**ME 3340: Undergraduate Fluid Mechanics**
**Last updated 4/1/26**

"If you want to build a ship, don't drum up people to gather wood, divide the work, and give orders. Instead, teach them to yearn for the vast and endless sea."— Antoine de Saint-Exupéry

**Instructor** David L. Hu

**Office:** Love 124

**General questions:** Use class groupme

**Private questions:** DM in groupme, or hu@me.gatech.edu
Please avoid sending message by canvas email since I don't check it very often.

**Class Schedule:** Section D 08:00 - 09:15 MW IC 205

**Recitation instructor:** Ryu, Young Jae <youngjaeryu@gatech.edu>

- **Fridays, 2:00–3:15 PM, Mason 3132**

Teaching Practicum

Hu Office hours: MW11-12 in Love 124 or by appointment.

**Hu's OneNote:** **OneNote** (updated July 2025)

**Hu's 2020 recorded lectures:** **YouTube**

**Online Office Hours:** Hu zoom. Tues/Thurs at 730pm. For online office hours, I recommend you send a picture of your problem ahead of time. Stylus and tablet highly recommended

**Shell tutoring:** Schedule to be updated by third week of class.
Location: 4th floor of the MRDC building every Tuesday & Thursday, 6pm to 8pm.
Rizzuto, Max C mrizzuto3@gatech.edu

Small group/individual tutoring (by appointment): through knack tutoring.

**Journal club/Course project sign up** link

Course project peer evaluations

**Important Dates**

| **Unit** | **Date** |
|---|---|
| Quiz 0 | Wed Sept 2 |
| Quiz 1 | Wed Sept 2 |
| Labor Day | Sept 7 |
| Quiz 2 | Mon Sept 21 |
| Course project phase 1 | Sept 18 |
| Course project phase 2, Midterm grades | Oct 2 |

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| Fall Break | Oct 5 |
| Quiz 3 | Wed Oct 7 |
| Quiz 4 | Wed Oct 21 |
| Withdrawal Deadline | Oct 31 |
| Quiz 5 | Wed Nov 4 |
| Quiz 6 | Mon Nov 23 (proctor, Hu traveling) |
| Thanksgiving | Wed Nov 25 |
| Course Project Presentations | Nov 30, Dec 2, 7 (note its right after Thanksgiving break, those on unexcused absence/travel, please let instructor know and sign up for other presentation date) |
| Grades submission deadline | December 16, noon |
| | |
| | |

**Hu gone: Sept 23, Nov 23.**

**Course grade**

70% Seven quizzes
20% Course project
5% Homework
5% Participation (Journal club, attendance, and active participation)
Final grades are generally not curved. (90.0-100% is an A, etc)

**Active Participation**
Attendance will be taken. In class, active participation credit will be given for: correcting my errors, working on assigned problems in class, working together with your classmates, and coming prepared for class and office hours. I encourage you to groupme or email me ahead of office hours or class with any questions (including pictures of your work) so I can have time to process and address them to the whole class. If we haven't made any contact over the entire semester, and you are doing poorly in the class, I have the right to reduce credit here. I will give additional credit for good communication skills, helping with and giving constructive feedback on the course.

**AI statement:** If AI helps you with this course, please acknowledge use of it in any assignments. If there is a question on use, please ask instructor ahead of time.

**Quizzes**

One-page equation sheet (front only) is allowed for the quiz. No calculators or other notes are allowed.

**Makeup quizzes**

Excused absences on quiz day will be made up with a 15-30 minute oral exam. The student will bring their homework and notes to the instructor. The student will be given several minutes to prepare an answer to 1-2 questions provided by the instructor. They will then explain their methodology on the board. Effort will be made to make the quiz of the same level of difficulty as the class. For difficult questions, hints will be given but points will be taken off for incorrect statements. The instructor will give bullet points indicating where mistakes were made. The meeting will be recorded. The goal of the exam is to test the students ability to explain the choices they made.

**Journal club**

A student presentation every day for the first 5 min of class which includes at most 3-4 min presentation (just a few slides uploaded to desktop before class), 1 min Q&A.

1. Desktop has HDMI, VGA and flash drive
2. The purpose of the journal club is to try out some ideas for your course project. The journal club can be done in groups of two to three people. (approx 20 lecture classes)
3. I suggest finding a popular YouTube video, or reading a popular press pieces on the subject, and collect movies and images, and physical concepts to show the class
4. Read the original article, if applicable
5. Discuss how the experiment is done
6. Show less than 5 equations.
7. If possible, discuss how a home-made experiment can be done.

