ME 471 / AE 420 / CSE 451: Finite Element Analysis

Spring 2025

Instructor:	Brian Mercer	**Time:**	MW 12:00pm – 1:20pm
Email:	bmercer@illinois.edu	**Place:**	114 Transportation Building

Course Web Pages:

1. Canvas - Syllabus; assignments and due dates; lecture notes; etc.
2. Gradescope - Written homework submission
3. PrairieLearn - Programming assignment submission
4. Campuswire - Online forum for homework help and conceptual questions

Teaching Assistants:

1. Pavan Ravi, pavanr2@illinois.edu
2. Junren Ran, jran2@illinois.edu

Office Hours: Instructor and TA office hours will be listed on the Canvas course page.

Credit: 3 or 4 undergraduate hours; 4 graduate hours. Students seeking the additional hour will be assigned extra requirements or work on homework and/or projects.

Textbook: There is no required textbook for this class. Recommended references are listed below:

1. R. D. Cook, D. S. Malkus, M. E. Plesha, R. J. Witt, *Concepts and Applications of Finite Element Analysis*, 4th edition, John Wiley & Sons, 2002.
2. K. H. Huebner, D. L. Dewhirst, D. E. Smith, T. G. Byron, *The Finite Element Method for Engineers*, 4th edition, John Wiley & Sons, 2001.
3. T. J. R. Hughes, *The Finite Element Method: Linear Static and Dynamic Finite Element Analysis*, Dover, 2000.

Prerequisites: CS 101 and ME 371 or TAM 470. Alternatively, AE 370 for AE students..

Course Learning Objectives: After completing the course, students will:

1. Understand the mathematical theory and foundation of the finite element method for linear differential equations.
2. Be able to write computer subroutines and/or full programs to carry out key finite element computations involving heat transfer and linear elasticity.

3. Be able to use commercial FEA software to model and solve complex engineering problems in heat transfer and linear elasticity.

Course topics:

1. Direct approach to finite element method, applications to spring and truss problems.
2. Weighted residual and variational formulation approaches.
3. Review of common element types for 1D, 2D and 3D analyses; isoparametric element formulations; beam elements.
4. Finite element formulations for solving steady-state and transient heat transfer problems.
5. Finite element formulations for solving static and transient problems in linear elasticity.
6. Modal (frequency) analysis for linear elastic structures.
7. FEM error behavior.
8. Computer programming implementation of finite element analysis: concepts and applications.
9. Use and applications of Abaqus commercial FEA software.
10. Special topics (time permitting): Nonlinear FEA, contact mechanics, plate and shell elements, engineering industry case studies and practical applications.

Grading Scheme: The final course grade is assessed based on your scores in the following categories:

1. Homework (50%)
2. Projects (35%)
3. Final Exam (15%)

The total score s corresponds to the final letter grade as follows:

$97\% \leq s \leq 100\%$	A+	$93\% \leq s < 97\%$	A	$90\% \leq s < 93\%$	A-
$87\% \leq s < 90\%$	B+	$83\% \leq s < 87\%$	B	$80\% \leq s < 83\%$	B-
$77\% \leq s < 80\%$	C+	$73\% \leq s < 77\%$	C	$70\% \leq s < 73\%$	C-
$67\% \leq s < 70\%$	D+	$63\% \leq s < 67\%$	D	$60\% \leq s < 63\%$	D-
$s < 60\%$	F				

Homework:

1. In this course, you are allowed to discuss homework assignments with other students, form study groups, etc, **but all submitted work and code must be your own**.

2. All problems on a given homework assignment must be submitted through the required platform (Gradescope or PrairieLearn) by the indicated due date to be considered for full credit.

3. The schedule of homework due dates will be maintained on the Canvas course page.

4. The Homework grade category for your final course grade is calculated as

$$\frac{\text{(total points earned)}}{\text{(total points available)}} \times 100\%,$$

Note that individual homework assignments are <u>not</u> weighed equally towards your final grade calculation. The relative weight of an assignment depends on how many points the assignment is worth.

