Course Syllabus and Guidelines [Spring 2025]
ME 618 – Selected Topics: Numerical Fluid Mechanics
Date: Monday 02:30 PM – 5:20 PM
Location: CKB 114

Prof. Samaneh Farokhirad
Email: samaneh.farokhirad@njit.edu
Office Location: Department of Mechanical Eng. – Room ME329
Office Hours: by prior appointment
Office Phone: (973) 596-3350

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: Numerical Fluid Mechanics aims to analyze and solve fluid mechanics problems using numerical method strategies. Through the use of modeling software, you will leverage the computational capability of the computer to simulate and study complex systems that would otherwise be impossible to do by hand. Topics covered include Navier-Stokes, direct and iterative methods for linear systems, finite differences for elliptic, parabolic, and hyperbolic equations, Fourier decomposition, error analysis and stability, and curve fitting methods.

Credit Hours: 3
Prerequisite: There are no formal prerequisites. However, students will benefit from having had previous exposure to fluid dynamics classes. Also helpful are previous classes in matrix methods. Students who are unsure whether they are prepared to take this class should contact the professor.
Lecture: 1 day per week at 170 minutes

Primary Textbooks:
- Steven Chapra, and Canale Raymond. *Numerical Methods for Engineers*. 8th ed. McGraw–hill Higher Education, 2021.
- Joel H. Ferziger and Peric Milovan. *Computational Methods for Fluid Dynamics*. 4th ed. Springer, 2020.
- Jian P. Shao and Tuncer Cebeci. *Computational Fluid Dynamics for Engineers: From Panel to Navier-stokes Methods with Computer Programs*. Springer, 2005.

Fluid Dynamics Textbooks:
- Philip M. Gerhart, Andrew L. Gerhart, and John I. Hochstein. Fundamentals of Fluid Mechanics, 8th ed. John Wiley & Sons, Inc., 2016.
- Frank White. *Fluid Mechanics*. 7th ed. McGraw-hill Education, 2010.

Course Policies:

- Homework & Project Assignments
  - *Unless the assignment specifies otherwise, you must work in teams of three to four, handing in one team solution per assignment.* The instructor will designate the teams.
  - *Team Roles*. On each group assignment, your team should designate a coordinator who organizes work sessions, make sure everyone knows where and when to meet and understands who is supposed to be doing what. A recorder who prepare and turn in the final solution set, and one or two checkers who check the solution for correctness and verify that everyone in the group understands both the solutions and strategies used to obtain them. 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.
  - Submission rule. Each completed homework should be in one person's handwriting (the coordinator). Put the names and roles (coordinator and checker) of participating group members and the problem set number and date on the outside. *If a student's name appears on a solution set, it certifies that he/she has participated in solving the problems*.
  - Project assignment format. Project assignments are computer projects focusing on the practical implementation of numerical methods as described in lecture. The overall project report should be broken down into
    - Problem statement
    - Solution method (equations, explanations, ...)
    - MATLAB Code
    - Result
    - Conclusion

  - 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.*
  - Posted solutions. *Problem set solutions will not be posted*. The burden is on you to make sure you find out how to solve the problems by getting help before they are due and/or asking about them in class after they have been handed in.

- Coding and Software
  - MATLAB is selected as the course basic coding software. You can use other software (e.g., Python) with prior approval but you may have a tougher time. 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" found on the Canvas site. Other files can be viewed with text readers or common software.

- 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.

