Fluid and Solid Operations

ECH 3203 Section 2073

Class Periods: Monday, Wednesday, Friday : Period 4, 10:40AM – 11:30AM

Location: Monday, Wednesday, Friday : Newins-Ziegler Hall 0112

Academic Term: Fall 2023

Instructor:

Henry Chu, h.chu@ufl.edu, (607) 319-6298

Office Hours: To be confirmed. Location: Chemical Engineering Building 329A.

Teaching Assistant/Peer Mentor/Supervised Teaching Student:

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Office Hours: To be confirmed. Location: To be confirmed.

Course Description

3 credits; Characteristics of laminar and turbulent flow, mechanical energy balance, flow through packed beds and fluidization of solids, design of pumping systems and piping networks and metering of fluids

Course Pre-Requisites / Co-Requisites

COT 3502 and ECH 3264

Course Objectives

Upon completion of this course, a student is expected to be able to:

- Identify key fluid properties and list the corresponding units in analyzing fluid behavior
- Determine the hydrostatic pressure and buoyancy force on a submerged body; calculate pressure readings in various manometers
- Apply conservation of mass and energy as well as Newton's second law of motion to the contents of a finite control volume in analyzing behavior of fluids in motion
- Identify and determine flow kinematic quantities such as the acceleration field given a velocity field
- Analyze and design flows in pipe(s); calculate exact solutions for laminar, viscous, incompressible flows
- Use constitutive relations to model simple non-Newtonian fluid flows
- Apply stream functions and velocity potentials to model inviscid flows
- Determine the flow characteristics of a boundary layer, including laminar, transitional, to turbulent regimes
- Apply knowledge in above objectives in designing turbomachines
- Characterize a porous medium and compute the fluid flows
- Characterize and determine the mixing and dispersion in a static and/or dynamic fluid medium

Specific topics covered will include:

- Common fluid properties, e.g. density, viscosity, compressibility; dimensions and units
- Fluid statics pressure and force, manometry, and buoyancy
- Newtonian's second law, conservation of mass and energy (Bernoulli equation with/without shaft work and head loss), and finite control volume analysis
- Eulerian and Lagrangian descriptions; steamlines, streaklines, and pathlines; Reynolds transport theorem
- Navier-Stokes equation; exaction solutions to plate-driven and pressure-driven flows
- Generalized non-Newtonian constitutive relations such as the power-law and Casson fluid models
- Euler equation of motion, velocity potential and stream function, and superposition of plane potential flows
- Boundary layer structure and thickness, momentum integral boundary layer equation, lift and drag force
- Flow, energy, and momentum in pumps, fans, and turbines
- Porosity, partition coefficient, Darcy and Brinkman flows in packed and fluidized beds
- Mixing time and length scales; Taylor hydrodynamic dispersion

Materials and Supply Fees
None.

Relation to Program Outcomes (ABET):

Outcome	Coverage*
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	High
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	Medium
3. An ability to communicate effectively with a range of audiences	Medium
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	Low
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	Medium
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	Low
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	Medium

Required Textbooks and Software

- Fundamentals of Fluid Mechanics; Munson, Young, and Okiishi; 8th Edition; ISBN 978-1-119-08070-1

Course notes are developed by the instructor based on this textbook and will be given to students via Canvas.

Recommended Materials

- Transport Phenomena in Biological Systems; Truskey, Yuan, and Katz; 2nd edition (Chapter 8.1-8.3); ISBN 978-0-13-156988-1
- Transport Processes and Unit Operations; Geankoplis, 3rd edition (Chapter 3.1); ISBN 0-13-045253-X

Course notes are developed by the instructor based on these textbooks and will be given to students via Canvas.

Course Schedule

The instructor will follow the course schedule below as much as possible, with possible minor adjustments due to students' learning progress and unexpected events.

