MECHANICAL ENGINEERING SCIENCE

Dr. Mantesh B Khot

Department of Mechanical Engineering

MECHANICAL ENGINEERING SCIENCE

Stress and Strain

Dr. Mantesh B Khot
Department of Mechanical Engineering

INTRODUCTION TO MECHANICS OF MATERIALS

- **Mechanics of materials** is a branch of applied mechanics that deals with the behavior of solid bodies subjected to various types of loading. Other names for this field of study are **strength of materials** and **mechanics of deformable bodies**.

- The principal objective of mechanics of materials is to determine the **stresses, strains, and displacements** in structures and their components due to the loads acting on them. If we can find these quantities for all values of the loads up to the loads that cause failure, we will have a complete picture of the mechanical behavior of these structures.

- An understanding of mechanical behavior is essential for the safe design of all types of structures, whether airplanes and antennas, buildings and bridges, machines and motors, or ships and spacecraft. That is why mechanics of materials is a basic subject in so many engineering fields.

NORMAL STRESS AND STRAIN

- The most fundamental concepts in mechanics of materials are stress and strain. These concepts can be illustrated in their most elementary form by considering a prismatic bar subjected to axial forces.

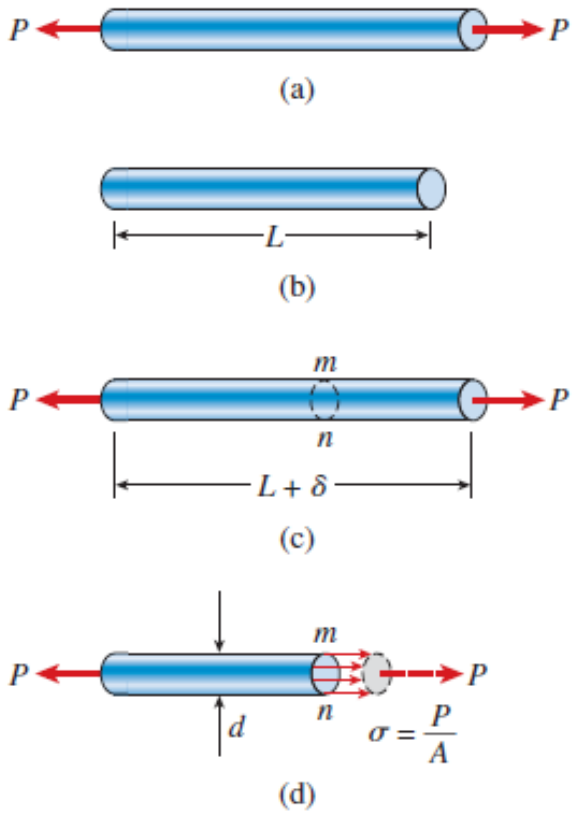
- A ***prismatic bar*** is a straight structural member having the same cross section throughout its length, and an axial force is a load directed along the axis of the member, resulting in either tension or compression in the bar.

- Examples are the tow bar, a prismatic member in tension; the landing gear strut, a member in compression; the members of a bridge truss, wing struts in small airplanes etc.

NORMAL STRESS AND STRAIN

- Consider a bar subjected to equal and opposite tensile forces of magnitude P.
- The internal actions in the bar are exposed if we make an imaginary cut through the bar at section mn.
- If we consider the equilibrium of either the left part or the right part at section mn, taken as a free body, we observe that the resultant of the ***internal resisting forces*** acting on the section must be equal to P and they may be assumed to be uniformly distributed over the whole area of the cross – section.
- ***The average intensity of these distributed forces is equal to the force per unit area and is called stress denoted by the Greek letter σ.***

$$\sigma = \frac{P}{A}$$



NORMAL STRESS AND STRAIN

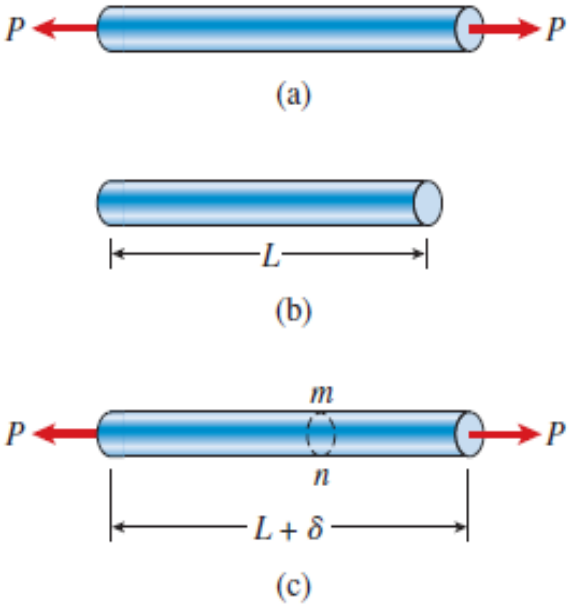
- When the bar is stretched by the forces P, the stresses are ***tensile stresses***; if the forces are reversed in direction, causing the bar to be compressed, we obtain ***compressive stresses***. The stresses act in a direction perpendicular to the cut surface, they are called ***normal stresses***. Thus, normal stresses may be either tensile or compressive.

- When a sign convention for normal stresses is required, it is customary to define ***tensile stresses as positive and compressive stresses as negative***.

- Because the normal stress σ is obtained by dividing the axial force by the cross-sectional area, it has units of force per unit of area (N/m^2).

NORMAL STRESS AND STRAIN

- As already observed, a straight bar will change in length when loaded axially, becoming longer when in tension and shorter when in compression.



- For instance, consider again the prismatic bar. The elongation δ of this bar is the cumulative result of the stretching of all elements of the material throughout the volume of the bar.

- In general, the elongation of a segment is equal to its length divided by the total length L and multiplied by the total elongation δ. Therefore, a unit length of the bar will have an elongation equal to 1/L times δ.

- ***This quantity is called the elongation per unit length, or strain, and is denoted by the Greek letter ε***. We see that strain is given by the equation

$$\epsilon = \frac{\delta}{L}$$

NORMAL STRESS AND STRAIN

- If the bar is in tension, the strain is called a **tensile strain**, representing an elongation or stretching of the material.
- If the bar is in compression, the strain is a **compressive strain** and the bar shortens.
- **Tensile strain is usually taken as positive and compressive strain as negative**.
- The strain ε is called a normal strain because it is associated with normal stresses.
- Because normal strain is the ratio of two lengths, it is a **dimensionless quantity**, that is, it has no units.

THANK YOU

Dr. Mantesh B Khot
Department of Mechanical Engineering
mahanteshbk@pes.edu
+91 87 2202 4584