**AI statement:** Please acknowledge use of AI in any assignments. If there is a question on use, please ask instructor ahead of time.

**Experimental Course Project Tools**

The following equipment is available for supervised use during office hours. They may be available for overnight checkout.

EXTECH Anemometer , AN100: 1 fpm Air Velocity Resolution, CFM, Rotating Vane, Temp, 100-4000 fpm $400

Dwyer Series Avul Anemometer: 5-20 m/s, 5% accuracy $500

VWR Hot wire anemometer $800

Ryobi Power inflator with battery $230
Fog machine with fog fluid, $50
Incense sticks, food coloring should be purchased on own

Inspiration on flow visualization: van Dyke Gallery of fluid motion

**Homework**
Each homework will be graded out of 10 points. Homework is due on gradescope by 11pm the night before the quiz. Late homework will be penalized 1% per hour late (or approximately 24% per day). Homework solutions will be given upon request closer to the quiz date.

1. Choose one homework problem and one practice quiz problem to do and include solutions to best of your ability (4 points). Note the most challenging steps of the problems.
2. Write summary of challenges you faced during the last quiz and give corrections (4 points). Full credit for this will be given for HW 1 since there is no “last quiz”.
3. Write a 1-page cheat sheet (front only) sheet for the quiz. Only words, formulas, and diagrams are allowed. No solved problems allowed (1 point).
4. Neatness: did you assign each page in your solution to the correct problem? Is the scan legible? (1 point)

On quizzes you can use the cumulative cheat sheets you have made for previous quizzes.

Quiz 0 on Pre-requisites: Derivatives, Integrals, Vector Calculus, ODEs, Miscellaneous. See Canvas Files for "quiz 0 materials" a 22-page pdf. Useful for working out integrals and graphing: https://www.integral-calculator.com

Quiz 1 on Dimensional Analysis: units, dynamic similarity, when dynamic similarity not possible, weirs, pouring, propellers, force, torque, FLT vs MLT. Suggested reading
7.3.14
7.3.20
7.8.1
7.8.3
7.9.11
7.35 (see canvas files).
Also I suggest you do practice problems in sections: 7.7, 7.8: Correlation of experimental data

Quiz 2 on Hydrostatics: slanted surface, curved surface, manometers, gate, round cut-out, problem with two densities, buoyancy, Archimedes Law. Problems will be unit depth into page. You will not be responsible for parallel axis theorem, 3-D problems, pressure prism method. Instead, you will need to form integrals to calculate force and torque.
2.6.5
2.6.6
2.6.11
2.6.24
2.6.32
2.8.13
2.8.18
2.8.34
(Ref. P 2.8.33)
2.10.2

Quiz 3 on Bernoulli's Law: pipe branch, pipe contraction, syphon, manometer, multiple tanks, free jet, nozzle
3.6.19
3.6.27
3.6.30
3.6.37
3.6.62
3.6.72
3.6.84
3.6.87
3.6.89

Quiz 4a on Control Volumes, Part I: Mass and Linear momentum: y-duct, filling a container, leaky needle, pipe bend; fluid striking inclined plate, conical deflector, or a dish; impact of two water jets, sluice gate water sprayed radially
5.1.14
5.1.27
5.1.30
5.2.4
5.2.5
5.2.17
5.2.20
5.2.23
5.2.25
5.2.29

Quiz 4b on Control Volumes, Part II: Rotation and Energy: sprinkler, inclined pipe, syphon, pipe elbow and expansion, hydraulic jump

5.2.49
5.3.8
5.3.10
5.3.11
5.3.12
5.3.16
5.3.33
5.3.35
5.3.38

Quiz 5 on Potential Flow: flow rate given velocity potential, flow against infinite plane, wedge, bathtub vortex, hump, pond, hut, cylinder
6.2.12
6.4.11
6.5.4
6.6.1
6.6.5
6.6.7

Quiz 6 on Navier-Stokes Equations: Rectilinear: flow between two parallel discs, Couette flow with stationary walls, moving walls or two fluid viscosities; lubrication flow. Cylindrical: Poiseuille flow, rotating cylinder—flow inside or outside, flow in an annulus

