

## Fluid and Solid Operations

ECH 3203 Section 4009

**Class Periods:** MWF, period 7, 01:55PM – 02:45PM

**Physical Location:** Architecture Building 0423

**Virtual Location:** <https://ufl.zoom.us/j/96954153883?pwd=TGILQStlOW5VQkJxY2xPRXpDRHdUUT09>

**Academic Term:** Spring 2022

### **Instructor:**

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

Office Hours: **To be confirmed**

### **Teaching Assistant/Peer Mentor/Supervised Teaching Student (ST):**

Ziyao Liu, ziyao.liu@ufl.edu, (352) 681-0879

Office Hours: **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; streamlines, streaklines, and pathlines; Reynolds transport theorem
- Navier-Stokes equation; exact 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*
(a) An ability to apply knowledge of mathematics, science, and engineering	High
(b) An ability to design and conduct experiments, as well as to analyze and interpret data	Medium
(c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	High
(d) An ability to function on multi-disciplinary teams	Medium
(e) An ability to identify, formulate, and solve engineering problems	High
(f) An understanding of professional and ethical responsibility	High
(g) An ability to communicate effectively	High
(h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Medium
(i) A recognition of the need for, and an ability to engage in life-long learning	Medium
(j) A knowledge of contemporary issues	Medium
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Medium
(l) A recognition of industrial health and safety issues, and an ability to engage in fostering and exercising health and safety rules and regulations	Medium

\*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not covered or assessed in the course.

### **Required Textbooks and Software**

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

The majority of the 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; 2<sup>nd</sup> edition (Chapter 8.1-8.3); ISBN 978-0-13-156988-1
- Transport Processes and Unit Operations; Geankoplis, 3<sup>rd</sup> edition (Chapter 3.1C-3.1D); ISBN 0-13-045253-X

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

## Course Schedule

Week	Date	Lecture	Content
1	1/5	1	Covid protocol, Introduction (Munson Chapter 1,2)
1	1/7	2	Introduction, Fluid statics (Munson Chapter 1,2)
2	1/10	3	Fluid statics (Munson Chapter 2)
2	1/12	4	Fluid statics (Munson Chapter 2)
2	1/14	5	Fluid statics (Munson Chapter 2)
3	1/19	6	Fluid statics (Munson Chapter 2)
3	1/21	7	Fluid statics (Munson Chapter 2)
4	1/24	8	Quiz 1
4	1/26	9	Fluids in motion (Munson Chapter 3, 5, 8)
4	1/28	10	Fluids in motion (Munson Chapter 3, 5, 8)
5	1/31	11	Fluids in motion (Munson Chapter 3, 5, 8)
5	2/2	12	Fluids in motion (Munson Chapter 3, 5, 8)
5	2/4	13	Fluids in motion (Munson Chapter 3, 5, 8)
6	2/7	14	Fluids in motion (Munson Chapter 3, 5, 8)
6	2/9	15	Fluids in motion (Munson Chapter 3, 5, 8)
6	2/11	16	Quiz 2; Group list due
7	2/14	17	Fluid kinematics (Munson Chapter 4, 6)
7	2/16	18	Fluid kinematics (Munson Chapter 4, 6)
7	2/18	19	Fluid kinematics (Munson Chapter 4, 6)
8	2/21	20	Viscous flow (Munson Chapter 6, 8)
8	2/23	21	Viscous flow (Munson Chapter 6, 8)
8	2/25	22	Viscous flow (Munson Chapter 6, 8)
9	2/28	23	Viscous flow (Munson Chapter 6, 8)
9	3/2	24	Quiz 3
9	3/4	25	Inviscid flow (Munson Chapter 6)
10	3/14	26	Inviscid flow (Munson Chapter 6)
10	3/16	27	Inviscid flow (Munson Chapter 6)
10	3/18	28	Inviscid flow (Munson Chapter 6)
11	3/21	29	Boundary layer (Munson Chapter 9)
11	3/23	30	Boundary layer (Munson Chapter 9)
11	3/25	31	Boundary layer (Munson Chapter 9)
12	3/28	32	Boundary layer (Munson Chapter 9)
12	3/30	33	Quiz 4; Group video due
12	4/1	34	Mixing and dispersion (notes by instructor)
13	4/4	35	Video Showcase (Munson Chapter 12)
13	4/6	36	Mixing and dispersion (notes by instructor)
13	4/8	37	Flows in porous media (Truskey)
14	4/11	38	Flows in porous media (Truskey)
14	4/13	39	Flows in porous media (Truskey)
14	4/15	40	Flows in packed/fluidized bed (Geankoplis) (by ST)
15	4/18	41	Flows in packed/fluidized bed (Geankoplis) (by ST)
15	4/20	42	Recitation
16	4/28		Final exam (12:30pm - 2:30pm)

Video showcase for turbomachines : 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 an optional "General Consent and Release Form" signed by each member; to be distributed) to the ST no later than the following day of Quiz 2. 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/ST will send the finalized list of teams to all students within 5 days after Quiz 2.

