ENGR 461: Mechanical and Structural Vibrations

Elective

Civil and Mechanical Engineering

Bulletin Description

ENGR 461 Mechanical and Structural Vibrations (3 units)
Prerequisites: ENGR 201, 309 and MATH 245
Dynamic excitation and response of mechanical and structural systems; frequency and time
domain; energy methods; Rayleigh’s principle; modal analysis; vibration damping,
resonance, isolation, absorption parametric excitation, and influence coefficients.

Textbook


References


Coordinator

Dr. Chen, Assistant Professor of Civil Engineering

Prerequisites by Topic

1. Construction of free–body diagrams for static and dynamic forces
2. Application of the equations of dynamic equilibrium
3. Deformation of rods and beams to various types of loads
4. Methods for creating solutions to 2nd-order differential equations
5. Matrix algebra

Course Objectives2

1. Enhance student understanding of basic system characteristics of a single–degree–of–freedom
   (SDOF) system. [a, e, c, i]
2. Develop student knowledge of basic response of SDOF systems to various vibration sources. [e, c, i]

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1 You should have taken the required prerequisite courses at SFSU or the equivalent ones from other colleges or
universities. No exceptions will be considered.
2 Numbers in brackets refer to the educational objectives and outcomes of the School of Engineering
3. Develop student understanding for modal response of multi-degree-of-freedom (MDOF) systems. [a, e, c, i]
4. Establish the design concepts for vibration isolation and absorption. [e, c]

Topics
1. Free vibrations of systems with a single degree of freedom.
2. Energy methods for determining system stiffness, mass, and natural frequency.
3. Vibrations of single degree of freedom systems under harmonic excitations.
4. Vibrations of single degree of freedom systems under general forcing functions.
5. Response spectra.
6. Free vibrations of systems with multiple degrees of freedom.
7. Forced vibrations of systems with multiple degrees of freedom.

Professional Component

Engineering Science 100%

Relationship to Other Courses

This is an essential science course for the students who are interested in pursuing a career as structural and mechanical engineers.

Evaluation

- Attendance 10%
- Quizzes 10%
- Homework Assignments 15%
- Group Projects 10%
- Midterm Exams 25%
- Final Exam 30%
- Bonus Problem 10%

Performance Criteria

Objective 1 Enhance student understanding of basic system characteristics of a single-degree-of-freedom (SDOF) system
1.1 Student understands basic concepts of mass, stiffness, and damping for a SDOF system. [1, 2, 3, 4]
1.2 Student is able to determine the mass and stiffness for a SDOF system using dynamic equilibrium. [1, 3]
1.3 Student is able to obtain system damping using log decrement from free vibration test. [1, 2, 3]

Objective 2 Develop student knowledge of basic response of SDOF systems to various vibration sources
2.1 Student is able to generate the free vibration response to an impact load. [1, 2, 3]
2.2 Student is able to generate the steady-state response due to a harmonic load or

3 Numbers in brackets refer to evaluation method used to assess student performance.
2.3 Student can determine the transient vibration to shock loads and earthquake motion. [1, 2, 4]
2.4 Student can determine maximum response using response spectra. [1, 2, 4]

Objective 3 Develop student understanding for modal response of multi-degree-of-freedom (MDOF) systems
3.1 Student can use dynamic equilibrium to create the differential equation of motion for a MDOF system, thus determining mass and stiffness matrices. [1, 2, 4]
3.2 Student can obtain stiffness and flexibility matrices using influence coefficients. [1, 2, 4]
3.3 Student can obtain modal frequencies and mode shapes. [1, 2, 4]
3.4 Student can obtain steady-state solutions for harmonic loads using modal analysis. [1, 2, 4]
3.5 Student can obtain transient solutions and maximum responses for non-harmonic loads using modal analysis. [1, 2, 4]

Objective 4 Establish the design concepts for vibration isolation and absorption
4.1 Student understands the concept of using a vibration absorber to eliminate excessive vibrations when SDOF systems are subjected to input frequencies at or near resonant frequency. [1, 2, 4]
4.2 Student can select the stiffness and mass for a vibration absorber. [1, 2, 4]
• Students with disabilities who need reasonable accommodations are encouraged to contact the instructor. The Disability Programs and Resource Center (DPRC) is available to facilitate the reasonable accommodations process. The DPRC is located in the student service building and can be reached by telephone (voice/TTY 415-338-2472) or by email (dprc@sfsu.edu). If you have a disability for which you are or may be requesting academic accommodations, please contact the instructor as early as possible in the semester. You must have documentation before accommodations can be granted.

Notes on Evaluation:

First midterm: October 03 2012
Second midterm: November 14 2012
Final exam: December 12, 2012, 5:10-8:10

Homework:

• Homework will typically be due at the beginning of the lecture/recitation on the specified day. ZERO points will be given to late homework without justified excuses.
• Name, date, course number, and homework problem number should be placed at the top of each page.
• Homework should be done on one side of the 8.5x11-in paper only; Neatness is of essence; each problem should be clearly labeled; multiple pages should be stapled in order at the top left corner.
• A straight edge should be used for all sketches, diagrams, and graphs.
• Units must be included in solution.
• Academic integrity is expected from all students in all matters related to this course. In particular, a student assumes responsibility for every assignment that he/she submits.

Quizzes and Exams

• Quizzes and exams will be closed book and closed notes;
• No makeup quiz, midterm or final exams will be given except for emergency situations.
• Name, date and course number should be placed at the top of each page.
• Quizzes and exams should be done on one side of the 8.5x11-in paper only; each problem should be clearly labeled; multiple pages should be stapled at the top left corner.
• Units must be included in solution.
• Academic integrity is expected from all students in all matters related to this course. In particular, a student assumes responsibility for every quiz and exam that he/she submits.

What does the Instructor expect from you and what should you know to make the grade you want?

• Not interested in students memorizing equations.
• Practice class examples.
• Participate constructively in class analysis and discussion.
• Ask questions and offer constructive personal insights and opinions in classes.
• Always sit in your assigned seat; be prepared for class; take good notes.
• Do your homework honestly and turn it in on time; spend enough time on assigned reading, reviewing notes, practicing examples and doing homework.
• Come to class every time (not just most of the time). Attendance counts as part of your grade.
• No cheating. I maintain a zero tolerance policy toward cheating. All submissions must be original work of the student. If there is the slightest evidence of cheating for the first time, no credit will be given for the entire project or homework assignment for both students. If caught cheating for the second time, both students will be reported to student discipline office.
• See me during my office hours if you feel it is necessary. Or email/call me for appointments if necessary.
• Do not distract other students by talking, eating, etc.
• Well prepare for the quizzes and exams.

Policy on Add, Drop and Withdrawal:

Students are responsible for their class enrollments. Students should check their enrollment records periodically throughout the semester to ensure that the enrollment record is correct. Particularly, all students should check their enrollment record a day or two after any enrollment changes are made and take immediate action if the university record does not reflect the changes. Also make sure to maintain a record of any adds, drops, or withdrawals. First week through fourth week of instruction is the open add/drop period. No late add will be allowed after the deadline.