EGM 7819 Computational Fluid Dynamics Spring, 2026

Instructor:

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Class Time: MWF Period 5 (11:45am–12:35 PM)
Location: MAEB 020238
Office Hours: Monday 10:00 – 11:30 AM
Wednesday 10:30 – 11:30 AM

Teaching Assistant:

None

Course Description and Objectives

Advanced concepts and numerical techniques for the solution of the system of partial differential equations governing fluid flows. I intend to make this course informative and relevant to all researchers in fluid mechanics. This is an advanced course, so the emphasis will be on learning advanced state-of-the-art topics, and not on grading.

The objective of this course is to expose the students to the various numerical and modeling techniques that are used for solving the equations governing fluid flows (the Navier-Stokes Equations). Numerical methods designed to cover flows at all Mach numbers will be reviewed.

Course Pre-Requisites / Co-Requisites

EGM6812, EGM6813 or equivalent for fluid mechanics knowledge; EGM6342 equivalent on basic CFD. Basic knowledge in ordinary differential equations, partial differential equations (PDEs), matrix analysis, and basic numerical methods is required. Also, you are expected to be reasonably proficient in computer programming (in a language of your choice). Some of the homeworks and projects will require actual implementation of numerical methods.

Required Textbook and Recommended Books

- **The primary source of reference will be the lecture notes and slides.**

- The following book is required:
  An Introduction to Computational Fluid Dynamics: The Finite Volume Method, H.K. Versteeg and W. Malalasekera, Second Edition, Pearson Education Limited, 2007.

  Additionally, the following books are useful references:
  1. *Computational Fluid Mechanics and Heat Transfer*, J.C. Tannehill, D.A. Anderson & R.H. Pletcher, Taylor & Francis, 1997
  2. *Computational Methods for Fluid Dynamics*, J.H. Ferziger & M. Peric, Springer, 2002 (new edition: 2020)
  3. *Finite Volume Methods for Hyperbolic Equations*, R.J. Leveque, Cambridge, 2002

Required and Recommended Software and Hardware

- Access to a computer with appropriate compiler is required
- Use of a high level language: FORTRAN90, C, C++, Python, etc. or MATLAB is required

Attendance Policy, Class Expectations, and Make-Up Policy

- Attendance for class lectures is not required but highly recommended.
- Should your weighted average be just below the lower boundary of a letter grade range (e.g., 89.2), you may receive the higher letter grade depending on your attendance record, and your level of participation in class.
- Tardiness in homework submission will not be tolerated unless prior permission has been obtained.
- No credit will be given for missed homework, missed quizzes, and missed exams unless prior permission has been obtained.
- All cell phones and laptops must be tuned off during class lectures.

Excused absences must be consistent with university policies in the Graduate Catalog (https://catalog.ufl.edu/graduate/regulations) and require appropriate documentation. Additional information can be found here: https://gradcatalog.ufl.edu/graduate/regulations/

Evaluation of Grades

Assignment	Total Points	Percentage of Final Grade
Homework Sets	100 each	40%
Computer projects	100 each	60%
		100%

Grading Policy

- Should your weighted average be just below the lower boundary of a letter grade range (e.g., 89.2), you may receive the higher letter grade depending on your attendance record, whether you handed in all homeworks, and your level of participation in class.
- The course letter grade will be determined from the weighted average as shown below:

Percent	Grade	Grade Points
90.0 - 100.0	A	4.00
87.0 - 89.9	A-	3.67
84.0 - 86.9	B+	3.33
80.0 – 83.9	B	3.00
77.0 - 79.9	B-	2.67
74.0 - 76.9	C+	2.33
70.0 – 73.9	C	2.00
67.0 - 69.9	C-	1.67
64.0 - 66.9	D+	1.33
60.0 - 63.9	D	1.00
57.0 - 59.9	D-	0.67
00 0- 56.9	E	0.00

- More information on UF grading policy may be found at: http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades

Homework Policy

Homework assignments are due at the beginning of the period on the due date. All assignments should be neat and legible. Points will be taken off for sloppy work. You may discuss the assignments with other students, but you are expected to put in individual effort. Copying and plagiarizing assignments will not be accepted. You are expected to uphold academic honesty and

failure to comply will result in disciplinary action. It is in your best interest to put in the time and effort to understand the homework problems and projects – emphasis will be on grading the process and just the final answer.

Online Course Recording
Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

Attendance Policy and Make-Up Policy
Excused absences must be in compliance with university policies in the Graduate Catalog (http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#attendance) and require appropriate documentation.

