Mechanics of Materials I:

Fundamentals of Stress & Strain and Axial Loading

Dr. Wayne Whiteman
Senior Academic Professional and Director of the Office of Student Services
Woodruff School of Mechanical Engineering

Georgia Institute of Technology

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 40 Learning Outcomes

- Describe the differences between analysis and design
- Define the Factor of Safety
- List typical values for the Factor of Safety

Analysis

Analyze, evaluate, and/or predict the behavior of an engineering component or structure based on performance criteria and/or industry standards

Design

Create a new engineering component or structure that will meet specifications and performance criteria

What Do Engineers Do?

**“The scientist describes what is.
The engineer creates what never was.”**

Theodore von Karman–Hungarian-American physicist and aeronautical engineer

**“Application of science
to fill a human need”**

Design

Create a new engineering component or structure that will meet specifications and performance criteria

Factor of Safety (FoS)

$$Factor\ of\ Safety = FoS = \frac{Failure\ Stress}{Actual\ Stress} = \frac{Strength\ of\ Material}{Max\ Computed\ Stress}$$

$FoS > 1$ **avoids failure**

The design criteria the engineering component/structure must achieve

The designer defines failure; component/structure doesn't meet performance criteria; e.g. excessive deformation, fracture, etc.

Typical Values for the Factor of Safety (FoS)

Buildings $FoS \geq 2$

Automobiles $FoS \geq 3$

Aircraft/Spacecraft $FoS \geq 1.2 \; to \; 2.5$

Boilers/Pressure Vessels $FoS \geq 8.5$

Lifting Equipment/Hooks $FoS \geq 8 \; to \; 9$

Bolts $FoS \geq 8.5$

In General:

Use higher FoS for brittle materials (to avoid catastrophic failure)

Use lower FoS when using materials for which the material properties are very well known

Use higher FoS for uncertain environments/ stresses