Course Syllabus and Guidelines [Fall 2025]
ME 622 – Finite Element Methods in Mechanical Engineering
Date: Friday 02:30 PM – 5:20 PM
Location: CKB 310

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It is the responsibility of the student to read and understand this course syllabus. This syllabus is subject to change and may be updated throughout the semester.

Course Description: This course will cover principal ingredients of the Finite Element Method (FEM) for boundary value problems, including variational formulations, methods of approximation, convergence of approximations, triangular and quadrilateral elements, linear and higher-order shape functions, and solution of steady state problems. This method is based on the idea of dividing the domain of the solution into a finite number of simple subdomains, the finite elements, and using variational concepts to construct an approximation of the solution over the collection of finite elements. Because of the generality and richness of the ideas underlying the method, it is an extremely powerful tool for constructing approximate solutions and has been used with remarkable success in solving a wide range of problems in structure analysis, elasticity, fluid dynamics, electromagnetics, biomechanics, just to name a few.
For this introductory course, we will begin with a simple one-dimensional problem to introduce the essence of the FEM from both the mathematical and the analytical point of view. We will then study two-dimensional problems with different elements including triangular elements and isoparametric elements and show how to implement the FEM in MATLAB.

Credit Hours: 3
Prerequisite: Desirable prerequisites include calculus, elements of ordinary and partial differential equations, elements of linear algebra (in particular matrix and vector calculus and algebra), and computing experience with software or programming languages such as MATLAB, Python, C++, etc.
Since this course focuses on topics relevant to mechanical engineering, a working knowledge of basic heat conduction, basic linear elasticity, and basic fluid flow, are all considered prior knowledge.

Lecture: 1 day per week at 170 minutes

Primary Textbooks: There are many books on finite element methods. This class does not have a required textbook. However, I do recommend the following books for more detailed and broader treatments than can be provided in any form of class:

- A First Course in Finite Elements, J. Fish and T. Belytschko, Wiley, 2007.
- The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, T.J.R. Hughes, Dover Publications, 2000.
- The Finite Element Method: Its Basis and Fundamentals, O.C. Zienkiewicz, R.L. Taylor and J.Z. Zhu, Butterworth-Heinemann, 2005.
- Introduction to the Finite Element Method and Implementation with MATLAB, G. Li, Cambridge University Press, 2020

Course Policies:

- Homework & Programming Assignments
  - Assignments are due online on the posted date/time, unless modified by the instructor.
  - Unless an assignment specifies otherwise, you must work in teams of two, handing in one team solution per assignment. The instructor will designate the teams.
  - ***Name, roles, certifications (cover)***. On every submission's first page (or "outside"), list:

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    •Course  •HW/Project# •Due date
    Team: First Last (Coordinator), First Last (Recorder/Submitter)
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    Include this line signed or typed by both partners: "If my name appears on this solution set, I certify that I participated in solving the problems and understand the submitted work."
  - ***Team Roles (rotate every assignment)***.
    - *Coordinator:* On each group assignment, your team should organize work sessions, splits tasks, ensure both contribute and understand solutions.
    - *Submitter:* writes/edits the final text, assembles the file, checks format, and uploads.
    - *Checker:* the non-Submitter reviews the full set before upload for correctness and clarity.
  - The team roles must rotate on every assignment, once a team member has carried out a role, he/she may not do it again until everyone else on the team has done it.
  - ***Collision weeks (HW + Project due in same week)***: If the rotation would make the same student Recorder for both HW and Programming assignments, the Project Recorder flips to the other partner.
  - ***Programming assignment format***. Programming assignments are computer projects focusing on the practical implementation of a finite element method as described in lecture. The overall project report should be broken down into
    - Problem statement
    - Solution method (equations, explanations, ...)
    - MATLAB Code

    - Result
    - Conclusion

- ***Group responsibility***: One submission = one shared grade. Both partners are fully responsible for the content and academic integrity. Misrepresentation of participation is a violation.
- ***Late assignment***. Completed assignments should be turned in at the beginning of class on the due date. Solution sets will be accepted up to one week after the due date. Late assignments will receive a maximum grade of 50%. *However, once a group hands in several late assignments, they will no longer be accepted.*

