Spring 2022

CE 634-852: Structural Dynamics

Ezra Jampole

CE 634: Structural Dynamics

(3 credits)

Lectures: Posted to the Canvas at the beginning of the week

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Prerequisites: The student must have a working knowledge of structural analysis including determinate and indeterminate beams and frames, differential equations, and matrix algebra. Students will benefit from previously completing or concurrent enrollment in CE 639: Applied Finite Element Methods, but it is not strictly required. Some experience with coding will be beneficial for solving larger problems later in the course, but it is not strictly required.

Required Textbook: Chopra, A.K., 2017. *Dynamics of structures: theory and applications to earthquake engineering 5th Edition*. Pearson. ISBN-13: 978-0134555126

Course Description

Students are introduced to concepts in structural dynamics and their applications in structural engineering. Methods to determine dynamic response of single degree of freedom systems with free and forced vibrations are studied first, followed by similar concepts in multi-degree of freedom systems. Numerical methods to determine response over time will also be investigated.

Course Objectives and Purpose (General)

By the end of this course, the student will be able to:

Single Degree of Freedom Systems: Formulate and solve the equation of motion for single degree of freedom systems with stiffness and damping in free vibration and subjected to harmonic and general loading. Discuss the influence of input and design parameters on system response.

Multiple Degree of Freedom Systems: Formulate and solve the equation of motion for multi-degree of freedom systems, with an emphasis on shear buildings. Determine mode shapes, modal frequencies, and modal participation factors. Determine the response of shear buildings during earthquakes.

Response Spectrum: Calculate the displacement, velocity, and acceleration spectra for pulse and earthquake ground motions. Use the response spectrum for simplified design problems.

Damping: Explain the importance and effect of damping on structures. Infer damping parameters in single degree of freedom and multiple degree of freedom structures based on observed structure response and using classical methods.

Numerical Evaluation of Dynamic Problems: Use numerical methods to solve dynamic analysis problems. Explain the difference between conditionally stable, unconditionally stable, explicit, and implicit time integration schemes.

Distributed Elasticity: Formulate and solve the equation of motion for simple members with distributed elasticity.

POLICIES & PROCEDURES

Academic Integrity: It is expected that NJIT's University Code on Academic Integrity will be followed in all matters related to this course. Refer to NJIT's Dean of Students website to become familiar with the Code on Academic Integrity and how to avoid Code violations.

Communication: All communication by the Instructor will be done through Canvas. It is your responsibility to check e-mail, and the course page on Canvas regularly.

Lectures/Class: Viewing all lecture/class periods is expected. I will post several videos each week covering mini-topics within an over-arching weekly theme.

Handouts: Copies of the notes used in class will be posted on Canvas throughout the quarter at the same time as the lecture videos. It is highly recommended that you print out a set of notes to follow along with during lecture, as notes will be filled on these handouts.

Prerequisites: It is assumed that you have a background in structural analysis, ordinary differential equations, and matrix algebra. These topics are critical for success in this course.

Homework: Homework will be assigned to encourage further reading, to extend the material presented in lectures, and to provide practice in arriving at engineering solutions to problems. Completion of the homework is an essential part of the learning process. All homework is collaborative and is to be turned in with a partner, though I suggest that each student attempt each problem. If there are an odd number of students, I will allow for one group of three. Homework will be due at 11:59 PM ET on Monday of the week it is due.

Homework Format: It is expected that all homework be presented in an organized manner; use green, yellow or white engineering paper, one side of each page (clear side, not grid side); begin each problem on a new page and number all pages.

Late Homework: Late homework will not be accepted.

Homework Solutions: Homework solutions will be posted two days after the homework is due. It is your responsibility to make sure you understand how to solve the problems by asking questions of the instructor. As with many engineering problems, multiple solutions may be possible. This means that all rational solutions to the assignments will be accepted.

Exams: There will be one midterm and one comprehensive final exam. You will have several days in which to complete each. The exams will be take-home, but you must complete the exams individually (no partners).

Homework Grading: All homework will be submitted electronically by students using Gradescope. It is your responsibility to scan your assignment in and upload it to the Gradescope website before 11:59 PM on the day that it is due.

If you believe that an error was made in grading the homework, you should write a short justification of your claim and attach it to the original homework assignment in question. Email the justification and homework paper to the Instructor. Your homework will be reviewed to address your concern. The deadline for submitting a re-grade request is one week after the homework is returned.

Software:

We will use MatLab for light coding so that we can tackle larger problems in the class. You can download it from the NJIT software center: http://ist.njit.edu/software-available-download/. You are free to use another software package, but the instructor may not be able to provide support.

Calculation of Course Grade: A weighted average grade will be calculated as follows:

Homework	40%	
Midterm	25%	
Final Exam	35%	(Cumulative final exam)

The minimum requirements for final letter grades are as follows:

A = 90.0%, B+ = 85.0%, B = 80.0%, C+ = 75.0%, C = 70.0%, F < 70.0%

Note: Grades are not curved. It is theoretically possible for everyone in the class to get an A (or an F). Your performance depends only on how you do and how much you learn, not on how everyone else in the class does. It is therefore in your best interest to help your classmates, while acting within the bounds of the stated academic integrity policy (i.e., NJIT's Code of Academic Integrity).

Instructor Commitment: You can expect the Instructor to be courteous, punctual, organized, and prepared for video lectures and other class activities; to answer questions clearly; and to grade uniformly and consistently.

Students with Documented Disabilities: NJIT is committed to providing students with documented disabilities equal access to programs and activities. If you have, or believe that you may have, a physical, medical, psychological, or learning disability that may require accommodations, please contact the Coordinator of Student Disability Services located in the Center for Counseling and Psychological Services, in Campbell Hall, Room 205, (973) 596-3414. Further information on disability services related to the self-identification, documentation and accommodation processes can be found on the webpage at: (http://www.njit.edu/counseling/services/disabilities.php)

Legal Disclaimer: Students' ability to meet outcomes listed may vary, regardless of grade. They will achieve all outcomes if they attend class regularly, complete all assignments with a high degree of accuracy, and participate regularly in class discussions. This syllabus is subject to change at the discretion of the instructor throughout the term.

Schedule:

Week (beginning)	Topic / Module	Chapters	HW Assigned	HW Due
1 (January 17)	SDOF: Introduction, Equations of Motion	1	1	
2 (January 24)	SDOF: Free Vibration	2		
3 (January 31)	SDOF: Forced Vibration - Response to Harmonic Excitation	3	2	1
4 (February 7)				
5 (February 14)	SDOF: Forced Vibration - Response to General Excitation	4	3	2
6 (February 21)				
7 (February 28)	Numerical Evaluation of Dynamic Response	5	Midterm	3
8 (March 7)	Midterm Exam			Midterm
NA (March 14)	Spring Break			
9 (March 21)	Response Spectrum Analysis	6,8	4	
10 (March 28)	MDOF: Introduction, Equation of Motion, Free Vibrations, Mode Shapes, Modal Frequencies	9,10	5	4
11 (April 4)				
12 (April 11)	MDOF: Damping Systems, Analysis and Response of Linear Systems	11,12	6	5
13 (April 18)				
14 (April 25)	MDOF: Systems with Distributed Mass and Elasticity	17	7	6
15 (May 2)	Final Exam		Final	7
16 (May 9)				Final