TAM 470 / CSE 450: Computational Mechanics

Fall 2025

Instructor:	Brian Mercer	**Time:**	MWF 1:00pm – 1:50pm
Email:	bmercer@illinois.edu	**Place:**	2101 Everitt Laboratory

Course Web Sites:

1. Canvas - Syllabus, lectures notes, gradebook, etc.
2. PrairieLearn - Auto-graded coding homework problems are hosted here
3. Gradescope - Written homework submission
4. Campuswire - Online forum to receive/answer students questions.

Teaching Assistants:

1. Pavan Ravi: pavanr2@illinois.edu
2. Songyuan Cui: cui20@illinois.edu

Office Hours: Instructor and TA office hours will be posted to the Canvas course page.

Required text: Parviz Moin, *Engineering Numerical Analysis*, Cambridge University Press, 2nd ed., 2010. Available on reserve at the Grainger Engineering Library.

Prerequisites: CS 101; MATH 285 or MATH 286 or MATH 441

Credit: 3 or 4 undergraduate hours; 4 graduate hours. Students seeking the additional hour will be assigned additional problems on some assignments.

Course topics: Items 1–6 correspond roughly to Chapters 1–6 of the Moin textbook. Applications to problems in solid mechanics, fluid mechanics, dynamics, and heat transfer will be discussed.

1. Polynomial and cubic spline interpolation.
2. Numerical differentiation via finite differences and Padé schemes; error analysis.
3. Numerical integration: error analysis, advanced techniques.
4. Numerical solution of ODEs: Runge-Kutta methods, multi-step methods, backwards difference methods; error and stability analysis.
5. Numerical solution of both steady-state and time-dependent PDEs: semi-discretization, stability analysis, implicit methods, iterative solvers.
6. Weighted residual methods; finite element methods; spectral methods; finite volume methods.

Course Learning Objectives: After completing the course, students will be able to;

1. Identify and analytically develop differential equations that govern the behavior of phenomenon such as fluid flow, convection, heat transfer, dynamical systems, etc.
2. Understand and apply the mathematical theory and foundation governing techniques to numerically solve ODEs and PDEs relevant to engineers.
3. Choose appropriate numerical methods and algorithms to use to solve commonly-encountered differential equations in mechanics applications.
4. Use Python (and appropriate libraries) to develop custom code to solve differential equations.
5. Use appropriate methods to test, verify, and validate numerical simulation results.

Final Grade Calculation: Homework (35%), Projects (25%), Quizzes (15%), Final Exam (25%). 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. Homework problems requesting a written solution must be submitted via Gradescope.
3. Homework problems involving auto-graded coding questions must be submitted via PrairieLearn.
4. All problems on a given homework assignment must be submitted through the required platform by the indicated due date to be considered for full credit.
5. The schedule of homework due dates will be maintained on the Canvas course page.
6. 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 therefore <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, **students are not permitted to work together on Projects; these must be fully individual efforts.**
2. Two projects will be assigned in this course. The project requirements and due dates will be maintained on the Canvas course page.
3. Your highest-scoring project will be counted as 15% towards your final grade, and your lowest-scoring project will be counted as 10% towards your grade.

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 may use **one** no-questions-asked (NQA) 48 hour extension on a **homework assignment**. Projects are not eligible for this extension. To request an NQA extension, follow instructions on our Canvas course page. 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. 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.
3. If you do not use your NQA extension request during the semester, then your lowest Homework score **among your submitted homework assignments** will be dropped.
4. Besides the NQA extension request, you may request a homework 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.
5. Note that regardless of documentation provided, the final decision to grant an extension always lies with the instructor.

AI Use Policy: You are allowed to use AI tools as a resource when working on homework or projects, provided the use is responsible and transparent. Any assistance from AI, such as code generation, debugging suggestions, or explanatory text, must be clearly cited in comments or documentation (e.g., "Generated with help from ChatGPT on [date]"). Students must not submit work that is entirely generated by AI without meaningful personal contribution; all submitted code and writing must reflect the student's own understanding and effort. Misuse of AI in a way that

obscures authorship or bypasses learning objectives may be considered a violation of academic integrity.

Quizzes: Three short in-class quizzes will be given during the semester. Quizzes are equally weighted and given during class time. The quiz dates for the Fall 2025 semester are:

1. Quiz 1: Monday September 22
2. Quiz 2: Monday October 20
3. Quiz 3: Monday November 10

Make-up quizzes will only be offered for students who provide appropriate evidence of an excusable absence situation (same guidance as late submission of Homeworks and Projects outlined earlier in this syllabus). Quiz topics will be communicated closer to the dates of each quiz.

Final Exam: The final exam for this course will be a written comprehensive exam. The final exam for this course is scheduled for **Wednesday December 17, 7pm – 10pm**. A conflict/alternate exam will only be considered if arranged well in advance and if the situation is aligned with University policies regarding conflict/alternate final exams.

Class attendance and participation: Class time will consist of a mixture of lectures, coding demonstrations and in-class activities (solving example problems, group/classroom discussions, etc.). Regular attendance and participation in class activities is expected. Occasionally, you may need to bring a laptop to class to be able to fully participate.

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. Anyone, including students, is welcome to answer a given question.
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. Please follow the guidelines on Canvas about seeking help on programming problems and debugging code.

Software: Homework and Projects involving coding must be completed using Python. Each student should have access to a Python development environment. Below are recommended options for this course.

1. Anaconda is recommended for the easiest Python installation on your computer, as it is packaged with all the libraries and software you will need for this course.
2. Self-install Python via https://www.python.org/downloads. In this case, you will be responsible for setting up your own development environment and installing required libraries like `numpy`, `scipy`, etc.

3. Google Colab provides a Jupyter notebook in your browser (no installation required) and should suffice for most assignments given in this course.

DRES Accommodations: If you have DRES accommodations you must send your letter to the instructor at the beginning of the semester. Please do this using the DRES letter intake form on Canvas. In addition to sharing your letter, you must also give advance notice for each assessment/deadline for which you'd like to use any accommodations. DRES accommodations for quizzes and the final exam must be requested at least one week in advance of the exam to ensure the logistics can be put in place to meet your needs.

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(s) 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. All exams will be scheduled on the same date (but not necessarily the same time) as the in-person exams indicated in this syllabus. Exams will be scheduled, administered and proctored in-person by a local proctor contact, arranged by the Office of Online & Professional Engineering Programs from the Grainger College of Engineering.

3. 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.

4. You are responsible for owning or having access to a computer that can support the software that we will be using in this course.