Syllabus

Course Name Vibration of Complex Mechanical Systems

Course Number ENG ME 515

Semester Spring 2021

Course Description Introductory course in mechanical vibrations for graduate students and for undergraduate students with substantial mastery of core undergraduate subjects in mechanics and mathematics. Course includes an elementary introduction to applicable concepts in linear algebra. Potential and kinetic energy functions of single- and multi-degree-of-freedom systems. Matrix formulations of forced vibrations of linear systems. Natural frequencies, resonance, and forced vibration response. Natural modes and mode shapes. Rayleigh's principle. Rayleigh's dissipation function, transient and forced responses of damped vibrations. Random excitation of vibrations. Impedance matrix. O'Hara-Cunniff theorem, modal masses, modal analysis. Vibrations of simple continuous systems such as strings, beams, rods, and torsional shafts. This course cannot be taken for credit in addition to ENG ME 441.

Prerequisite CAS MA 226; CAS PY 313; ENG ME 302; ENG EK 307; ENG ME 309

Required Course Materials *Mechanical Vibrations*, Sixth Edition, Singiresu S. Rao.

Required Course Software Matlab

Recommended Course Equipment 0.9 mm Pentel GraphGear 500 Automatic Drafting Pencil Gray (PG529N) with 2B lead

Lectures

- Lectures are held in PHO 202 on Tuesdays and Thursdays, 3:30 p.m. – 5:15 p.m.
- Physical attendance arranged through the LfA app.
- Lectures are live broadcast on Zoom and recorded for posting on Blackboard.

Instructor Professor J. Gregory McDaniel

Instructor Email `jgm@bu.edu`

Grader Luis Souza

Grader Email `luisdhvs@bu.edu`

Office Hours By appointment on Zoom. To arrange an appointment, email at least two suggested times and a summary of your questions.

Course Average The numerical course average will be an average of 10 assignments.

Course Grade The letter grade for the course will be determined from the following chart:

Percent Range	Letter Grade
92.5–100	A
90.0–92.5	A-
87.5–90.0	B+
82.5–87.5	B
80.0–82.5	B-
77.5–80.0	C+
72.5–77.5	C
70.0–72.5	C-
60.0–70.0	D
50.0–60.0	F

Collaboration Policy on Assignments Students are allowed to discuss the assignments with each other and help each other learn. However, each student must turn in a code that they wrote. Students are not allowed to share their code in any way.

- Code may not be electronically transmitted in any format.
- Code may not be posted online.
- Code may not be printed out and given to another person.
- Code may not be visually seen by another person, either on a screen or on paper.
- Code may not be read aloud to another person.

No portion of any assignment may be posted online. If identical portions of codes are found, that will be considered a violation of the academic conduct code and referred to the university for investigation.

Grading Concerns All grading concerns must be reported to the professor within one week of returning the graded work.

Lecture Topics

6.1 Introduction to Multidegree-of-Freedom Systems

6.2 Modeling of Continuous Systems as Multidegree-of-Freedom Systems

6.3 Using Newton's Second Law to Derive Equations of Motion

6.5 Potential and Kinetic Energy Expressions in Matrix Form

6.6 Generalized Coordinates and Generalized Forces

6.8 Equations of Motion of Undamped Systems in Matrix Form

6.9 Eigenvalue Problem

6.10 Solution of the Eigenvalue Problem

6.11 Expansion Theorem

6.12 Unrestrained Systems

6.13 Free Vibration of Undamped Systems

6.14 Forced Vibration of Undamped Systems Using Modal Analysis

6.15 Forced Vibration of Viscously Damped Systems

8.1 Introduction to Continuous Systems

8.2 Transverse Vibration of a String or Cable

8.3 Longitudinal Vibration of a Bar or Rod

8.4 Torsional Vibration of a Shaft or Rod

8.5 Lateral Vibration of Beams

8.6 Vibration of Membranes

9.1 Introduction to Vibration Control

9.10 Vibration Isolation

9.11 Vibration Absorbers

10.1 Introduction to Vibration Measurement and Applications

10.2 Transducers

10.3 Vibration Pickups

10.8 Experimental Modal Analysis

12.1 Introduction to the Finite Element Method

12.3 Equations of Motion of an Element

12.3 Mass Matrix, Stiffness Matrix, and Force Vector

12.4 Transformation of Element Matrices and Vectors

12.5 Equations of Motion of the Complete System of Finite Elements

12.6 Incorporation of Boundary Conditions