



CEE 423 Matrix Analysis of Structures Fall 2023

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: 3.30-4.50PM @ M166, Tuesday and Thursday

Required Textbook None

Reference Textbooks

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

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 structure behavior

Course Assessment Grades are determined based on the following components

- 30% Homework
- 30% Midterm (Tu-10/31/23)
- 35% Final Project (due Tu-12/5/23)
- 5% Participation

Academic Integrity

Student-teacher relationships are built on trust. Acts, which violate this trust, undermine the educational process. Students in this course are required to comply with the policies found in the booklet, "Academic Integrity at Northwestern University: A Basic Guide". All work submitted for credit in this course must be submitted electronically unless otherwise instructed. Your written work may be tested for plagiarized content. Submission of any assignment that is in violation of this policy will result in zero points granted for that specific assignment.

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Students who experience a personal emergency should contact the instructor as soon as possible to arrange to complete coursework. Should public health recommendations prevent in person class from being held on a given day, the instructor or the university will notify students.

Support for Wellness and Mental Health

Northwestern University is committed to supporting the wellness of our students. Student Affairs has multiple resources to support student wellness and mental health. If you are feeling distressed or overwhelmed, please reach out for help. Students can access confidential resources through the Counseling and Psychological Services (CAPS), Religious and Spiritual Life (RSL) and the Center for Awareness, Response and Education (CARE). Additional information on all of the resources mentioned above can be found here:

<https://www.northwestern.edu/counseling/>
<https://www.northwestern.edu/religious-life/>
<https://www.northwestern.edu/care/>