Spring 2021

CE 630-102: Matrix Analysis of Structure

Matthew Bandelt

CE 630: Matrix Analysis of Structures

(3 credits)

Lectures: Monday 6:00pm – 9:05pm (with a 15-minute break mid-way)
ECEC 100
Online Converged Course Runs Synchronously via WebEx

Instructor: Matthew Bandelt, Ph.D., P.E.
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Office Hours: Mon: 4:00pm-5:30pm, Thurs: 8:00-9:30am, *or by appointment*
Note: I am available in person or by WebEx at the link below at these times
https://njit.webex.com/meet/bandelt

Prerequisite: An undergraduate course in structural analysis and computer programming.

Required Textbook: McGuire, William, Richard H. Gallagher, and Ronald D. Ziemian. *Matrix Structural Analysis*. 2nd Edition. Wiley, Middletown, DE. 2015. ISBN: 978-1507585139.

Required Software: *MATLAB*. Version 2018A or later. Mathworks, Inc., Natick, MA. 2018. Available at: http://ist.njit.edu/software/download.php

Course Description *(from NJIT's course catalog)*

A review of matrix operation and energy method, and development of flexibility and stiffness methods used in linear-elastic structural analysis. Behavior of continuous beams, plane trusses, space trusses, and frames will be studied

Course Themes
Structural design requires calculations of element forces, displacements, and support reactions of structural elements using analysis techniques. This course builds upon undergraduate structural analysis techniques to introduce students to the theoretical development and practical implementation of the direct stiffness (i.e. matrix method) of structural analysis. Topics covered include virtual work principles; flexibility and stiffness methods of analysis; computation of element stiffness matrices and load vectors; coordinate transformation; distributed, self-straining and thermal loads; numerical solution of systems of equations; modeling with symmetry; and static and kinematic condensation techniques. Advanced topics such as continuum finite element methods and nonlinear analysis techniques will be introduced.

Learning Objectives (General)
By the end of this course, the student will be able to:

Theoretical Background & Behavior: Define degrees of freedom as they relate to structural analysis; Develop an idealized structural model for analysis; Utilize the principles of virtual work (PVF and PVD) to calculate unknown forces and displacement.

Systematic Formulation of Direct Stiffness Methods: Calculate the element stiffness matrix of truss and beam-column elements; Describe how elements are transformed from local to global coordinates; Construct a global stiffness matrix from element stiffness matrices; Assemble load vectors from nodal, thermal, and distributed loads; Solve for unknown element forces, support reactions, and nodal displacements.

Special Procedures: Utilize condensation techniques to reduce the computational effort required to solve matrix structure analyses; Develop models using sub structuring methods to solve analyses for complex structures; Describe methods for solution of simultaneous equations and the implications of numerical accuracy.

Introduction to Advanced Concepts: Describe how results from second-order elastic analysis can differ from first-order elastic analysis; Solve for equilibrium on deformed structural geometry; Compare and contrast the uses of line and continuum structural models.

POLICIES & PROCEDURES

Academic Integrity: Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. Cheating is strictly prohibited and devalues the degree that you are working on. As a member of the NJIT community, it is your responsibility to protect your educational investment by knowing and following the academic code of integrity policy that is found at: http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf.

Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. *Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university.* If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at dos@njit.edu.

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

Lectures/Class: Attendance at all lecture/class periods is expected. Students participating online are expected to participate live via WebEx with their cameras turned on, and microphones muted unless they are asking a question or participating in a course discussion. Students participating in-person must follow NJIT's policies on social distancing, mask wearing, and other COVID-19 related health and safety policies.

During class, I will often ask you to work on a problem or brainstorm ideas and you will then be called on to provide one of more of your answers. The goal of this in-class work will be to get you started on a problem (not necessarily finish) that we will then discuss. Please be respectful to the course instructor and your classmates. You should always bring a pencil and calculator with you to class.

Handouts: Copies of the lecture handouts used in class will be posted on Canvas throughout the semester. It is highly recommended that you fill in and take notes on these handouts during the lecture period. A "filled in" version of these notes will be posted after class.

Prerequisites: It is assumed that you have a background in undergraduate structural analysis, mechanics of materials, and statics. Further, basic understanding of computer programming and matrix operations are expected. You will not necessarily be given every piece of information you need to solve a problem, but enough to be able to solve it with some looking up of expressions or conducting analyses.

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 to be turned in individually unless specified otherwise on the assignment. If you collaborate with a classmate (or two) be sure to state that collaboration and their names at the top of your assignment.

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; staple all homework pages together and have your name written clearly on the front page. An example of an acceptable homework solution is available on Canvas.

Late Homework: Homework will be due at the beginning of class on the date it is due. Late Homework will be accepted up to two days after the due date with a 10% reduction for each day the assignment is late. After that time, assignments 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 attending office hours with the instructor and/or asking questions in class. As with many engineering problems, multiple solutions may be possible. This means that all rational solutions to the assignments will be accepted.

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.

Homework questions will be graded in terms of a nine point scheme.

Format

One (1) point will be awarded if the solution is formatted with a problem statement and a statement on what is required in the solution

One (1) additional point will be awarded if the engineering solution is presented in an organized and neat fashion that is easy to follow along.

One (1) additional point will be awarded if the solution is completed with a boxed-in answer, including a properly formatted drawing if it is requested in the problem statement.

Concept

One (1) point will be awarded if the solution has major errors in the conceptual basis of the solution.

Two (2) points will be awarded if the solution has minor errors in the conceptual basis of the solution.

Three (3) points will be awarded if the solution has no errors in the conceptual basis of the solution.

Execution

One (1) point will be awarded if the solution has two or more math or execution errors.

Two (2) points will be awarded if the solution has one math or execution error.

Three (3) points will be awarded if the solution has zero math or execution errors.

If you believe that an error was made in grading the homework, you should write a short justification of your claim and submit a regrade request through Gradescope. 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.

Exams: There will be one midterm exam and one final exam. Both exams will be oral exams administered via an individual meeting on WebEx. In an oral exam format, the instructor will pose questions to the student in spoken form. Students will need to answer the questions in such a way to demonstrate sufficient knowledge of the subject to pass the exam.

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

Homework	20%
Project	25%
Midterm Exam	25%
Final Exam	30%

The minimum requirements for final letter grades are as follows:

A = 90%, B+ = 84%, B = 77%, C+ = 71%, C = 65%, F < 65%

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 lecture and other class activities; to answer questions clearly; to be available during office hours or to notify you beforehand if he is unable to keep them; to provide a suitable guest lecturer when they are traveling; 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)