

Fall 2006

CE 131L. Matrix Structural Analysis

Instructor:	Henri Gavin, 162 Hudson Annex, Henri.Gavin@Duke.edu
Class Time:	Tu Th 11:40–12:55, Room 208 Hudson
Recitations:	We 4:25–5:40, Room 208 Hudson
T.A.:	Nicole Axelrod, , Nicole.Axelrod@Duke.edu
Office Hours:	HG: Th 1:00 – 2:00, Rm 162; NA: , Rm ; and by appointment
Textbook:	A. Kassimali, <i>Matrix Analysis of Structures</i> , Brooks/Cole, 1999.
Website:	http://www.duke.edu/~hpgavin/ce131/
Prerequisites:	EGR 75L. Solid Mechanics, Math 103. Multivariable Calculus or Math 107. Linear Algebra and Diff. Eq'ns.
Academic Integrity:	http://www.integrity.duke.edu/ugrad/student.html
Short Term Illness:	http://www.aas.duke.edu/trinity/t-reqs/illness/
Grading:	Homeworks(14) 30%; Tests(3): 45%; Final(1): 20%; Participation: 5%

Bulletin Description

Development of stiffness matrix methods from first principles. Superposition of loads and elements. Linear analysis by hand and computer of plane and space structures comprising one-dimensional truss and beam elements. Prerequisites: Engineering 75L and Mathematics 103 or Mathematics 107.

Course Requirements

- Completion of the assigned reading is recommended prior to each lecture. (See the attached syllabus and reading list.)
- Homeworks are due by 4pm on their due date. Due dates are listed on the syllabus. Late homeworks require a short-term illness notification form, otherwise they **will not** be accepted. Collaboration with friends on the homework assignments is permitted. Homeworks will be returned one week after they are collected.
- Every student can get one automatic 48 hour homework extension. To arrange an extension, send e-mail at least 24 hours before the due-date to: Henri.Gavin@Duke.edu
- Please do not ask Nicole to solve homework problems for you. She will, however, solve problems similar to your homework problems. Solution sets to the homeworks will be posted after the homeworks have been graded and returned.
- Neatness counts. Straight lines should be drawn with a straight edge. Homeworks must be stapled. Nicole will describe her own requirements in detail early in the semester.
- There will be one final, three tests, and fourteen homeworks. (See the attached syllabus.)

The Duke Community Standard

Duke University is a community of scholars and learners, committed to the principles of honesty, trustworthiness, fairness, and respect for others. Students share with faculty and staff the responsibility for promoting a climate of integrity. As citizens of this community, students are expected to adhere to these fundamental values at all times, in both their academic and non-academic endeavors.

The Pledge

Students affirm their commitment to uphold the values of the Duke University community by signing a pledge that states:

- 1. I will not lie, cheat, or steal in my academic endeavors, nor will I accept the actions of those who do.*
- 2. I will conduct myself responsibly and honorably in all my activities as a Duke student.*

The Reaffirmation

Upon completion of each academic assignment, students will be expected to reaffirm the above commitment by signing this statement: "I have adhered to the Duke Community Standard in completing this assignment."

COURSE OBJECTIVES

The objectives of this course are to teach students how to:

- Distinguish between energy-based flexibility approaches and matrix-based stiffness approaches to structural analysis;
- Determine deflections and forces in statically determinate and indeterminate structures using the matrix stiffness method;
- Understand the physical interpretation of stiffness matrices and use this interpretation to assemble the stiffness matrix by hand;
- Compute deflections and rotations, internal forces and moments, and reactions in trusses, beams and frames; and
- Write and use computer programs which implement the direct stiffness method.

COURSE GOALS

Students who successfully complete this course will demonstrate:

- An ability to apply knowledge of mathematics (linear algebra), science and engineering (material behavior), and computer programming;
- An ability to master a powerful method of structural analysis;
- An understanding of professional and ethical responsibility; and
- A recognition of the need for, and an ability to engage in life-long learning.

ASSESSMENT

This course measures students' progress in meeting the above objectives by requiring them to:

- Calculate the forces within members of trusses, beams, and frames using analytic and computer-based techniques;
- Determine fixed-end reactions using energy-based methods;
- Understand and use the principle of superposition in simplifying the analysis of statically indeterminate structures;
- Apply the stiffness method to determine the behavior of plane truss, beams, and frames subject to various loads;
- Extend the planar analysis to include three-dimensional trusses and frames; and
- Extend the scope of linear analysis to include stability and dynamic effects.