Projects:

1. Unlike Homework assignments, Projects should be treated like a take-home exam, and **students are not permitted to work together or discuss their work on Projects; these must be fully individual efforts.**

2. There will be three (3) projects assigned in the class, with due dates staggered throughout the semester. Project due dates will be maintained on Canvas.

3. The relative weight of each project towards the Projects grade category will be communicated on the Canvas course site.

Homework and Project late submission policy: Late Homework and Project submissions will be penalized 10% per day (24 hour period), up to 2 days (48 hours) late. After 48 hours beyond the original due date have passed, the assignment will receive a zero. Please carefully review the rules below regarding extension requests for Homeworks and Projects:

1. All extension/make-up work requests must be received **in advance of the due date** or they will not be considered.

2. Every student gets **one** no-questions-asked (NQA) 48 hour extension on a **homework assignment**. Projects are **not** eligible for this extension.

3. You must email the instructor **and** TAs to indicate you would like to use your NQA extension request for the given assignment. As the name implies, there is no need to explain your situation or provide documentation. No penalty will be assessed if the assignment is turned in within the 48 hour extension window.

4. All NQA requests must be received before the due date, and cannot be applied retroactively to an assignment that has already been turned in late.

5. Besides the NQA extension request, you may request a homework or project deadline extension for the following situations, and must also provide appropriate documentation:

    - Short illness (requires doctor's note with specific days to be excused from class).
    - Illness for 3 or more days (requires letter from the Dean of Students)
    - Personal crisis (e.g., car accident, required court appearance, death of a close relative).

- Required attendance at an official UIUC activity (e.g., varsity athletics, band concert).
- For more extreme situations that involve an extended absence for more than a few days, please contact the instructor as soon as possible so we can discuss how to proceed.

6. Note that regardless of documentation provided, the final decision to grant an extension always lies with the instructor.

Final Exam:

1. The only exam in the course is the final exam.
2. The final exam will be a take-home exam, assigned Wednesday May 7, 2025 and due Friday May 9, 2025. Note that May 9 is the official final exam date assigned to the course by the University Registrar.
3. Students are not permitted to work together or discuss their work on the take-home final exam; the submitted work must be a fully individual effort.

Class attendance and participation: Class time will consist of a mixture of lectures, FEA computer labs, and in-class activities (solving example problems, group/classroom discussions, etc.). Regular attendance and participation in class activities is expected.

Campuswire online forum: Campuswire can be used by students to get help on assignments or conceptual questions from class. Campuswire should be used in lieu of email for these kinds of questions (please use email for issues outside the scope of getting help with course content). Please follow these guidelines:

1. Consider posting your questions to "Everyone" (rather than just "Instructor & TAs"), even if anonymously, so that everyone can benefit from the answer/feedback.
2. Do not make posts to "Everyone" about homework/programming problems you are working on that contain the entire written or code solution. Such posts will be deleted.
3. Anyone, including students, is welcome to answer a given question.
4. Please follow the guidelines on Canvas about seeking help on programming problems and debugging code.

Software: You will need access to the following software in this class:

1. Python: All coding assignments in the course must be completed using Python. Information regarding installing/accessing Python can be found on the Canvas course page.
2. Abaqus: We will use the FEA software Abaqus for some in-class lab sessions and assignments. You can use Abaqus in EWS labs or you can install on your personal computer, see getting an educational license through the UIUC WebStore.

Academic integrity: Every student is expected to review and abide by the university's Academic Integrity Policy as outlined in the Student Code. It is your responsibility to read this policy to avoid any misunderstanding. Ignorance is not an excuse. Do not hesitate to ask the instructor if

you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

Online Section (ONL): The online section of this course is conducted as described in the syllabus sections above, with the following additions and modifications:

1. Lecture sessions will be made available as asynchronous recordings, posted soon (generally same-day) after the live class meeting has concluded. A link to the UIUC Mediaspace channel hosting the video lectures will be maintained on the Canvas course page.

2. Office hours are offered over Zoom by appointment, with either the instructor or TA. Please send us an email if you would like to meet, and we can work together to schedule a time.

3. You are responsible for owning or having access to a computer that can support the software that we will be using in this course. Abaqus, in particular, is a resource-intensive program and may not run smoothly on older computers, so please plan accordingly and aim to install and test the software early in the semester.