EGM5533: Applied Elasticity and Advanced Mechanics of Solids

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- **Objectives**:
  - Solidify students’ knowledge of analytical methods for simple structural analysis problems.
  - Allow them to use this knowledge to assess whether a solution obtained numerically is likely to be at least approximately right.
Topics

- Theory of stress and strain
- Stress-strain-temperature relation
- Inelastic material behavior
- Energy methods
- Torsion of shafts
- Bending of beams
- Thick cylinders
- Stability of columns
- Fracture mechanics
Homework and exams

• **Homework**: 10% penalty per day after due date (distance students have two extra days). Cannot be submitted after a solution is posted (2-3 days after it is due).

• **Exams**: Closed book, except for one 8.5"x11" page (student may bring a magnifier). No calculators. No make-up exams. **Distance students must take at same time!** Students who miss an exam because of valid medical problem or family emergency will have final exam count also for missed exam. Comprehensive final exam is optional for other students; if taken it may lower grade.
My idiosyncrasies

• I like to have fun teaching
  – Help students do well
  – Encourage participation
  – Minimize surprises (grade predictor)

• I value communication skills
  – Homework and exam grades depend on clarity

• I emphasize the what over the how
  – Understanding concepts and jargon is as important as solving problems

• I prefer letters to numbers and minimal use of calculators (none on exam).
Front-loaded course

• My goal is to have you work hard at the beginning of the semester when I cover the most important material (qualifying exam)

• If you do well in first two exams, final exam covers only last third of material

• Comprehensive option is tough!

• Extra credit work spread throughout the semester
2.1 Definition of stress at a point

- **Stress definition**

  **Stress Vector:**
  
  \[ \sigma = \lim_{\Delta A \to 0} \left( \frac{\Delta F}{\Delta A} \right) \]

  **Shear Stress Vector:**
  
  \[ \sigma_S = \lim_{\Delta A \to 0} \left( \frac{\Delta F_S}{\Delta A} \right) \]

- **What area?**

**Normal Stress Vector:**

\[ \sigma_N = \lim_{\Delta A \to 0} \left( \frac{\Delta F_N}{\Delta A} \right) \]

**Figure 2.2** Force transmitted through incremental area of cut body.
### 2.2 Stress notation

First subscript refers to the direction of the normal.
Second subscript refers to the direction of the stress.

Due to moment equilibrium:

$$
\sigma_{xy} = \sigma_{yx} \quad \sigma_{xz} = \sigma_{zx} \quad \sigma_{yz} = \sigma_{zy}
$$

$$
\sigma_x = \sigma_{xx} i + \sigma_{xy} j + \sigma_{xz} k
$$

$$
\sigma_y = \sigma_{yx} i + \sigma_{yy} j + \sigma_{yz} k
$$

$$
\sigma_z = \sigma_{zx} i + \sigma_{zy} j + \sigma_{zz} k
$$

$$
\begin{bmatrix}
\sigma_{xx} & \sigma_{xy} & \sigma_{xz} \\
\sigma_{yx} & \sigma_{yy} & \sigma_{yz} \\
\sigma_{zx} & \sigma_{zy} & \sigma_{zz}
\end{bmatrix}
= 
\begin{bmatrix}
\sigma_{xx} & \sigma_{xy} & \sigma_{xz} \\
\sigma_{yx} & \sigma_{yy} & \sigma_{yz} \\
\sigma_{zx} & \sigma_{zy} & \sigma_{zz}
\end{bmatrix}
$$
Reading assignment

Section 2.4: Question: What stress measures stay constant as we change coordinate systems?

Source: www.library.veryhelpful.co.uk/Page11.htm