


# Mechanics of Materials I:

## Fundamentals of Stress & Strain and Axial Loading

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## Mechanics of Materials I:
## Fundamentals of Stress & Strain and Axial Loading

- ✓ Internal Forces due to External Loads
- ✓ Axial Centric Loads
- ✓ Normal Stress and Shear Stress
- ✓ General State of Stress at a Point (3D)
- ✓ Plane Stress (2D)
- ✓ Normal Strain and Shear Strain
- ✓ Stress-Strain Diagrams
- ✓ Mechanical Properties of Materials
- ✓ Linear Elastic Behavior, Hooke's Law, and Poisson's Ratio
- ✓ Stresses on Inclined Planes
- ✓ Principal Stresses and Max Shear Stress
- ✓ Mohr's Circle for Plane Stress
- ✓ Stress Concentrations
- ✓ Mohr's Circle for Plane Strain
- ✓ Strain Transformation and Measuring Strains
- ✓ Factor of Safety and Allowable Stresses/Loads
- ✓ Nonlinear Behavior and Plasticity
- ✓ Statically Indeterminate Structures
- ✓ Thermal and Pre-strain Effects

# Module 44 Learning Outcomes

- Describe the temperature effects on engineering materials

# Thermal Effects

Most engineering materials:

- Expand when heated
- Contract when cooled

$\alpha \equiv$ coefficient of thermal expansion

= strain per 1° temperature change

## Thermal Strain

$$\varepsilon_T = \alpha(\Delta T)$$

We will assume α is constant
(actually it is generally higher at higher temperatures)
For homogeneous, isotropic materials,
α is the same coefficient in all directions

## Thermal Stress

exists when the member is restrained

# Examples

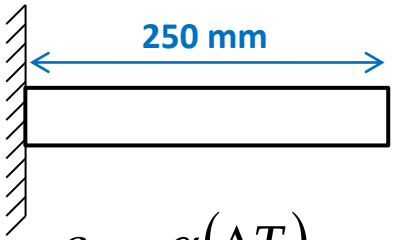
**Bronze**

$\Delta T = 40°\ \ increase$

$\alpha = 16.9\ x\ 10^{-6}\ /°C$

E=100 GPa

**Unrestrained**




$$\varepsilon_T = \alpha(\Delta T)$$

$$\delta_T = \varepsilon_T L = \alpha(\Delta T)L = 16.0\ x\ 10^{-6}\ /°C(40°C)250\ mm$$

$$\delta_T = 0.169\,mm$$

$\sigma = 0$ **unrestrained**

**ANS**

# Examples

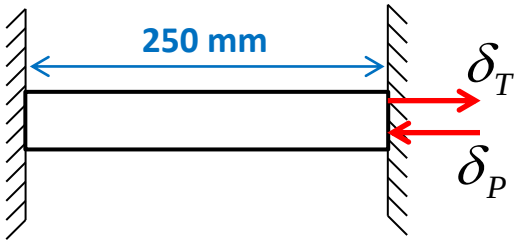
**Bronze**

$\Delta T = 40°\ \ increase$

$\alpha = 16.9\ x\ 10^{-6}\ /°C$

E=100 GPa

**Fully restrained**




$\delta_{total} = \delta_T - \delta_P = 0$

$\alpha(\Delta T)L - \frac{PL}{AE} = 0$

$\sigma$

$\sigma = 0.0676\ GPa(C) = 67.6\ MPa(C)$

ANS

$\sigma = \alpha(\Delta T)E = 16.9\ x\ 10^{-6}\ /°C(40°C)(100\ GPa)$

$\varepsilon_T$

# Examples

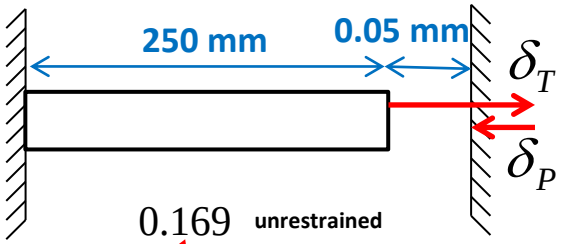
**Bronze**

$\Delta T = 40°\ \ increase$

$\alpha = 16.9\ x\ 10^{-6}\ /°C$

E=100 GPa

## Partially restrained




$\delta_{total} = \delta_T - \delta_P = 0.05$

$\delta_P = 0.169 - 0.05 = 0.119 = \frac{PL}{AE}$

$\sigma$

$\sigma = \frac{0.119\,mm(100\,GPa)}{250\,mm}$

$\sigma = 0.0476\ GPa(C) = 47.6\ MPa(C)$

**ANS**