ME556: Experimental Stress Analysis I

Take-Home Final Exam:

- Distributed via e-mail at/before 2pm on Tuesday 5 December
- Open-book, open notes
- Cannot be discussed with anyone other than Prof. Mark Tuttle
- If questions, call or e-mail:
  - tuttle@uw.edu
  - 206-543-5710
- Submit completed exam by 5pm on Thursday 7 December to dropbox:
  https://www.dropbox.com/request/9d9vP8PYXIQ7ILkHoWbQ
  Clearly describe how solutions were obtained

ME556: Experimental Stress Analysis I

Summary of Topics Covered

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Review of Stress, Strain, and Hooke's Law

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- Both σ_{ij} and ε_{ij} are symmetric second-order tensors (assuming body forces negligible and tensoral shear strain used)

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- Six components must be specified to define a stress (or strain) tensor

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- Mathematical form of Hooke's law depends on
  - Material type (e.g., isotropic vs anisotropic)
  - Stress or strain state (e.g., 3-D, plane stress, plane strain, uniaxial stress, uniaxial strain)

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Review of Methods to Predict Failure

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  - Mode I, Mode II, Mode III loading

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  - Measurement of K_I using strain gages (Lab 3)
  - Use ΔK_I to predict fatigue life via Paris Law/Paris Plot (Lab 4)

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Strain Measurement Systems:

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- Optical (covered in ME557 Experimental Stress Analysis II, offered Winter quarter, taught by Prof. Junlan Wang)

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Strain Measurement Systems:

- Mechanical (levers, dial gages, etc)
- Optical (covered in ME557 Experimental Stress Analysis II, offered Winter quarter, taught by Prof. Junlan Wang)
- Electrical
  - Based on capacitance measurements
  - Based on inductance measurements
  - Based on resistance measurements (*strain gages*)

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Resistance Strain Gages (Gauges):

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Resistance Strain Gages (Gauges):

- Wire vs Foil
- Foil:
  - Produced using photolithography
  - Common alloys
  - Proper bonding practices (Lab 1)

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  - Strain sensitivity (S_A) vs Gage Factor (S_g)
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  - Strain sensitivity (S_A) vs Gage Factor (S_g)
  - Transverse sensitivity coefficient (K_t)
  - Temperature effects
    - Change in S_g (usually minimal; often ignored)
    - Apparent strain due to temperature (usually pronounced; never ignored) …self-temperature-compensated (STC) gages

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Resistance Strain Gages (Gauges):

- Commercially available forms:
  - Uniaxial (Lab 1, Lab 2)
  - Biaxial rosettes
  - Three-element rosettes
    - Rectangular (Labs 3, 4)
    - Delta
  - Special forms
    - Shear strain gages
    - Stress gages
    - Residual stress gages (“hole drilling method”)
    - Strip gages (“virtual” Lab 6)

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Wheatstone Bridge Circuit:

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  - "Balanced" condition

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- Circuit analysis
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  - Nonlinearities

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  - Methods of increasing sensitivity

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  - Leadwire effects ("gage factor desensitization")

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  - Shunt calibration

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Strain Gage-Based Load Cells:

- Common configurations (S-beam, shear-beam, torque, etc)
- Common specifications (capacity, excitation, output, etc)

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Brief Discussion of

- Amplifiers
  - Gain
  - Phase
  - Cutoff frequency (“3 dB down point” or “half-power point”)

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  } Bode plots

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  } Bode plots
  - Cutoff frequency ("3 dB down point" or "half-power point")

- Digital Data Acquisition
  - Unipolar vs bipolar A/D boards and D/A boards
  - Range and wordlength
  - Potential aliasing errors