NCSU Department of Civil, Construction, and Environmental Engineering
CE 325 – (Matrix) Structural Analysis I
Spring 2026, T/Th 1:30-2:45 pm, 4106 James B. Hunt Library

INSTRUCTOR: Sandeep Kumar
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OFFICE HOURS: Tue/Thu: 3:00 – 4:00 pm
Other times: By Appointment

TA: Zach Phillips **Email:** zphilli@ncsu.edu

Office hours: Mon/Wed: 3:00 – 4:00 pm

Note: *Office hours will be held virtually via Zoom web-link(s) that are emailed directly to registered students.*

CREDIT HOURS: 3
PRE-REQUISITES: CSC 111 or equivalent; C- or better in CE 225
DEGREE PROGRAM: Must be matriculated into Civil or Construction Engineering (CE or CON)

COURSE OBJECTIVES: To present the material in such a way that students will be able to:

- Apply the Matrix Displacement Method (MDM) to 1D: uniaxial, beam, 2D: truss, and frame structures
- Program Python code to implement the MDM computationally
- Use SAP2000 commercial software proficiently, knowledgeably and efficiently
- Verify the correctness of solutions for problems solved by hand, Python, or SAP2000.
- Read technical literature with understanding and confidence

LEARNING OUTCOMES: By the end of this course you will be able to do the following:

- recognize the difference between **bending moment** and **equilibrium** sign conventions
- draw **qualitative deflected shapes** in addition to **axial (A), shear (V) & bending moment (M) diagrams** for beams and frames
- manipulate **vectors and matrices** as needed for the MDM of analysis
- derive the **stiffness matrices** for beam, 2D truss, and 2D frame elements by applying fundamental mechanics principles: *equilibrium*, *compatibility*, and *constitutive* (force-displacement) relations
- derive **fixed end forces** for beam and frame elements
- recognize and define **Kassimali's notation** for stiffness matrices and force and displacement vectors ([k], $\{Q_f\}$, {Q}, {u}; [K], $\{F_f\}$, {F}, {v}; [S], $\{P_f\}$, {P}, {d})
- use **Structural** and **Member level** superposition to show the relationships between these variables
- summarize the **solution steps** in the MDM using this notation and appropriate figures/diagrams
- **solve** small MDM problems **by hand**
- **solve** medium sized problems using **basic Python programming**
- **solve** large problems using a commercial structural analysis program - **SAP2000** - with proficiency
- determine **tributary areas** for assignment of loads
- apply **multiple loading conditions** and combine results as needed
- use analysis results to do the following (**post-processing**):
  - verify equilibrium
  - draw axial, shear and bending moment diagrams
  - compute normal, shear, principal, maximum shear and mean stresses and show them on appropriate two-dimensional stress blocks

TEXTBOOK: *Matrix Analysis of Structures, 3rd Edition*, Aslam Kassimali, 2020
(recommended) ISBN: 9780357710463 (~ $150.00)

COURSE NOTES: Notes for most of the topics covered in the class will be available on the course website. However, the notes will not be a substitute for the lecture. Lectures and good notes taking practices are your best source of information in this course.

REFERENCES: A Solid Mechanics textbook (e.g. Mechanics of Materials by James M. Gere)
Python documentation (https://www.python.org/)

SOFTWARE: Python is available to download for free at: https://www.python.org/

SAP2000, Computers & Structures, Inc. https://www.csiamerica.com/products/sap2000
A 30-day trial version is available from the website above. NC State is also working out a new licensing agreement and further information will be provided here once finalized.

CALCULATORS: There will be a lot of linear algebra (matrix-vector) operations. Make sure you are familiar with the use of these operations on your calculator (e.g., TI-83). It will also be beneficial to learn how to store variables.