Rectilinear coordinates:
6.9.6
6.9.8
6.9.10
6.9.11
6.9.14
6.9.15

Cylindrical coordinates:
6.9.21
6.9.26
6.9.27
6.9.29

In-class practice problems:
Quiz 1a: one dimensionless group,
Quiz 1b: two dimensionless groups, possibly including Reynolds number
Quiz 1c: dynamic similarity with numbers
Quiz 2a: manometer
Quiz 2b: vertical dams
Quiz 2c: diagonal dams
Quiz 3a: gravity-driven flow
Quiz 3b: syphons
Quiz 3c: several containers
Quiz 4a: converging jets
Quiz 4b: forces from jets
Quiz 4c: sprinkler
Quiz 4d: turbine/generator
Quiz 5a: half-body
Quiz 5b: cylinder
Quiz 5c: Rankine oval
Quiz 6a: rectilinear coordinates, Couette flow, pipe flow
Quiz 6b: cylindrical coordinates, pipe flow, rotating plate
Quiz 6c: simplifications to Couette flow

**In-class Demos**

First day: pink flapper

Unit 1 on Dimensional Analysis: dropping balls in different viscosity

Unit 2 on Hydrostatics: hinged dam, hydraulic lift, dome

Unit 3 on Bernoulli's Law: ping pong ball in cone, potato gun, water clock, venturi suction, flow rate measurement

Unit 4a on Control Volumes, Part I: Mass and Linear momentum: none

Unit 4b on Control Volumes, Part II: Rotation and Energy: sprinkler

Unit 5 on Potential Flow: magnus effect on a Styrofoam cylinder, wind tunnel

Unit 6 on Navier-Stokes Equations: rectilinear coordinates: none

**Prerequisites** Multivariable calculus (derivatives, integrals, vectors), ordinary and some partial differential equations , statics (free-body diagrams), Mechanics (Forces and movements; equilibrium; stress and strain), Dynamics of rigid bodies (Center of mass motion, kinematics and kinetics, energy and momentum), Thermodynamics.

**Course Expectations**

This course involves homework, in-person quizzes, and a team-based course project with deliverable throughout the semester. The latter involves coordination with classmates, regular discussions with the professor, and either a numerical or a hands-on component to the project.

**Course Objectives**

- explain the problem "physically"
- start and finish fluid mechanics problems (math) and present concise explanations
- use tools of fluid mechanics: dimensional arguments, relations between velocity and pressure, control volumes and differential analysis
- check problem answers for correctness and physical plausibility

**How to succeed in this class**

- come to class on time and prepared
- actively try the warm-up and group problems and ask questions
- come to recitation and office hours. Students who work together in office hours usually get an A or B in this class
- know your calculus pre-requisites, which will be used for most quizzes
- consider reading the textbook
- review the online lectures and skim through the examples in the book after class
- get 1-on-1 help from office hours, Shell Tutoring, or a study group.
- quizzes 4-6 are the most difficult. Prepare to spend extra time on them.
- if you fail the first two quizzes, please contact the instructor with a plan for: forming a study group, changing study habits, and improving your performance.

**Text** The only recommended text for the class is:

*Fundamentals of Fluid Mechanics* (9th edition, 2021) by Munson, Young, Okiishi, Huebsch.

Note that the 7th and 8th edition will have different problems than the ones covered in class, so we encourage you to get the 9th edition. **There is no need to buy the more expensive Wiley Plus version.**

**Course projects**

A group of 2-3 people will build a portable demonstration of a fluid mechanics phenomenon or I2P prototype. The demo should be robustly built, small (able to fit in a grocery bag) and lightweight (so that one person can carry or push on a cart). It should be visible from 20-50 feet away, able to be refilled/recharged easily, and capable of being seen and appreciated by elementary school children. A brief proposal is due mid-semester that will be graded for completeness and receive a few brief guiding comments.

Final presentations will be pre-recorded YouTube videos with a maximum duration of three minutes and thirty seconds. After the video is shown in class, two additional minutes will be given for demonstrations and answering questions. To receive credit for this assignment, attendance is required for all presentations. The final video will be graded on originality and ability of the project to engage an audience (10 pts), relation to fluid mechanics (10 pts), communication skills (10 pts), and level of difficulty (10 pts). Any images/movies used from other sources should have a short citation (author, year) when shown on the video. Previous students recommend using SolidWorks Flow Simulation provided free by OIT.

