# ME 7774: Fatigue of Materials and Structures

Offered Every Spring

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| Credit Hours: | 3-0-3 |
| Prerequisites: | AE 7772 or CEE 7772 or CHE 7772 or ME 7772 or MSE 7772, graduate standing or consent of instructor. |
| Catalog Description: | Mechanical and microstructural aspects of nucleation and growth of cracks under cyclic loading conditions, notch effects, cumulative damage, multiaxial loading and fatigue crack propagation. Crosslisted with AE, CEE, CHE, and MSE 7774. |
| Textbooks: | Julie A. Bannantine, Jess J. Comer, and James L. Handrock, *Fundamentals of Metal Fatigue Analysis*; First Edition, Pearson Education, 1997.<br>Subra Suresh, *Fatigue of Materials*; 2nd Edition, Cambridge University Press, 1998. |
| Instructors: | David McDowell (ME), Richard Neu (ME), William Johnson (MSE), George Kardomateas (AE) |
| Goals: | To provide a working knowledge of stateoftheart methods and contemporary issues of fatigue life prediction and associated physical processes, with emphasis on metal fatigue. |

Topics:

- Course Overview; Physics of Fatigue Processes
  - Crack nucleation
  - Crack propagation
    - metals, polymers, ceramics
- Stress & Strain Response of Metals
  - Monotonic tensile tests
  - Temperature and rate dependence
  - Cyclic response
    - hardening, softening
    - cyclic stress-strain curve
- Strain Life Relationships: LCF, HCF
  - Stress-life and Basquin's Law
  - Coffin-Manson Law
  - Cyclic property estimates
  - Combined strain-life curve
- Influence of Mean Stress, Surface Finish, Hardness
  - Role of mean stresses on small crack nucleation/growth
  - Models for mean stress effects
  - Load sequence effects on mean stress
  - Effects of surface finish and hardness on fatigue

- Fatigue at Notches
  - Theoretical stress concentration, size effects and Kf
  - Neuber's rule and notch root stress-strain analysis
  - Load sequence effects on notch root behavior
- Variable Loading
  - Cycle counting techniques and history reconstruction
  - Damage summation - linear and nonlinear approaches
  - Component calibration curves
  - Applications to loading spectra
- Scatter in Fatigue
  - Probability distributions for scatter of
  - fatigue strength
  - fatigue life
  - Size effects and weak link theory
  - Scatter in HCF versus LCF
- LEFM Concepts and growth laws for physically long cracks
  - Stress intensity factor and DK
  - Cyclic crack tip fields
  - Paris growth law
  - Threshold and fracture regimes
  - Crack closure and DKeff
  - Load sequence effects and closure/plasticity models
- Growth of small/short cracks
  - Characteristics of microstructurally small crack growth
  - Mechanics considerations
  - Kitagawa diagram and HCF thresholds
  - Small cracks growing from notches
  - Transition to long crack behavior
- Multiaxial fatigue
  - Historical overview of multiaxial HCF and LCF crack initiation
  - Critical plane observations for small fatigue cracks
  - Gamma plane representation
  - Recent models for multiaxial fatigue
- Time-dependent and high temperature fatigue
  - Intergranular versus transgranular formation/growth
  - Interaction with bulk damage
  - Damage rate and damage mechanics approaches
  - Thermomechanical fatigue

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| Grading scheme: | Homework | 1/3 |
| | Midterm | 1/3 |
| | Final | 1/3 |