COURSE WEBSITE: **http://www.jfpatric.com/**

TENTATIVE SCHEDULE: **# LECTURES**

1.	Introduction (Kassimali, Chap. 1)	1
2.	Review of statics, solid mechanics, (Kassimali, Chap. 2)	4
3.	Matrix analysis of uniaxial structures, Programming, SAP (notes only)	5
4.	Matrix analysis of trusses, Programming, SAP (Kassimali, Chap. 3)	4
5.	Matrix analysis of beams, Programming SAP (Kassimali, Chap. 5)	5
6.	Matrix analysis of frames, Programming, SAP (Kassimali, Chap. 6)	4
7.	Modeling of realistic structures (Tributary areas, moment releases, etc.)	2
8.	Last day (TBD)	1
	Exams/Post-Review	4

HOMEWORK: *Schedule:* Homework will normally be assigned on Thursday, collected **at the beginning of class** the following Thursday.
Teams: Working in teams is **mandatory**. Teams of 3-4 members will submit a group solution, however each member must contribute and be able to arrive at the final solution alone. See below for the statement that must appear on the solutions turned in.
Format: All homework solutions will be submitted in an **electronic**, **professional report** format (template posted on the course website) that includes the following:

- a **Cover Sheet** with your signature(s) under the following statement "**I have neither given nor received any unauthorized assistance on this assignment**" and, when done in teams, "**We, the undersigned, all agree that we have each participated appropriately on this assignment.**" Anyone's signature missing from cover page will NOT receive credit for the assignment unless cleared otherwise with instructor. Include your **Group Number** on the top right-hand corner of the Cover Sheet.
- a brief **Executive Summary** which contains the problem statement, important results, and conclusions (the length of these components will vary with assignment)
- a **Technical Summary** which includes the details of the solution with figures, equations etc. and the complete results, and if needed:
- an **Appendix** with annotated computer input and output, etc. If the TA cannot follow your solution, then you will get no credit for that problem, even for a correct answer.
- You may use any type of paper as long as it is 8½ x11 and has no ragged edges, i.e. not torn from a notebook. Scan/combine the pages and **submit as a single PDF file**. Late homework will only be accepted with a valid excuse.

- Homework will be collected and evaluated **primarily for completeness**. Sometimes one or two problems **might be graded for correctness**. Detailed homework solutions will be provided for each student to evaluate his/her own solution for correctness. Students are expected to compare their own homework solutions with the provided solution and discuss any aspects with the TA or instructor within a couple of days after the solutions are returned to the class/posted on website.

EXAMS AND FINAL:
Each exam will normally consist of three or four problems. *The exams will be individual, in-class, closed book and closed notes (calculators allowed), with equations provided on the test cover page as needed.* I will distribute a study guide and the exam cover page before the test date. The exam questions may involve derivations or problems. For the problems, either a complete solution or only part of a solution may be asked for. You need to be familiar enough with the complete solution procedure such that you will not be confused by a question asking for only part of the solution. Partial credit will be given for most problems. The Final Exam will be comprehensive. *Make-up exams will NOT be given for any reason.* If you miss an exam for a university accepted reason, then that exam percentage is added to your Final Exam percentage (i.e. miss one exam and your final exam is worth 50%, miss two exams and your final exam is worth 75%). *Make-up final exams will only be given with valid excuses.*

COURSE GRADE:
Homework (No HW grades dropped. About 10 assignments) 20%
SAP Proficiency Test (Apr. 28) 5%
Exams (two at 25% each: Feb. 24, Mar. 31) 50%
Final Exam (May 5, 12-2:30 pm) 25%

Score	≥ 97	96.9-92	91.9-89	88.9-82	81.9-77	76.9-72	71.9-67	66.9-62	61.9-60	≤ 60
Grade	A+	A	A- or B+	B	B- or C+	C	C- or D+	D	D-	F

If you fall into one of the "gray areas" (A- or B+, B- or C+, C- or D+) your grade will be determined by whether your performance has improved or remained consistent (higher grade) or gotten worse (lower grade), especially on the final exam.

Note: *I do not curve grades in this course.* It is theoretically possible for everyone in the class to get an A. Your performance depends only upon how you do, not on how everyone else in the class does. It is therefore within your best interests to help your classmates within the limits of the academic integrity policy.

GRADING ERROR: If you believe that an error was made in grading, you should write a short justification of your claim and attach it to the ***original*** homework/exam problem in question and return to the instructor within one week for review and potential re-grade. Any falsification will result in a **ZERO** for the assignment.

