ME 614, Computational Fluid Dynamics

Instructor:

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Class Meetings:

Monday and Wednesday: 6:00-7:15 pm, SL010

Office Hours:

Monday and Wednesday: 3:00-4:00 pm

References:

Textbook

1. T. J. Chung, *Computational Fluid Dynamics*, 2nd Edition, Cambridge University Press
2. Versteeg and Malalasekara, *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, 2nd edition, 2007, Pearson.

Recommended reference books.

3. J. D. Anderson, *Computational Fluid Dynamics*, McGraw-Hill Education
4. J. H. Ferziger and M. Peric, *Computational Methods for Fluid Dynamics*, Springer.
5. John C. Tannehill, Dale A. Anderson and Richard H. Pletcher, *Computational Fluid Mechanics and Heat Transfer*, Taylor &Francis.
6. J. Blazek, *Computational Fluid Dynamics: Principles and Applications*, Elsevier.

Prerequisite:

ME581 or equivalent
ME509 or ME510
or
Consent of the instructor.

Course Description:

This course consists of three parts: (1) principle numerical approaches including finite difference, lattice Boltzmann method, and finite volume method for solving compressible and incompressible flows, (2) computing techniques of grid generation and parallel computing, (3) projects for benchmark problems and real application of CFD.

Course outcomes:

Upon completion of the course, students can do the following.

- Understand the governing partial differential equations for modeling compressible and incompressible flows.

- Derive the discrete flow equations using the finite difference method.
- Derive the stability condition using von Neumann stability analysis
- Understand how to derive the discrete flow equations using the finite volume method.
- Solve non-linear time-dependent fluid equations of motion using implicit and explicit methods.
- Understand the lattice Boltzmann method and its implementation
- Understand the principles of grid generation.
- Understand parallel computing
- Obtain first-hand experience of CFD for flow problems

Grading Scale:

The course grade scale will follow the Latter Grades with +/- on Canvas.

Name:	Range:	
A+	100%	to 97.0%
A	< 97.0%	to 93.0%
A-	< 93.0%	to 90.0%
B+	< 90.0%	to 87.0%
B	< 87.0%	to 83.0%
B-	< 83.0%	to 80.0%
C+	< 80.0%	to 77.0%
C	< 77.0%	to 73.0%
C-	< 73.0%	to 70.0%
D+	< 70.0%	to 67.0%
D	< 67.0%	to 63.0%
D-	< 63.0%	to 60.0%
F	< 60.0%	to 0.0%

The instructor may or may not provide opportunities for students to earn extra credits based on the entire class performance. Grade upgrade requests based on personal expectation/imagination or special needs will not be issued.

Project ---------- 25 %
Homework (HW) ---------- 25 %
Midterm exam ---------- 25 %
Final exam ---------- 25 %

- **Projects** are to numerically solve flow systems through self-developed code or commercial software. The project topics and related instructions, requirements, and grading policy will be specifically announced in Week 5. A survey regarding the background of computer and computation capability will be completed in the second week.
- **Homework** consists of 4 sets. HW is required to be submitted electronically and then graded on Canvas. It is important that the HW problems are solved correctly and the presentations of the solutions are logical, complete, and

understandable. Students are responsible for high-quality electronic copies. If the HW is returned because of the bad quality, the student is responsible for re-scan and uploading within 24 hours after the notice, and the penalty will be 10% of the HW points per late day. Late HW will cause a penalty, 10% of the HW points off per late day. **Once the HW is graded, no late HW or no late resubmission is accepted.**

- **Exams** will cover the entire learning from the lectures and project. The format of the exams will be announced one week before the exams. There will be **NO PRIOR or MAKEUP** exam, oral presentation, or final project report. On the rare occasion that a student is excused with **valid written documents for an emergency** (e.g. doctor notes or medicine purchase receipts for illness, evidence or witness for vehicle failure, etc.) or a **prior written request and approval for non-emergency** (e.g. travel itinerary, conference registration, etc.), the missed points can be credited. The instructor reserves the right to decide how to credit based on specific cases.
- **Canvas**: The entire course-related communication outside of lectures and office hours is through http://canvas.iu.edu.
    - All the information and materials will be accessed on this system throughout the semester including messages and announcements, syllabus and course schedule, supplementary handouts, assignments, grades, and so on.
    - Students are required to **send course-related messages through Canvas/Inbox**.
    - Students are responsible to set up notifications on Canvas and check their emails as well as the course website on Canvas time accordingly for any course information.
    - Students are encouraged to discuss course issues on Canvas/Discussion.

~~~~~~~~~~~~~~~~~~~~~~ IMPORTANT POLICY NOTES ~~~~~~~~~~~~~~~~~~

- Each student should complete the pre-requisite questionnaire on Canvas by the assigned due date. Failing to meet the prerequisite requirements will cause an invalid grade at the end of the semester.
- Students are required to sign on a provided sign sheet for each in-person class. If a Zoom meeting, sign in using the chat function. Written prior/subsequent excuse from a class is highly expected to show respect to the instructor.
- Students are required to show appropriate behaviors in the classroom. Electronics such as a laptop, pad, cell phone, etc. are allowed to use per permitted. Food and drinks should not be consumed during class. Any student who is found to be a distraction to the instructor and/or other students will be dismissed immediately.
- Students are highly encouraged to turn the video on whenever it is practical during the Zoom lecturing. Interactive communication is very important for effective teaching and learning.

- Students are aware of the Code of Student Rights, Responsibilities, and Conduct (https://studentcode.iu.edu/index.html). Acts of academic misconduct and personal misconduct will be handled according to the guidelines in the Code. Penalties include lowering a student's grade as well as dismissal from the class.
- If any students need any special accommodations or assistance due to a disability-related issue, please contact **Adaptive Educational Services** (AES, https://diversity.iupui.edu/offices/aes/index.html) at (317)-274-324 or email (aes@iupui.edu). No qualified individual with a disability shall, because of such disability, be either excluded from participation in or be denied the benefits of the services, programs, or activities" of Indiana University-Purdue University Indianapolis."

Course Schedule[1]

Week	Topics	Assignment Due[2]
1	Syllabus and Introduction	
	Math review	
2	Martin Luther King Jr. day	
	1-CFD Preliminaries	HW1(Math)
3	2-Governing Equations-1	
	2-Governing Equations-2	
4	2-Governing Equations-3	
	3-FDM for 1-D	HW2 (Equations)
5	3-Derivations of FD equations - 1	
	Project Assignment	
6	Project mentoring	
	Problem demonstration (Index Notation)	MS1
7	3-Derivations of FD equations -2	
	4-Solution methods of FDM-1	
8	4-Solution methods of FDM-2	
	Midterm Review	HW3 (FD)
9	Problem demonstration (FD)	
	In-class exam (Chs 1-3)	
10	Spring Break	

[1] This schedule is tentative and subject to change with or without prior update. Please be aware of Canvas notices, such as announcement, emails, assignment updates, etc.
[2] The HW due dates are tentative, just for a guideline. The real dates will be on the assignment file and Canvas assignment.

	Spring Break	MS2
11	5-FD solutions of IncomFlows	
	6-FD solutions of Com. Flows -1	
12	6-FD solutions of Com. Flows -2	
	7-FVM for Diffusion Problems	
13	7-FVM for Convection-diffusion Problems	MS3
	7-FVM for unsteady flows	
14	Project time	HW4 (FVM)
	8-Grid Generation	
15	9-Parallel computing	
	Lattice Boltzmann Method	
16	Course Review	MS4
	Project wrap-up	
17	Project oral presentation	Final report due
	Final Exam (Chs 4-8)	