

10-1

Introduction

Structural materials deform under the action of forces.

There are three kinds of deformation:

Elongation an increase in length

Contraction decrease in length

Angular Distortion a change in shape

Deformation (either elongation or contraction) per unit length is called *linear strain*.

10-2

Linear Strain

Linear strain of a deformed body is defined as the ratio of the change in length of the body due to the deformation to its original length in the direction of the force.

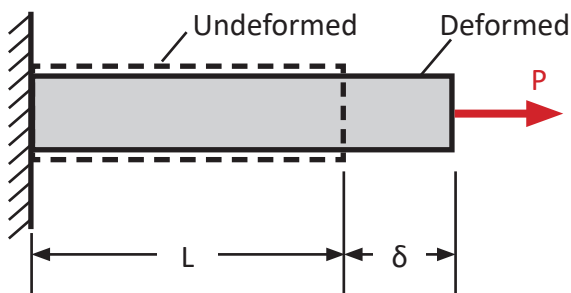
Linear Strain

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

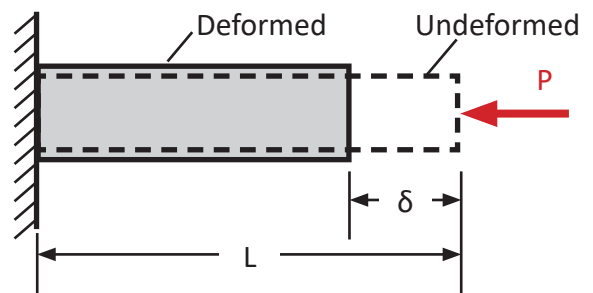
where ϵ = the linear strain

δ = total axial deformation (elongation or contraction)

L = the original length of the member



Elongation



Contraction

Linear strain may be tensile or compressive strain according to an increase in length or decrease in length of the body.

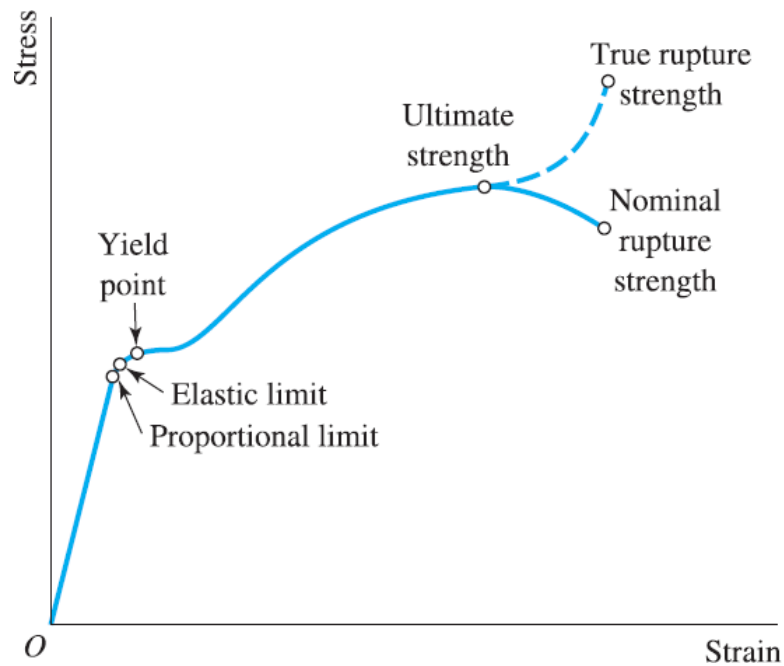
The convention used in this book is deformation caused by tensile forces are usually considered positive; those caused by compressive force are considered negative.

10-3

Hooke's Law

For most engineering materials a linear relationship exists between stress and strain; that is, up to a certain limiting value of stress, the stress is proportional to the strain.

The linear relationship between stress and strain is known as Hooke's Law.



Hooke's Law

$$\frac{\sigma}{\epsilon} = E$$

or

$$\sigma = E\epsilon$$

where E is the constant of proportionality between stress and strain and is called the *modulus of elasticity*.

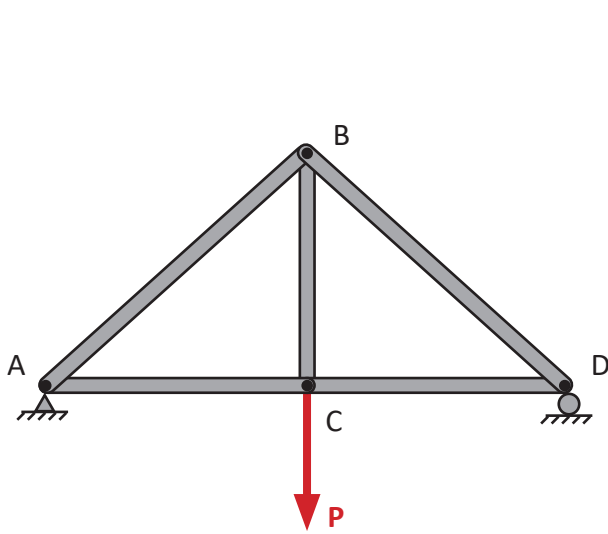
Example

10-1 A 10-ft steel bar is subjected to a tensile stress of 20 ksi. Determine (a) the linear strain and (b) the total deformation of the bar. The modulus of elasticity of the steel is 30×10^3 ksi.