ETHICS:
There may be some homework problems (and even exam problems) where the final answer is known, e.g. an answer may be given in the back of the book for a homework problem, or a test question may be to derive a stiffness term that appears on the equation sheet such as: $12EI/L^3$. In these cases, ***if your work does not give you the correct answer, but you say that it does,*** you will get a **ZERO** on that problem, regardless of your mistake. It is a breach of ethical conduct to write down something that you know is based on an incorrect analysis. If your work does not lead to the known solution, the proper response is to write down your (presumably incorrect) answer and then state that it is different from the known (presumably correct) solution.

ATTENDANCE POLICY:

Attending on-campus lectures is strongly encouraged, but not mandatory as these will be recorded and posted online. Students are responsible for all material presented in every class. Refer to https://policies.ncsu.edu/regulation/reg-02-20-03-attendance-regulations

ACADEMIC INTEGRITY STATEMENT

Students will adhere to the academic policy set forth by University Code of Student Conduct (http://policies.ncsu.edu/policy/pol-11-35-01). Plagiarism and cheating are attacks on the very foundation of academic life and cannot be tolerated within universities. Section eight (8) of the Code defines academic dishonesty and provides information on potential sanctions for violators of academic integrity. You will be asked to sign the following statement on each exam and on the final: "I have neither given nor received any unauthorized aid on this test." All cases of academic misconduct will be submitted directly to the Office of Student Conduct.

STUDENTS WITH DISABILITIES:

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Disability Resource Office (DRO) located at Holmes Hall Suite 304, 2751 Cates Avenue, Campus Box 7509, (919) 515-7653. https://dro.dasa.ncsu.edu. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation (NCSU REG 02.20.01 - http://policies.ncsu.edu/regulation/reg-02-20-01).

HEALTH AND WELL-BEING RESOURCES:

The physical and mental health of NC State University students and the broader community is of upmost importance. There are a number of resources available to help keep you and others stay safe, healthy and successful. Please refer to the online links below:

Campus Health: https://healthypack.dasa.ncsu.edu/

Counseling Center: https://counseling.dasa.ncsu.edu/

Wolfpack Wellness: https://wellness.ncsu.edu/resources/

STUDENT PRIVACY:

Students may be required to disclose personally identifiable information to other students in the course, via digital tools, such as email or web-postings, where relevant to the course. Examples include online discussions of class topics, and posting of student coursework. All students are expected to respect the privacy of each other by not sharing or using such information outside the course.

STUDENT RESPONSIBILITY:

Students are responsible for reviewing the NC State University Policies, Rules, and Regulations (PRRs) which pertain to their course rights and responsibilities, including those referenced both below and above in this syllabus:

Equal Opportunity and Non-Discrimination Policy Statement: https://policies.ncsu.edu/policy/pol-04-25-05 with additional references at: https://oied.ncsu.edu/divweb/policies/

Code of Student Conduct: https://policies.ncsu.edu/policy/pol-11-35-01

INSTRUCTORS' COMMITMENT:

You can expect your instructor/TA to be safe, courteous, punctual, well-organized, and prepared for lecture; to answer questions clearly; to be available during office hours or to notify your beforehand if they are unable to keep them; to provide a suitable guest lecturer when they are traveling; and to grade uniformly and consistently according to posted guidelines.

HOW TO MAXIMIZE YOUR LIKELIHOOD OF GETTING AN A IN THIS COURSE:

- Preview the material before coming to class by reading the chapter in the textbook.
- Ask questions in class or during office hours on anything that is not clear.
- Rework the example I do in class and the examples given in the textbook. You should get to the point where you can solve them without looking at the notes. Ask questions if you have trouble.
- Be sure that as an individual you understand and can solve any of the homework problems worked out by your team. Team cooperation is encouraged to facilitate the learning process and prepare you for real-world engineering workplace scenarios.
- In addition to the homework problems (which are really the minimum amount of practice needed), look at as many other problems as you can and work through, or at least think through, their solutions. Ask questions if you have trouble.
- Be excited about the subject matter for this course, if you put in the required effort to learn and implement the matrix displacement method, you will have the necessary knowledge and state-of-the-art toolbox for solving a variety of problems encountered in modern, real-world structural analysis/engineering.

Welcome Back Wolfpack and looking forward to an enriching and productive semester with you all!