SYLLABUS

Week	Dates	Topics	Reading
1.	8/29 Due 9/7	8/31 Stiffness (displacement); Flexibility (force); Linearity; Castigliano, Maxwell, and review (?) of matrix math. HW 1: 2.2, 2.5, 2.9, 2.11, 2.15, 2.18, 2.20, 2.23	Ch. 1 Ch. 2
2.	9/5 Due 9/14	9/7 PART ONE - TRUSSES: local and global coordinates; joints, reactions, and degrees of freedom; Coordinate transformation; Local and global element stiffness matrices. HW 2: 3.1, 3.4, 3.5, 3.6, 3.7, 3.9, 3.11	3.1-3.5
3.	9/12 Due 9/21	9/14 Stiffness matrix assembly methods; Deflections, bar forces, and reactions. Matlab implementation for 2-D trusses. HW 3: 3.15, 3.20, 3.21, 3.22, 3.24	3.5-3.8 Ch. 4
4.	9/19 Due 9/28	9/21 Geometric stiffness effects in 2-D trusses. HW 4: Matlab implementation for geometric stiffness in trusses	course-pack
5.	9/26	9/28 PART TWO - BEAMS: local and global coordinates; Element stiffness matrix.	5.1-5.2
6.	** 10/3 10/5 Due 10/12	** TEST 1 - Stiffness Matrix Methods for Plane Trusses Stiffness matrix assembly methods; Superposition, fixed end forces, and load vector. HW 5: 5.8, 5.9, 5.12, 5.21, 5.23	5.4-5.5
7.	10/10 Due 10/19	10/12 *** Fall Recess *** Stiffness Matrix Assembly Methods; deflections, reactions, and internal forces. HW 6: 5.26, 5.28, 5.31, 5.34	5.5-5.7
8.	10/17 Due 10/26	10/19 Matlab implementation for continuous beams HW 7: Matlab analyses for 2-D beams	course-pack
9.	10/24	10/26 PART THREE - FRAMES: local and global coordinates; Coordinate Transformation Matrices; Frames with vertical and horizontal beams	6.1-6.4
10.	** 10/31 11/2 Due 11/9	** TEST 2 - Stiffness Matrix Methods for Beams Frames with inclined beams: Stiffness matrix assembly, fixed-end forces, load vector, deflections, reactions, and internal forces HW 8: 6.7, 6.13, 6.18, 6.27, 6.30, 6.31	6.5-6.6
11.	11/7 Due 11/16	11/9 Matlab implementation for 2-D frames HW 9: Matlab implementation for 2-D frames	course-pack
12.	11/4 Due 11/28	11/16 Structural Dynamics and Natural Modes HW 10: WEAVE exercises	course-pack
13.	11/21 11/23	Matrix Condensation, Shear, Temperature, Connections *** Thanksgiving Recess ***	9.3,9.7-9.9
14.	11/28 ** 11/30 Due 12/7	11/28 PART FOUR - Space Trusses and Space Frames ** TEST 3 - Stiffness Matrix Methods for Frames HW 11: 8.2, 8.3, 8.12, 8.17 --- using FRAME software	8.1, 8.3
15.	12/5	12/7 Geometric stiffness effects and Buckling of 2D and 3D Frames	course-pack
	** 12/13 **	*** FINAL EXAM *** 9:00am - 12:00pm ... 208 Hudson	

REFERENCES

Vesic Library Call Numbers: 624.17, 624.171.

1. H.G. Allen and P.S. Bulson, *Background to Buckling*, McGraw-Hill, 1980.
2. F. Arbabi, *Structural Analysis and Behavior*, McGraw-Hill, 1991.
3. L.P.Felton and R.B.Nelson, *Matrix Structural Analysis*, Wiley,1997.
4. E.H. Gaylord, Jr., *Structural Engineering Handbook, 3rd ed.*, McGraw-Hill, 1990.
5. K.H. Gerstle, *Basic Structural Analysis*, Prentice-Hall, 1974.
6. R.C. Hibbler, *Structural Analysis*, 5th ed., Prentice-Hall, 2002.
7. A. Kassimali, *Matrix Analysis of Structures*, Brooks/Cole, 1999.
8. R.L. Ketter, Lee, and Prawel, *Structural Analysis and Design*, McGraw-Hill, 1979.
9. H. Laursen, *Structural Analysis*, McGraw-Hill, 1988.
10. R.K. Livesley R.K., *Matrix Methods of Structural Analysis*, 2nd ed. Pergamon Press, 1975.
11. J.C. McCormac and J.K. Nelson, *Structural Analysis*, 2nd ed. Addison-Wesley, 1997.
12. W. McGuire, R.H. Gallagher and R.D. Ziemian, *Matrix Structural Analysis*, 2nd ed. John Wiley, 2000.
13. J.L. Meek, *Matrix Structural Analysis*, McGraw-Hill, 1971.
14. M. Paz and W.E. Leigh, *Integrated Matrix Analysis of Structures - Theory and Computation*, Kluwer Pub., 2001.
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16. R.L. Sack, *Matrix Structural Analysis*, Waveland Press, 1994.
17. R.E. Sennet, *Matrix Analysis of Structures*, Waveland Press, 2000.
18. C-K Wang, *Matrix Methods of Structural Analysis*, International Textbook Co., 1970.