Prerequisites: You need to have some background in dynamics and structural dynamics. AE 6210 and 6230 (or equivalent) will be helpful.

Goals: To introduce students to the fundamentals of rotorcraft dynamics and aeroelasticity and provide necessary background to equip the student to do additional research and analysis in the field.

Topics: The outline below will be followed by Prof. Hodges in the first half of the course (Jan. 7 – Feb. 25) with the intent to cover as much of the material as time permits. Prof. Prasad will take over on Feb. 27 and will cover the material that he will post separately.

Text: No text is required, but I suggest that you acquire at least one of the books (Johnson, Bielawa, or Bramwell) in the bibliography below. Note that Johnson’s older book, although dated, is now available in paperback from Dover. Johnson’s newer book was only recently published. Finally, for those interested in mastering the details of rotor blade modeling, I suggest acquiring the book Nonlinear Composite Beam Theory by Hodges.

1. Introduction
   1.1. Overview of the course
   1.2. Review of techniques for derivation of equations of motion
      1.2.1. Notation and kinematical concepts
      1.2.2. Lagrange’s equations
      1.2.3. Lagrange’s form of D’Alembert’s principle
      1.2.4. Hamilton’s principle
      1.2.5. Principle of virtual work
   1.3. Review of dynamics of rotating bodies

2. Stability of a Hingeless Rotor Blade with a Rigid-blade Model
   2.1. Inertial forces
   2.2. Blade/root flexibility
   2.3. Behavior of the in-vacuo solution – homework
   2.4. Simple aerodynamic model
      2.4.1. Lift and drag
      2.4.2. Induced inflow velocity
      2.4.3. Incorporation into rigid-blade equations
   2.5. Behavior of the stability from closed-form expression of Peters (1975)
   2.6. Behavior of the stability – homework

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1 See Bramwell et al. (2001), chapter 2, or Bielawa (2006), chapters 2 and 4.
2 See Johnson (1980), article 12-3.3; Bramwell et al. (2001), chapter 11; or Bielawa (2006), chapter 10.
3. Linear Free Vibration of a Rotating Elastic Beam
   3.1. Internal forces
   3.2. Inertial forces
   3.3. Solution methods
      3.3.1. perturbation method
      3.3.2. transfer matrix method
      3.3.3. Ritz method
      3.3.4. collocation method
      3.3.5. mixed method
      3.3.6. finite element method
   3.4. Behavior of the solution – homework
4. Coupled Rotor/body Systems
   4.1. Multi-blade coordinate transformation
      4.1.1. azimuthally periodic structure transformation
      4.1.2. rotating structure transformation
      4.1.3. use in a virtual work analysis
   4.2. A practical example: ground resonance
      4.2.1. example derivation of governing equations
      4.2.2. solution of governing equations – homework
5. Flexible-blade Modeling for Aeroelasticity
   5.1. Hodges and Dowell – which many analysts still view as state of the art
      5.1.1. brief walk through the report
      5.1.2. nonlinear phenomena
         5.1.2.1. flap-lag coupling
         5.1.2.2. bending-torsion coupling
            5.1.2.2.1. Mil’s terms
            5.1.2.2.2. controversy over torsion variables
            5.1.2.2.3. nonlinear $GJ$ terms
         5.1.2.3. quasi-coordinates
            5.1.2.3.1. analogous to generalized speeds in dynamics
            5.1.2.3.2. discretize strains rather than displacements
            5.1.2.3.3. how they affect equations
            5.1.2.3.4. example
   5.2. Nonlinear kinematics of beams
      5.2.1. polar decomposition theorem
      5.2.2. local versus global deformation
   5.3. Elasticity
      5.3.1. solution of the local deformation problem
      5.3.2. warping: isotropic versus anisotropic
   5.4. External forces
      5.4.1. body forces, including inertial forces
      5.4.2. aerodynamic forces

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3 See Bramwell et al. (2001), chapter 12, or Bielawa (2006), chapter 11.
5.5. Equilibrium equations
   5.5.1. intrinsic form
   5.5.2. solution of statics of a cantilever with tip mass
5.6. Overview of various special cases and theoretical issues
   5.6.1. Uncoupled equations
       5.6.1.1. lead-lag equation
           5.6.1.1.1. negative spring term
           5.6.1.1.2. fundamental frequency versus rotor angular speed
           5.6.1.1.3. what happened to the Coriolis term?
       5.6.1.2. torsion equation
           5.6.1.2.1. pretwist
           5.6.1.2.2. tennis racquet term
           5.6.1.2.3. trapeze term
Bibliography