Date	Lecture	Content
8/23	1	Introduction (Munson Chapter 1,2)
8/25	2	Fluid statics (Munson Chapter 2)
8/28	3	Fluid statics (Munson Chapter 2)
8/30	4	Fluid statics (Munson Chapter 2)
9/1	5	Fluid statics (Munson Chapter 2)
9/6	6	Fluid statics (Munson Chapter 2)
9/8	7	Fluid statics (Munson Chapter 2)
9/11	8	Fluids in motion (Munson Chapter 3, 5, 8)

9/13	9	Fluids in motion (Munson Chapter 3, 5, 8)
9/15	10	Fluids in motion (Munson Chapter 3, 5, 8)
9/18	11	Fluids in motion (Munson Chapter 3, 5, 8)
9/20	12	Fluids in motion (Munson Chapter 3, 5, 8)
9/22	13	Fluids in motion (Munson Chapter 3, 5, 8)
9/25	14	Fluids in motion (Munson Chapter 3, 5, 8)
9/27	15	Fluid kinematics (Munson Chapter 4, 6)
9/29	16	Fluid kinematics (Munson Chapter 4, 6)
10/2*	17	Fluid kinematics (Munson Chapter 4, 6) [Pre-record]
10/4*	18	Fluid kinematics (Munson Chapter 4, 6) [Pre-record]
10/9	19	Team list due; HW1 due; Quiz 1 (Cover Introduction, Fluid statics, and Fluids in motion)
10/11	20	Viscous flow (Munson Chapter 6, 8)
10/13	21	Viscous flow (Munson Chapter 6, 8)
10/16	22	Viscous flow (Munson Chapter 6, 8)
10/18	23	Viscous flow (Munson Chapter 6, 8)
10/20	24	Mixing and dispersion (notes by instructor)
10/23	25	Mixing and dispersion (notes by instructor)
10/25	26	Flows in porous media (Truskey)
10/27	27	Flows in porous media (Truskey)
10/30	28	Flows in porous media (Truskey)
11/1	29	Inviscid flow (Munson Chapter 6)
11/3	30	Inviscid flow (Munson Chapter 6)
11/6*	31	Inviscid flow (Munson Chapter 6) [Pre-record]
11/8*	32	Inviscid flow (Munson Chapter 6) [Pre-record]
11/13	33	HW2 due; Quiz 2 (Cover Fluid kinematics, Viscous flow, Mixing and dispersion, and Flows in porous media)
11/15	34	Inviscid flow (Munson Chapter 6)
11/17	35	Boundary layer (Munson Chapter 9)
11/20*	36	Boundary layer (Munson Chapter 9) [Pre-record]
11/27	37	Boundary layer (Munson Chapter 9)
11/29	38	Boundary layer (Munson Chapter 9)
12/1	39	Boundary layer (Munson Chapter 9)
12/4	40	Recitation class; Group video due; HW3 due
12/6	41	Video Showcase
12/14		Quiz 3 (Cover everything from lecture 1, except Munson Chapter 12 and Geankoplis) 5:30 pm – 7:30 pm at NZH0112

Attendance Policy, Class Expectations, and Make-Up Policy

Attendance of lectures is highly recommended, although not compulsory and no penalty will be imposed for absence. However, it is the student's responsibility to obtain any notes, assignments, etc. that they may have missed during their absence. Students should turn off the ringers for all cell phones during lectures and they should not answer incoming calls. If a student is expecting an emergency call, please notify the instructor prior to class.

If a student misses a quiz without submitting formal documentations accepted by the university to the instructor, no credit will be given to the quiz.

If a student misses a quiz with submitting formal documentations accepted by the university to the instructor, there is no makeup quiz but the overall grade of the student will be calculated based on the homework, the video, and the other two quizzes. The student should notify the instructor about his/her absence prior to the quiz, preferably at least two weeks in advance, or as soon as possible after the quiz in case of an emergency. Excused absences must be

consistent with university policies in the Graduate Catalog (https://gradcatalog.ufl.edu/graduate/?catoid=10&navoid=2020#attendance) and require appropriate documentation. Additional information can be found here: https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/.

A student must attend at least two quizzes in order to pass this course, even if the student's absence is supported by formal documentations.

Students are expected to check their email daily for any updates in the course schedule.