Upon team formation, students will read Chapter 12 of the course textbook (Munson) to learn about Turbomachines by themselves and via discussion. This topic is closely relevant to materials that they have learnt before Quiz 2. Each team will create a video (recommended < 10 mins in typical video format, e.g. avi, mp4) to teach the rest of the class what they have learnt from Chapter 12. The video should cover part of the materials from Chapter 12.1-12.3 (the fundamental knowledge of turbomachines) AND from Chapter 12.4-12.8 3-5 (concepts, applications, or examples of turbomachines). Students should give proper references to materials used in creating the video. All students, the ST, and the instructor will watch all the videos during the lecture "Video Showcase".

**Attendance Policy, Class Expectations, and Make-Up Policy**

Attendance of all online lectures is highly recommended. It is the student’s responsibility to obtain any notes, assignments, etc. that they may have missed during their absence. Repeated absences may lead to a lower grade in the class. Excused absences must be consistent with university policies in the undergraduate catalog (<https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>) and require appropriate documentation. As a courtesy to the other students and to the instructor, the students should turn off the ringers for all cell phones during lecture and they should not answer incoming calls. If a student is expecting an emergency call, please notify the instructor prior to class.

Makeup exams and quizzes will be given only in case of an emergency – documentation of the emergency has to be provided. It is required that, whenever possible, the student notifies the instructor about the situation prior to the exam, preferably at least two weeks in advance.

**Evaluation of Grades**

Assignment	Total Points	Percentage of Final Grade
Quizzes (4)	100 each	40% (10% for each quiz)
Video showcase	100	10%
Final Exam	100	50%
		100%

Quizzes: There are four 35-minute quizzes. All quizzes will be held during the lecture hours in the classroom. All quizzes will be closed book and closed notes. Partial credit will be assigned, and no credit will be given for problems that have a solution but all the work leading to this solution is not shown. No talking to any others or via any electronic devices is allowed. Students may use an electronic calculator; no other electronic devices, including their personal phones or computers, are allowed. Questions of the quizzes will be distributed to students at the beginning of the quiz-lecture hour. Once the quiz time is up, students should stop writing and the instructor/ST will collect students’ answer scripts. Late submission will result in a maximum penalty of the total points of the quiz and the instructor solely will determine the penalty. Any form of cheating will result in a penalty of the total points of the quiz.

Video showcase: The instructor and the ST will evaluate the videos based on their content, creativity, proper referencing, and presentation style. Students in the same team will receive the same grade. Late submission of the video after the day of Quiz 4 will result in 100% penalty to this part of the course. To encourage students learning from videos created by others, each team will vote for their favorite video. The winners will get a special prize 😊

Final exam: There is one two-hour final exam. The date/time for the exam is to be confirmed. The exam will be closed book and closed notes. Partial credit will be assigned, and no credit will be given for problems that have a solution but all the work leading to this solution is not shown. No talking to any others or via any electronic devices is allowed. Students may use an electronic calculator; no other electronic devices, including their personal phones or computers, are allowed. Questions of the exam will be distributed to students at the beginning of the exam session. Once the exam time is up, students should stop writing and the instructor/ST will collect students’ answer scripts. Late submission will result in a maximum penalty of the total points of the exam and the instructor solely will determine the penalty. Any form of cheating will result in a penalty of the total points of the exam.

### **Grading Policy**

<b>Percent</b>	<b>Grade</b>	<b>Grade Points</b>
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, whichever gives students a better grade. That means, if a student’s total score of the course is 90, the student gets an A. However, if the student’s score is 80 but the student is already in the top 10% (percentage to be confirmed) of the class, the student still gets an A because of “curving the 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%. As noted, the 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:

<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades>

### **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 Conduct 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. 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](mailto:jpennacc@ufl.edu)
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, [taylor@eng.ufl.edu](mailto:taylor@eng.ufl.edu)
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, [nishida@eng.ufl.edu](mailto: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](mailto: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](mailto: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](mailto: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 support**, 352-392-4357 (select option 2) or e-mail to [Learning-support@ufl.edu](mailto:Learning-support@ufl.edu).  
<https://lss.at.ufl.edu/help.shtml>.

**Career Resource 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:** <http://www.distance.ufl.edu/student-complaint-process>.