- Coding and Software
  - You need to know how to program in MATLAB, Fortran, Python, or C++
  - Although MATLAB is selected as the course basic coding software, you can use other software (e.g., Python, C++) with prior approval. While MATLAB might not be the fastest option for "Run Time," it often helps to concentrate on the algorithms themselves rather than on the "coding" of basic and elementary steps.
  - MATLAB software is required to run the ".m files".
- Quizzes
  - There will be quizzes every week except week one and the weeks of take-home exam.
  - The quizzes will be taken from lecture and textbook readings and at the beginning of class.
  - All quizzes will be closed notes and closed book.
  - Only non-programmable calculators are allowed during quizzes. *Mobile phones, smart watches, programmable calculators, and similar electronic devices are expected to remain out of sight — the sight of a mobile phone, smart watch, or programmable calculator* during a quiz results in a grade of F for the class.
- Exam
  - There will be two in-class or take-home exams (dates to be announced).
  - Only non-programmable calculators are allowed during exams. *Mobile phones, smart watches, programmable calculators, and similar electronic devices are expected to remain out of sight.*
  - Failure to submit the answers results in a grade of zero, unless the dean of students contacts the instructor, and a decision is made otherwise. Employment is not considered a valid reason for missing an exam, and no makeup exams will be given.
- Final Project
  - There will be an individual final project for this course. The project will involve numerical data analysis and implementation of FEM extending the material covered in class. Every project must be approved by the instructor.
  - Possible topics include:

1. Comprehensive reviews of material not covered in detail in class, with some numerical examples;
2. Specific engineering-related problems or questions that are numerically studied or solved by the applications of approaches, methods or schemes covered in class

- *Students are required to submit the title and a short abstract of their final project by Friday October 31.*
- Projects will be due at the last day of class.
- If time allows, there will be a final session where all students will make a presentation of their projects to the whole class.

- Attendance and Absences
  - Attendance is expected and will be taken each session.
  - Questions will be asked during class, and I expect your active participation.
  - Students are responsible for all missed work, regardless of the reason for absence.
  - In the case that a student is absent (or expects to be absent) for an exam, the following actions are required in order for that exam grade to be non-zero:

1. The student should write an email to the professor indicating that he/she is going to contact the dean of students office about their absence from the exam. Those expecting official travel (i.e., athletes, academic conferences, etc.) must notify the professor and the dean of students office at least 2 weeks prior to the exam. In extreme cases (i.e., unforeseen sickness, death, etc.) the student must notify the professor and dean of students office within 48 hours after the originally scheduled exam time. In the email sent to the dean of students office, students should at a minimum include the following: (i) name; (ii) ID number; (iii) course and section; (iv) professor's name and email; (v) regularly scheduled exam time; (vi) evidence for absence.
2. Upon receiving notice from the dean of students office, the professor will contact the course coordinator and provide the relevant information.
3. Since it is likely that multiple students are in a similar situation, the course coordinator will make a decision that is equitable to everyone involved.

Grade Distribution:

The weights shown in the table will be used in the determination of the final course grade.

Quiz: (every week)	10%
Programming Assignments (3)	15%
Class Participation	5%
HW Assignment:	10%
Exams:	40%
Final Project: (Last day of class)	20%
Total	100%

Grading will be based on:

A:	90-100%
B+:	80-89%
B:	70-79%
C+:	60-69%
C:	50-59%
F:	0-49%

Note: Any disagreement over grades must be brought to the attention of the instructor no later than the deadline specified by the instructor. Further, final grades are typically not discussed via email, an appointment should be made.

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 here.

Please note that it is the 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, using any online software inappropriately, or other forms of dishonesty in academics 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.

Use of generative AI tools

This course expects students to work without artificial intelligence (AI) assistance in order to better develop their skills in this content area. As such, AI usage is not permitted throughout this course under any circumstance.

Approximate Outline: A lecture period is 170 minutes.

Lecture	Topic
1	Introduction to finite element method for one-dimensional (1D) problem
2	Approximate, or finite-dimensional weak form for 1D problem
3	Finite-dimensional weak form in a matrix-vector form
4	Boundary conditions, higher-order basis functions, and numerical quadrature
5	Mathematical analysis of the finite element method
6	Finite element method for two-dimensional scalar problems