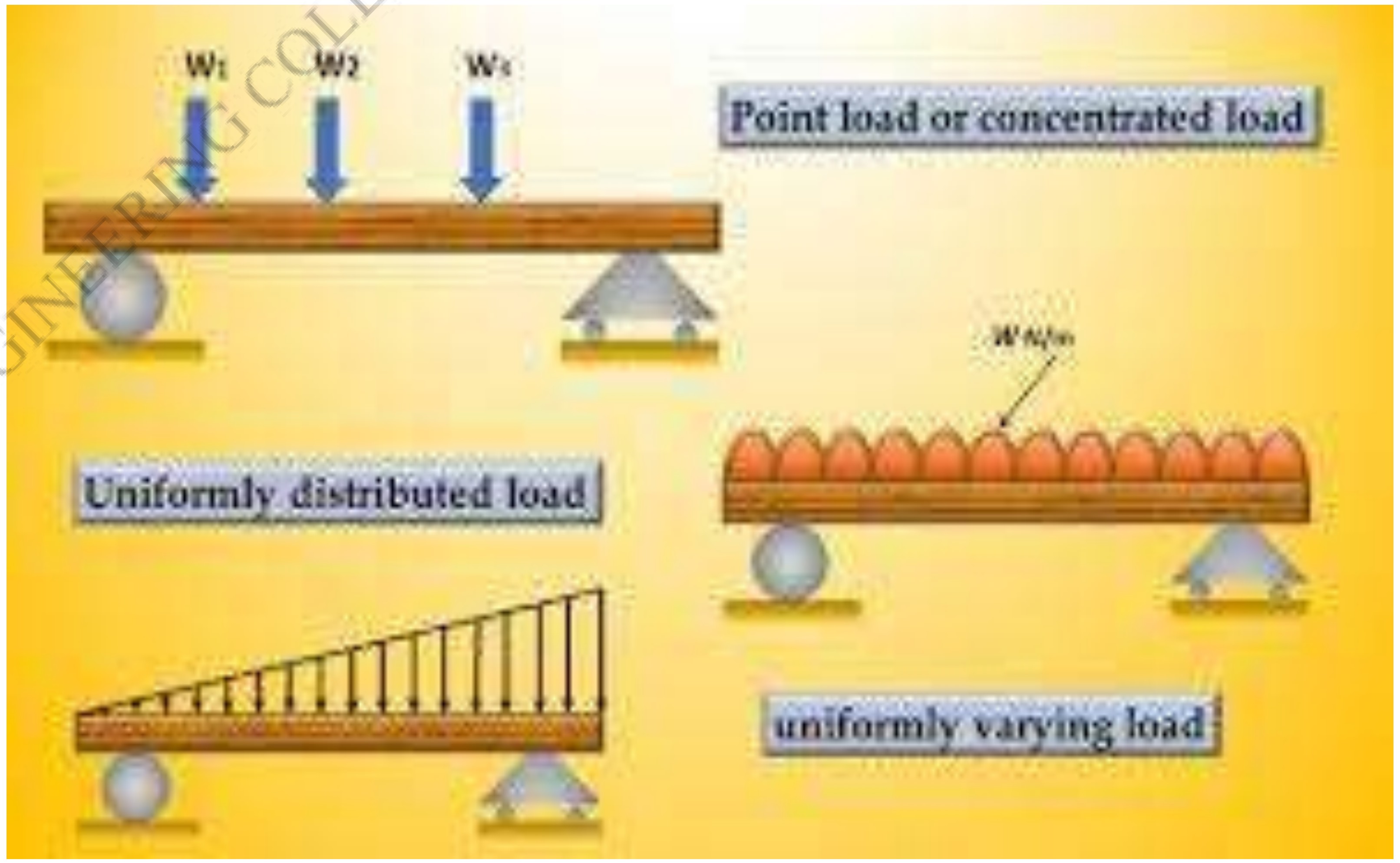




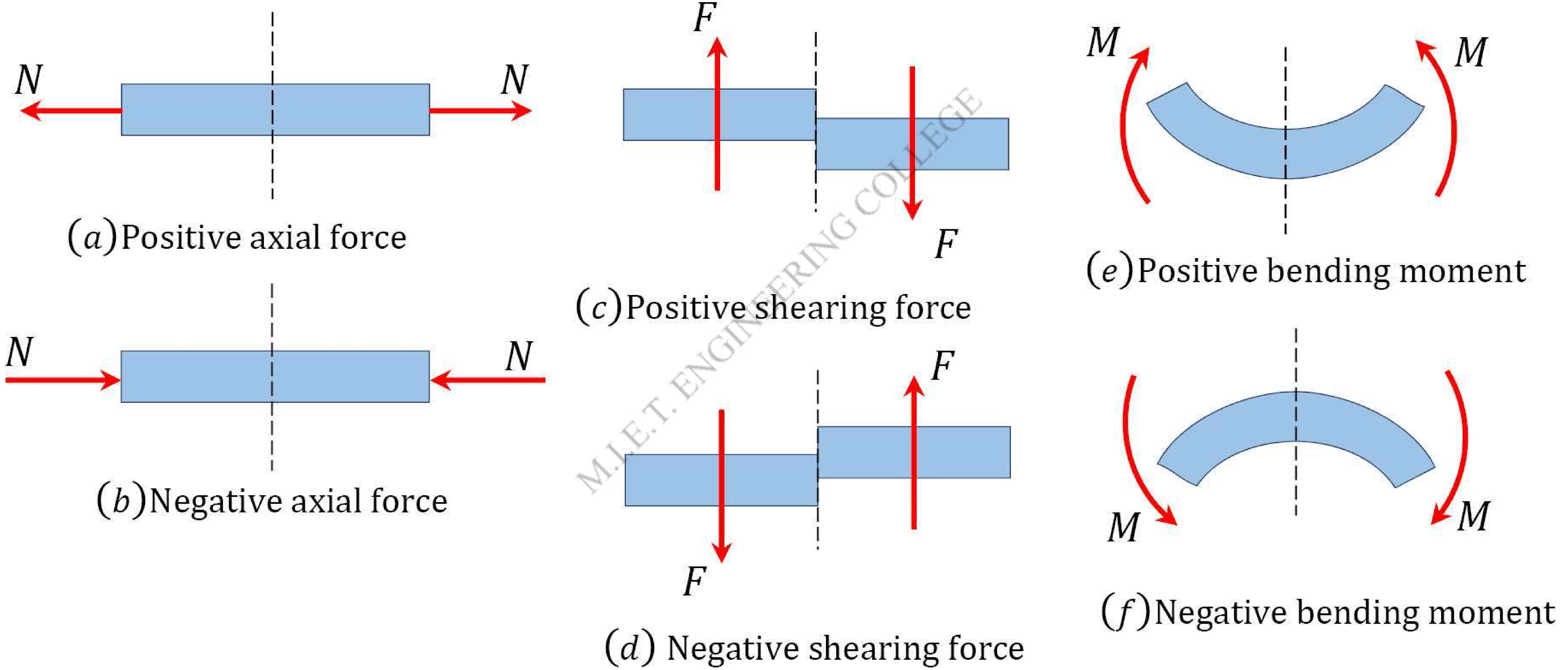


Types of Loads

1. Concentrated or Point load
2. Uniformly distributed load
3. Uniformly Varying load



Sign Conventions



(a) Positive axial force

(b) Negative axial force

(c) Positive shearing force

(d) Negative shearing force

(e) Positive bending moment

(f) Negative bending moment

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