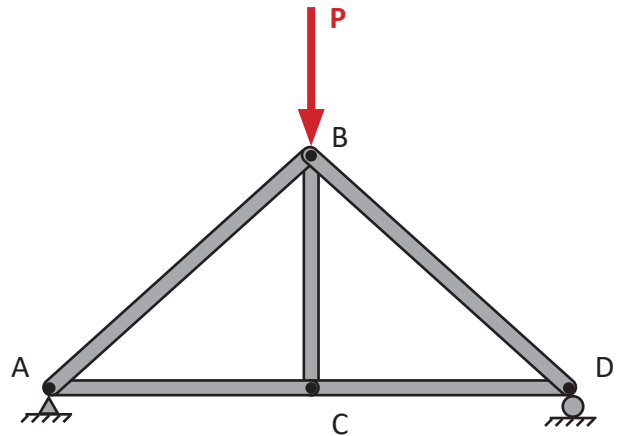
Solution.

10-4
Axial Deformation

An axially loaded member elongates under a tensile load and contracts under a compressive load.



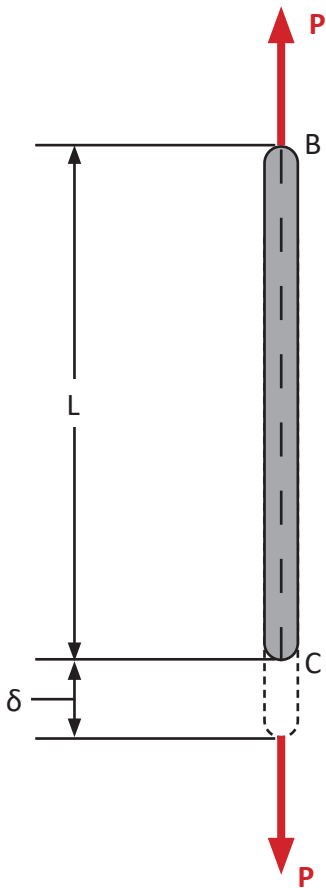
Member BC is axially loaded in Tension (T)



Member BC is axially loaded in Compression (C)

If the normal stress in an axially loaded member is within the proportional limit of the material, Hooke's Law applies and the axial deformation of the member can be computed.

Member BC has a cross-sectional area A and is subjected to an axial tensile force P .



Stress

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

Strain

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

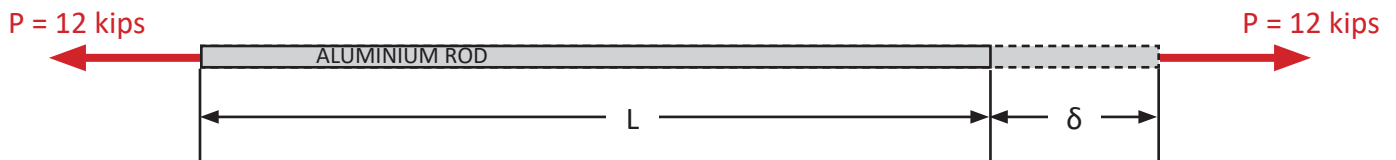
Important Points about the Axial Deformation Equation

$$\delta = \frac{PL}{AE}$$

- It is valid only when the normal stress in the member does not exceed the proportional limit.
- For most structural materials, the modulus of elasticity for tension and for compression are the same.
- Deformation caused by tensile forces are usually considered positive; those caused by compressive force are considered negative.
- If a member is subjected to several axial forces, the axial deformation of each segment must be calculated. The total axial deformation of the member is the algebraic sum of the axial deformation of all the segments.

Example

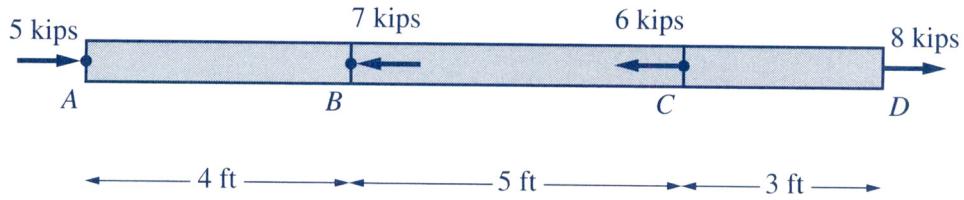
A aluminium rod has a diameter of $\frac{3}{4}$ in. and is subjected to a tensile axial load of 12 kips. The rod has an elongation of $\delta = 0.014$ in. along the longitudinal direction. Determine the original length of the rod. The modulus of elasticity of the aluminium is $E = 10.3 \times 10^3$ ksi and the proportional limit is 32 ksi.



Solution.

Example 10-2

Determine the total axial deformation of the steel bar between sections A and D. The bar has a cross-section $\frac{1}{2}$ in. X 1 in. and is subjected to the axial loads shown. The modulus of elasticity of steel is $E = 30 \times 10^3$ ksi and the proportional limit is 34 ksi.



Solution.