Students Requiring Accommodations
Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation
Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording
Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations

between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources:

Health and Wellness

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: http://www.counseling.ufl.edu/cwc, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

COVID-19

- You are expected to wear approved face coverings at all times during class and within buildings even if you are vaccinated.
- If you are sick, stay home and self-quarantine. Please visit the UF Health Screen, Test & Protect website about next steps, retake the questionnaire and schedule your test for no sooner than 24 hours after your symptoms began. Please call your primary care provider if you are ill and need immediate care or the UF Student Health Care Center at 352-392-1161 (or email covid@shcc.ufl.edu) to be evaluated for testing and to receive further instructions about returning to campus.
- If you are withheld from campus by the Department of Health through Screen, Test & Protect, you are not permitted to use any on campus facilities. Students attempting to attend campus activities when withheld from campus will be referred to the Dean of Students Office.
- UF Health Screen, Test & Protect offers guidance when you are sick, have been exposed to someone who has tested positive or have tested positive yourself. Visit the UF Health Screen, Test & Protect website for more information.
- Please continue to follow healthy habits, including best practices like frequent hand washing. Following these practices is our responsibility as Gators.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. https://www.crc.ufl.edu/.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall*,* 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://care.dso.ufl.edu.

On-Line Students Complaints*:* http://www.distance.ufl.edu/student-complaint-process.

EGM 7918 Advanced CFD

Spring 2024

Outline

PART 1 **Governing Eqns., Flow Regimes, Review of Numerical Methods**	
1	Introduction and Overview of CFD
2	RANS Equations
3	Governing equations: • Reynolds-Averaged Navier-Stokes (RANS) Equations • Different Forms of Navier-Stokes Equations
4	Finite Volume Method (FVM): An Overview
3	FVM for the General Transport Equation
4	Prototype equations; Mathematical classification of flows; Mathematical nature of flow equations
5	Review of spatial discretization schemes for first and second derivatives
6	Review of time integration schemes
PART 2 **Analysis of space- and time-discretization schemes using the Burgers equation**	
7	• Burgers Equation: FTCS scheme: o Peclet number; Boundary layer behavior o Solution behavior of FTCS at high Peclet number o Higher-order upwinding • Finite volume method for 1-D Burger's equation: discretized and discrete algebraic equation
8	• Convection schemes: FOU, Hybrid, SOU, QUICK schemes • Time discretization schemes: o Explicit vs. Implicit o Multi-step schemes: Adams-Bashforth, Adams-Moulton o Mutit-Stage schemes: Runge-Kutta
9	Solution Procedure: • Analysis of Iterative Methods • Unstructured mesh storage and Implementation (Gauss-Seidel Pseudo-Code) • General Iterative Scheme: Jacobi and Gauss-Seidel, Error analysis (multiple frequencies – Fourier series • Error analysis – eigenvalues of iteration matrix, Multigrid – basic idea and analysis
PART 3 **Pressure-Based Methods (Originally for Incompressible N-S equations)**	
10	• Role of pressure • Properties of convection & diffusion;
11	• Kinetic energy conservation • Discrete divergence, gradient & Laplacian operators
12	A simple explicit scheme

13	Treatment of pressure: compact and non-compact stencils
14	Non-compact Vs. compact stencils; Staggered grid

15	• Implicit treatment
	• Fractional step method (FSM):
	  o Basic idea; splitting error
	  o First- and second-order FSM methods

16	SIMPLE algorithm: • The basic method • Staggered grid
17	SIMPLE algorithm: collocated grid
18	SIMPLEC and SIMPLER algorithms
19	PISO and PIMPLE algorithms
20	Extension of pressure-based methods to compressible all-speed flows
PART 4 Density-Based Methods (Originally for Compressible Flows)	
21	Finite volume method (FVM) for Euler equations: • Cell average; Conservation • Flux computation (reconstruction) • 1D Euler equations
22	FVM for Euler equations (contd.): • Multi-dimensional Euler equations
23	Riemann problem • Euler equations: conservative form, characteristic form • The Riemann problem
24	Godunov's Methods: • Godunov's first method • Godunov's second method
25	Approximate Riemann Solvers: • Roe scheme – Flux Difference Splitting (FDS)
26	Flux vector splitting (FVS): • Upwinding and splitting • Application to Euler equations
27	Flux vector splitting (FVS): • Steger-Warming splitting • Implementation on unstructured grids
28	• Van Leer scheme • AUSM scheme
29	Total Variation Diminishing (TVD) Schemes: • Lax-Wendroff method • Origin of oscillations • Monotone methods • TVD criteria
30	FVM for Navier-Stokes Equations: Discretization in Physical Coordinates: • Integral/FV formulation: integration in computational space • Structured grid • Unstructured grid: quadrilateral and triangular control volumes

31	Solution Methods for the Discretized Equations:
PART 5 CFD Methods for Turbulent Flows	
32	Turbulent flows: a review
33	Introduction to Turbulence Modeling: • Scales of turbulence • Energy spectrum and energy cascade • Wall bounded and shear flow turbulence
34	Turbulence Modeling: • Near-wall turbulence • Law-of-the-wall and wall functions
35	Reynolds averaged Navier-Stokes (RANS) equations
36	One equation turbulence: Spalart-Allmaras (SA) model
37	Two-Equation Turbulence Models: • k-ε models • k-ω models: Wilcox, Shear Stress Transport (SST)
38	Detached Eddy Simulation (DES)
39	Large Eddy Simulation (LES): • Filtered Navier-Stokes equations • Smagorinsky model • Dynamic Smagorinsky-Lilly model • WALE model