EML 6278 - ADVANCED ROTOR DYNAMICS (3 CR)

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Textbook: *None Prescribed (Typed personal notes used will be distributed in the class)*
Recommended References:

Rotating Machinery Vibration by Maurice Adams
Rotordynamics of Turbomachinery by John Vance
Rotordynamics by Dara Childs

Goals: This course involves analysis and design of various types of rotating machinery. Topics covered include rigid and flexible rotating assemblies, effect of support flexibility, unbalance response, prediction of critical speeds and forced periodic response of flexible rotor systems, concepts of hydrodynamic lubrication and journal bearings and their influence on rotordynamic stability (speed dependent eigen values), design of bearings to place system critical speeds within a prescribed frequency range, and, finite-element modeling of flexible rotor systems. Several detailed analysis and design computer projects are assigned.

Homework: Several programming projects involving various aspects of analysis and design of rotor-bearing systems will be assigned. Problems are based on turbomachinery rotor system analysis/design at Pratt & Whitney and Allied-Signal Aerospace Co.

Computer Support: Use of mathematical software packages such as MATLAB will be required.

GRADING Course grade will be based on detailed homework projects. **No Exams**.

TOPICS COVERED

1. **Introduction**
   - 1.1 Historical Perspective
   - 1.2 Characteristics of Rotor Elements
   - 1.3 Modeling and Analysis Overview
     - a. Linear vs. Nonlinear
     - b. Finite Elements vs. Transfer Matrix
   - 1.4 Coordinate Systems

2. **Analysis of Rotor Motion**
   - 2.1 Elliptic Motion
   - 2.2 Complex Notation
   - 2.3 Energy Relationships
   - 2.4 Orbit Simulation

3. **The Laval-Jeffcott Rotor Model**
   - 3.1 A 2DOF Simple Model

3.2 Rotatory Inertia and Gyroscopic Coupling
3.3 Internally and Externally Damped Rotor
3.4 Residual Shaft Bow Effects
3.5 Rotating Asymmetry Effects
3.6 Torque and Power Requirements
3.7 Rotor System Dynamic Response Simulation

4. **Rigid Rotor Systems**
   4.1 Symmetrical Rigid Rotor
   4.2 General Rigid Rotor
   4.3 Maneuver Load Response
   4.4 Spline Connected Rotors
   4.5 Validity of Rigid Rotor Assumption for Practical Rotor Systems
      a. Comparison of Rigid and Flexible Rotor Model Simulations
      b. Comparison of Energy dissipated in bearings vs. Strain energy stored in the shaft.

5. **Flexible Rotor Systems: Finite Element Equations**
   5.1 Rotating Assembly components
      a. Rigid Disk
      b. Flexible Disk
      c. Shaft Finite Elements
   5.2 Interconnection components
      a. Rolling-Element Bearings
      b. Fluid-Film Bearings
      c. Squeeze-Film Dampers
   5.3 Assembly of the System Equations
   5.4 Coordinate Reduction Techniques
      a. Guyan Reduction
      b. Component Mode Synthesis
   5.5 Analyses
      a. Critical Speed
      b. Stability/Whirl Speeds

6. **Case Studies: Industrial Design Applications**
   6.1 Rotors supported on fluid-film bearings (Eg. Centrifugal compressor)
   6.2 Rotors Supported On Rolling-Element Bearings With Squeeze Film Dampers (overhung compressor and straddle mounted)
   6.3 Other Gas-Turbine Engine Applications
   6.4 Optimal Design Considerations: Case Studies
   6.5 Analysis Considerations (rigid vs. flexible rotor model, etc.)

7. **Bearing Supports**
   7.1 Fluid-Film Bearings
   7.2 Rolling-Element Bearings
   7.3 Magnetic Bearings
   7.4 Lubricant Properties

8. Balancing Methods: Single and multi-plane balancing**,** Modal balancing of flexible rotating assemblies