Evaluation of Grades

Assignment	Total Points	Percentage of Final Grade
Homework (3)	100 each	15% (4% each; 3% for submitting all three complete homework sets before due dates)
Video showcase	100	10%
Quizzes (3)	100 each	75% (25% each)
Total		100%

Homework sets: There are three homework sets in total. Student should submit the homework sets before the due date. No credits will be given for late submission**.** A submitted homework set will not be given back to the student and therefore students should make a copy of their homework prior to submission, if needed. Students may discuss and finish the homework with their peers.

Each homework set bear 4% of the final grade of the course. 3% of the final grade of the course will be given for submitting all three complete homework sets before due dates.

Video showcase: Students will form teams of 3 to 4 people (no more than 4 people are allowed). In each team, a representative should email the names of all their members (along with the "General Consent and Release Form" signed by each member; to be distributed) to the instructor no later than the "Team list due" date on the syllabus. Students who are not in a team by this date will be assigned into teams randomly. Once a team is formed, members cannot be changed. The instructor will send the finalized list of teams to all students within 5 days after the "Team list due" date.

Upon team formation, students will read (i) Chapter 12 of the course textbook (Munson) and (ii) Chapter 3.1 of the course textbook (Geanloplis) to learn about Turbomachines and Flows in packed/fluidized beds by themselves and via discussion. Each team will create a video (in typical video format, e.g. avi, mp4; recommended that each member contributes 2-3 mins) to teach the rest of the class what they have learnt from either (i) or (ii). The video should cover both fundamental knowledge and applications. Students should give proper references to materials used in creating the video. All students and the instructor will watch all the videos during the lecture "Video Showcase".

The instructor will evaluate the videos based on their content, creativity, proper referencing, and presentation style. Students in the same team will receive the same grade. The video bears 10% of the final grade of the course. No credits will be given to late submission. To encourage students learning from videos created by others, each team will vote for their favorite video. The winners will get a special prize ☺ A link to videos by past students: https://www.youtube.com/@henry.chu.uflorida

Quizzes: There are three quizzes. Each quiz bears 25% of the final grade of the course. Students will take the quizzes during the lecture hours. The date, time, and location of the quizzes will be announced by the instructor at least 1 week before the quiz. Rules for the quizzes are listed below:

- Students have 50 minutes to work on each quiz.
- Writing for the quiz is allowed only (i) after the proctor's announcement for the commencement of the quiz and (ii) before the proctor's announcement for the end of the exam.

- Write your name and page number on every answer sheet that you submit.
- The quizzes are closed book and closed notes.
- No questions pertaining to the quiz questions will be answered during the quiz. If you have other questions, e.g., a request to go to the restroom, please ask the proctor.
- You should not communicate with others during the quiz, except with the proctors.
- You may use a non-graphing calculator.
- Use SI units in your answers.
- Write the answers and steps in a neat and readable manner to get full marks of the questions.
- Box all final answers.
- Any form of cheating will lead to a penalty of the total points of the quiz.

Grading Policy

Percent	Grade	Grade Points
90.0 - 100.0	A	4.00
85 - 89	A-	3.67
80 - 84	B+	3.33
75 – 79	B	3.00
70 - 74	B-	2.67
65 - 69	C+	2.33
60 – 64	C	2.00
55 - 59	C-	1.67
50 - 54	D+	1.33
45 - 49	D	1.00
40 - 44	D-	0.67
0 - 39	E	0.00

The instructor will use the above grade table in addition to "curving the grade" for determining the final course grade. From the instructor's experience, "A" (range) will be given to the top 10~20% of the class, B (range) to the top 20~60%, C+/C (range) to the top 60~85%, and C- or below to the last 15%. These percentages are yet to be confirmed. However, it is expected that they will not change significantly. The typical mean grade is B or B-.
More information on UF grading policy may be found at:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

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/process/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 varied perspectives and lived experiences within our community and is committed to supporting the University's core values, including the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information, and veteran status.

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
- HWCOE Human Resources, 352-392-0904, student-support-hr@eng.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: https://counseling.ufl.edu, 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/.

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 Connections Center, Reitz Union, 392-1601. Career assistance and counseling; https://career.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://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

On-Line Students Complaints*:* https://distance.ufl.edu/getting-help/; *https://distance.ufl.edu/state-authorization-status/#student-complaint*.