- Take-home Exam
  - There will be one take-home exam (April)
  - To ensure a fair and equitable assessment process, the following rules and guidelines must be strictly adhered to:
    1. Individual Work: The take-home exam is to be completed individually. Collaboration with other students is strictly prohibited. Any form of academic dishonesty, including sharing solutions or working together, will be considered a violation of academic integrity.
    2. Time Limit: Exam Questions will be uploaded into the Canvas on Sunday, at 11 pm. The deadline to submit your solutions will be on Monday at 11:00 pm (the day after the exam upload). However, you must submit your solutions within three hours from when you first open the exam questions. For instance, if you start working on the exam at 5:00 pm on Monday, you must submit your completed answers by 8:00 pm on Monday. Or if you start working on the exam at 10:00 am on Monday, you must submit your completed answers by 110:00 pm on Monday.
       Please ensure to manage your time effectively within this three-hour window. Late submissions will not be accepted, so plan accordingly to avoid any issues with completing and submitting the exam within the allocated time frame.
    3. Resources Allowed: You are allowed to use textbooks, class notes, and course materials while working on the exam. 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.*
    4. Prohibited Resources: The use of external websites, forums, online collaboration tools, or any other resources not explicitly allowed is prohibited.
    5. Communication: During the exam period, direct any questions or clarifications regarding the exam to [samaneh@njit.edu]. Do not discuss the exam with your peers or seek assistance from anyone else.
    6. Original work: Upon completing the take-home exam, you have two options for submitting your answers through Canvas. (a) You may take a clear and readable photo of your completed answers using a camera or smartphone. Ensure that all pages are legible, and the images are of sufficient quality for review. (b) Alternatively, you can scan your completed answers using a scanner or scanning app. Please ensure that the scanned document is clear, and all pages are included in the submission. You will receive detailed instructions on where and how to

submit your answers on Canvas one day before the exam date. Follow these instructions carefully to ensure your submission is received successfully.

7. 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 a final project for this course. The project will involve numerical data analysis and modeling of a fluid flow of student's choice. Every project must be approved by the instructor.
  - Possible topics include:
    1. Comprehensive methodological reviews not covered in detail in class, with some numerical examples
    2. Computational fluid studies and applications: specific fluid-related problems that are numerically studied or solved by the applications of approaches, methods or schemes covered in class
    3. Combination of 1 and 2: combination of reviews and computational fluid studies
  - *Students are required to submit the title and a short abstract of their final project by April 5.*
  - Projects will be due at the last day of class.
  - 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.
  - 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%
Project Assignment:	15%
HW Assignment:	15%
Take-home Exam: April	30%
Final Project: (Last day of class)	30%
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	Reading
1	Introduction to Numerical Fluid Mechanics	**Ref [1]:** 1.1-1.3 and 3.1-3.4

		Ref [2]: Ch. 1 and 2
2	Truncation Errors, Taylor Series and Error Analysis, Error Propagations and Estimation, Condition Numbers	**Ref [1]:** 3.1-3.4 and 4.1-4.4
3	Roots of Non-Linear Equations, Bracketing Methods, Open Methods, Extension to Systems of Equations.	**Ref [1]:** 5.1-5.4 and 6.1-6.5
4	Navier-Stokes Equations and their Approximations, Conservation laws, Material Derivative, Reynolds-Transport Theorem, Constitutive Equations	**Ref [2]:** Ch. 1 **Ref [3]:** Ch. 5 **Ref [4]:** Ch. 4
5, 6,7	Systems of Linear Equations	**Ref [1]:** 9.1-9.8, 10.1-10.3, 11.1-11.3, Ch. 14, 18, 22, 8.1-8.2 **Ref [2]:** Ch. 5
8, 9, 10	Finite Difference (FD) Schemes, Stability, Elliptic/Hyperbolic Equations, Special Advection Schemes	**Ref [1]:** Ch. 23, 29, 30 **Ref [2]:** Ch. 3
11	Curve Fitting Methods	**Ref [1]:** Ch. 17

References:

Ref. No.	Textbook	Author(s)
Ref [1]	*Numerical Methods for Engineers*. 7th ed.	Steven Chapra, and Canale Raymond
Ref [2]	*Computational Methods for Fluid Dynamics*. 3rd ed.	Joel H. Ferziger and Peric Milovan
Ref [3]	Fundamentals of Fluid Mechanics, 8th Ed.	Philip M. Gerhart, Andrew L. Gerhart and John I. Hochstein
Ref [4]	*Fluid Mechanics*. 7th ed	Frank White