CEE 423 Matrix Analysis of Structures
Fall 2025[1]

Instructor:

Arancha Alarcon, PhD, PE, LEED AP, (arancha.alarconfleming @northwestern.edu), Tech A220

Office hours:

Monday & Wednesday 2.30 - 4 pm **or by appointment** at A220

Class times and location:

Tu & Th: 3.30-4.50PM **@** M166

Required Textbook:

None. Notes will be provided

Reference Textbooks:

These books are suggested reading. They can be found in the library.

1. W. McGuire, R. Gallagher, R. Ziemian, Matrix Structural Analysis, 2nd ed., 2014
2. Kassimali, *Matrix Analysis of Structures*, 2012
3. Felton L. P and Nelson R. B, *Matrix Structural Analysis*, 1997
4. J. Fish, T. Belytschko, *A First Course in Finite Elements*, 2007
5. R. Cook, D. Malkus and M. Plesha*, Concepts and Applications of Finite Element Analysis*, 1989
6. R. C. Hibbeler, *Structural Analysis*, 2018
7. K. H. Gerstle, *Basic Structural Analysis*, 1974

Prerequisites:

Graduate standing, Senior undergraduate or permission of instructor

[1] Updated 9/12/25

Description:

Use of matrix analysis for structural systems, geometric matrices, stability, analysis of geometrically nonlinear systems and introduction to the finite element method.

Course Objectives:

1. Combine classical methods of Structural Analysis with programming and commercial software.
2. Determine deflections and forces in statically determinate and indeterminate structures using force and stiffness methods
3. Use a physical interpretation of stiffness matrices to assemble stiffness matrices analytically
4. Write and use computer programs which implement the matrix stiffness method

Course Outcomes:

1. Calculate deflections, reactions and internal forces for trusses, beams and frames using analytical and computer-based methods
2. Extend the study of linear elastic analysis to include nonlinear aspects of structure behavior
3. Be able to interpret computer output and validate results using simplified models and hand calculations

Course Outline:

1. Introduction
2. Degrees of freedom. Coordinate Transformation. Matrix form of equilibrium, compatibility, and constitutive laws.
3. Contragradient law. Nodal Forces
4. Displacement Method of Analysis (Indirect Method): Trusses, beams and frames
5. Direct Stiffness Method for trusses, beams, and frames
6. Additional topics: Thermal effects, settlement, prestress tendons, initial stresses, and non-prismatic members
7. Principle of virtual work, Rayleigh-Ritz. Approximate interpolation functions
8. Introduction to the Finite Element Method
9. Nonlinear aspects of structural behavior

Course Assessment and Expectations:

Grades are determined based on the following components

- 30% Homework
- 35% Midterm Thursday 10/30/25
- 25 % Final Group Project (due Tu 12/9/25)
- 10% Participation

Participation: Students are expected to attend class and actively engage in discussion through questions and comments.

Uses of generative AI

In this course, you are allowed to use Generative Artificial Intelligence (GAI) on assignments only for the purposes specified in assignment prompts. Any use of GAI should be accompanied by a disclosure at the end of an assignment explaining (1) what you used GAI for; (2) the specific tool(s) you used; and (3) what prompts you used to get the results. Any use of GAI beyond where permitted will be viewed as a potential academic integrity violation.

Appropriate use of Generative AI in this course:

- Checking your grammar and spelling
- Synonym tools available in Microsoft Word, Grammarly, and some GPT platforms such as Bard
- Using app recommendations to rephrase sentences or reorganize paragraphs that you wrote
- To brainstorm ideas, however, note that the output of these programs may be inaccurate, incomplete, and problematic in terms of where it came from

Like other tools, however, the use of AI can also hamper the acquisition as well as application of skills. When using Generative AI, be mindful of this tool compromising your ability to create or understand information. Generative AI does not produce or create knowledge; AI is a tool and only a tool

Inappropriate use of Generative AI within this course

- Generative AI cannot, and may not, be presented as your own work. It is unethical to submit any AI-generated work as your own.
- You may not have any AI program generate (draft or final) any assignment given to you unless the assignment explicitly instructs you to use AI.

If you do include material generated by Generative AI in an assignment, it needs to be cited like any other reference materials.

Northwestern University Syllabus Standards

This course follows the Northwestern University Syllabus Standards. Students are responsible for familiarizing themselves with this information.