EGM 6934: Structural Dynamics

Fall 2021

Mechanical & Aerospace Engineering Department

University of Florida

1. Catalog Description: (3 credits) Graduate level Introduction to Structural Dynamics

2. Desired Background: Undergraduate Statics, Dynamics, Strength of Materials, Basic Vibrations

3. Course Objectives: This course is designed to establish the fundamentals of interaction between structural elastic forces and inertia effects. The students will learn to formulate the dynamic equations of motion of structures and seek solution techniques to solve for the dynamic response in time as well as in frequency domain.

4. Contribution of Course to Meeting the Professional Component: This course introduces the formulation of dynamic equations of motion of elastic structures for applications in aerospace engineering, mechanical engineering and engineering mechanics. Dynamic behavior of flying vehicles has far reaching implications on ride quality as well as fatigue life of the structure. The subject of structural dynamics provides the foundations for further studies in aeroelasticity and dynamic response control of structures.

5. Instructor: Dr. Vin Sharma
Email Address: vin.sharma@ufl.edu

6. Class Schedule: Tuesdays and Thursdays 2:30-3:45 (Lectures recorded at the REEF, Fort Walton Beach. The lecture videos should be available the same evening. In case of REEF closure, the lectures will be recorded on ZOOM.

7. Topics of Study:

- Brief Introduction to Structural Dynamics:
  - Statics versus dynamics
  - Stiffness and inertia
  - Dynamic amplification
  - Dynamic response control
  - Structural fatigue due to dynamic response
  - Dynamic instability
  - Significance of dynamic analysis in early phase of the design cycle
  - Dynamic model validation using ground vibration test
- Foundations
  - Elastic deformation of beams and rods
  - Stiffness and strain energy
  - Virtual work and energy principles
  - Inertia and kinetic energy
  - d 'Alembert's principle and equation of motion

    - Lagrange’s equations of motion
- Dynamic Equations of Motion
    - Single degree of freedom model
    - Natural frequency and free vibration response
    - Forced vibration response to harmonic and general dynamic excitation
    - Time domain and frequency domain analysis
- Multi-degrees of Freedom System
    - Two degrees of freedom model
    - Lagrange’s equations of motion
    - Eigenvalue, eigenvectors, generalized mass and generalized stiffness
    - Orthogonality of eigenvectors
    - Rayleigh-Ritz method for N-degrees of freedom system
    - Modal damping and dynamic response
- Vibration of Continuous Systems
    - Axial, torsional and transverse vibrations
    - Hamilton’ principle and Lagrange’s equations of motion
- Numerical Integration Techniques
    - Taylor series, Runge-Kutta, and Average acceleration
    - Newmark-beta
- Finite Element Modeling of Structures
    - Discretization of continuous system
    - Stiffness and inertia matrices
    - Guyan reduction for reduced order model
    - Dynamic response using numerical integration techniques
- Introduction to Component Modes Synthesis
    - System synthesis for free vibrations using fixed interface method (One significant problem will be assigned on this topic as a part of HW assignments)

8. Grading Policy: Grades will be based on several homework assignments, one final take-home exam. All assignments and take-home exam will be based on the material presented in the lectures and require computer programming. Use of MATLAB is highly encouraged and preferred for all work in this course. Can't provide much help for python programmers. Students must keep up with the lecture videos and answer questions that may be posed during the lectures.

Homework	70% (includes a 4-5 page-paper on a related subject)
Final Exam	30%

Important Note: You may search the web for all the help you want, but your best help will come from the lecture notes.