TAM 470 / CSE 450: Computational Mechanics

Fall 2024

Instructor:	Brian Mercer	**Time:**	MWF 1:00pm – 1:50pm
Email:	bmercer@illinois.edu	**Place:**	Ceramics Building 218

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 Assistant: Pavan Ravi, pavanr2@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 1–5 correspond to Chapters 1–5 of the Moin textbook; the extent of the coverage of Item 6 will be subject to availability in the course schedule. 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, particle dynamics, 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. Select and apply appropriate methods to test, verify, and validate numerical simulation results.

Final Grade Calculation: Homework (50%), Projects (25%), 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

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

Therefore, 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. 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 gets **one** no-questions-asked (NQA) 48 hour extension on a **homework assignment**. Projects are not eligible for this extension. You must email the instructor **and** TA to indicate you are using 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. 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. 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.

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

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 18, 7pm – 10pm**. A conflict/alternate exam will only be considered if arranged well in advance for an excusable absence situation per the university student code, or due to an unforeseeable emergency.

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. It is recommended that you install Python on your personal computer to be able to complete the assignments for the course. Anaconda is recommended for the easiest installation, as it is packaged with all the libraries and software you will need for this course. More experienced Python users may wish to download Python at 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. Alternatively, Python is available through campus computing resources:

- You can access python on campus via EWS labs, see `https://engrit.illinois.edu/ews` for locations and availability.

- See `https://answers.uillinois.edu/illinois.engineering/81693` for instructions on remote access to EWS machines.

DRES Accommodations: If you have DRES accommodations you must send your letter to the instructor at the beginning of the semester. You must also give advance notice for each assessment/deadline for which you'd like to use the accommodations. DRES accommodations for exams 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.

COVID-19: Please adhere to the latest University policies regarding COVID-19.