CEE 6512

Advanced Dynamics and Smart Structures
3 Credits

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Course Description: This course gives an overview of emerging technologies in advanced dynamics and smart structures. Topics include frequency response of single and multiple DOF structures, applications of Fourier transform and Laplace transform in structural dynamics, numerical techniques for signal processing and modal analysis, smart wireless sensor technologies for structural monitoring, as well as structural control technologies (e.g. base isolation, tuned mass damper, semi-active damper). The course can assist CEE graduate students in quickly grasping both theoretical fundamentals and numerical techniques needed for in-depth analysis in structural dynamics. The course also helps to broaden students' view with latest advancements in structural health monitoring and control technologies.

Prerequisites:
- CEE 6510 – Structural Dynamics or equivalence
- Basic linear algebra (matrices and vectors) and differential equations
- Experience with MATLAB is recommended

Course References (No formal textbook required):
- Theoretical and Experimental Modal Analysis, by Maia and Silva.
- Signals & Systems, by Oppenheim, Willsky, and Nawab.
- Dynamics of Structures, by Chopra

Course Requirements:
- Homework assignments (approximately 6 assignments): you are allowed to work in groups on all homework and out of class assignments, but any work you turn in must be completed by yourself.
- Midterm exam
- Final project: modal analysis and model updating of a laboratory four-story shear-frame structure. The structure will be instrumented with vibration sensors; vibration data will be provided to you first for extracting resonance frequencies and vibration modes of the as-built structure, and then for updating the inter-story stiffness and damping parameters. The updated matrices should provide resonance frequencies and (complex) modes that are much closer to these extracted from experimental data.

Grading: Five homework assignments (30%), midterm (40%), final project (30%)

Outline

Week 1	Introduction to sensors, data acquisition, and actuation
Week 2	Fourier series and Fourier transform **Homework 1** assigned
Week 3	Vibration transfer function of undamped and damped SDOF systems
Week 4	Impulse response and convolution for a SDOF system **Homework 1** due, **Homework 2** assigned
Week 5	Free vibration of MDOF systems (undamped and non-proportional viscous damping)
Week 6	Frequency response / transfer function matrix of MDOF systems
Week 7	From continuous to discrete: impulse-train sampling, signal reconstruction, aliasing **Homework 2** due, **Homework 3** assigned
Week 8	Discrete Fourier transform and convolution in discrete domain **Lab Demo -** Acceleration measurement of a laboratory MDOF structure using wireless sensors
Week 9	**Midterm** Experimental modal analysis: peak picking
Week 10	Linear algebra review **Field Demo -** Field instrumentation of wireless accelerometers (MARC Bridge or Bobby Dodd Stadium)
Week 11	Laplace transform and applications to free and forced vibrations of SDOF systems **Homework 4** due, **Homework 5** assigned
Week 12	Laplace transform and applications to free and forced vibrations of MDOF systems
Week 13	Discrete-time linear dynamical systems I
Week 14	Discrete-time linear dynamical systems II Singular value decomposition **Homework 5** due
Week 15	Experimental modal analysis: eigensystem realization algorithm
Week 16	Concepts and examples of passive, semi-active, and active structural control **Final project** due