**Grades for the course project in principle can be pulled from the whole spectrum of grades, A-F, but historically range from A-C with 10-15% of groups receiving an A.** To make sure teammates are working equally, we will conduct surveys of team members. Because this is a team-based project, the course project cannot increase your grade more than a single letter grade. The graders, TA, and instructor will all be judges on the project presentation, in which projects will be ranked on the following: an original idea, impressive build, relevant theoretical analysis, and a clear and engaging video.

Course Project Hall of Fame

| | | | |
|---|---|---|---|
| 2019 | Emily Fourney and Gabe Cervantes | plant watering | |
| 2020 | Danielle Newman, Dustin Coha, Davis Brown | water clock | |
| 2021 | Alex Castrejon, Claire Young, Koji Shimada | The Venturi Effect | |
| 2022 | Denzel Carter, Kwame McCollum, Matthew Mckenna | Wind Tunnel | |
| 2023 | Jacob Riesel, Austin Graves | Atmosphere-Breathing Electric Propulsion (ABEP) Ion Thruster | |
| 2024 | Nihanth Pinnaka, Elle Banach | Ramp Pump | |
| 2025 | Zun Chen, Nishant Sood, Muhammad Sarguroh | Fletner Rotor Car | |
| | Josh Jonathan, Shrey | Fluidic Oscillator | |

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|---|---|---|---|
| | Patel | | |
| 2026 | Your name here | | |

The projects above each chose a single simple fluid mechanics idea and did a great job with the build, the experimental measurement, and theoretical analysis. Ideas that don't score as well may be too ambitious, too complicated, or do not have a clear or surprising result.

Ideas that are routinely rejected, unless concerns with originality or feasibility are addressed:

1. reversible flow due to spinning cylinder at low Re
2. Heron's fountain (too much glue needed to make vacuum chamber)
3. hydraulic jack (not visual enough; several versions are in my office)

- **PROPOSAL PHASE 1** is a numbered list of at least 2-3 project ideas that the student would want to conduct. Each idea should have a question to be answered and 1-2 sentences about why this is an interesting and feasible project. A proposed team of 2-3 individuals should be suggested. Approval of at least 1 idea by the professor is required to proceed to phase 2. (this is ungraded, but late submissions will not be accepted). If you include web links paste the entire link since gradescope uploads pdfs as images without text.

- **PROPOSAL PHASE 2** will be a 1-2 page (single spaced, 12-point font) plan of the project to be conducted. The proposal should include title, background and justification (significance, novelty, feasibility, relationship to material in this class), a statement of hypotheses to be tested (these can be in the form of questions or falsifiable statements), how the hypotheses will be tested (i.e., what experiments will be conducted), and how data will be interpreted. It is also a good idea to include figures, preliminary results, and a statement of further expected results, and how the results relate to the goals of the project. The proposal can include a few citations, not included in the page limit. Future tense should be used. (this is ungraded, but late submissions will not be accepted)

- Final presentation advice. Keep on working on your topic until you get a surprising result. Try to convey the result so the class has intuition for the answer. Less is more. Make sure to cite any graphs or facts that you use with author last name, journal, year.

- Project idea 1: Construct an in-class portable demonstration of a fluid mechanics phenomenon. It should be aesthetically pleasing and robustly built. Transparent materials should be used if possible.

- Project idea 2: Do a computer simulation or mathematical model using solidworks or Comsol or Potentialflow.com
- Project idea 3: Problems can be adapted from fluid mechanics literature available online: examples include the websites and journals:
    a. https://fyfluiddynamics.com,
    b. http://www.smartereveryday.com
    c. https://physicstoday.scitation.org/journal/pto
    d. https://www.cambridge.org/core/journals/journal-of-fluid-mechanics
    e. https://journals.aps.org/prfluids/

**Grading questions** All grading questions must be brought up within **ONE WEEK** after the grades of homework or quizzes are posted on *Canvas*. It is your responsibility to visit me to review the solutions if you have questions regarding the results of your homework or quiz.

**Technical errors with homework and quiz uploads**

Quizzes uploads are due at the end of class. Please be responsible and check your upload. If you forget to upload the document or upload an incorrect document, you will receive at most 50% of their new grade once the correct document is submitted. I recommend using AdobeScan app and logging in with your GT username.

**Missing Classes for Personal Emergencies** Students may need to miss a quiz due to personal emergencies. The Office of the Vice President and Dean of Students can assist students with documented emergencies by contacting professors on behalf of the student. For more information, please call the Office of the Vice President and Dean of Students or complete the Request Assistance Form.

**Institute Approved Activities** Students who are absent because of participation in approved Institute activities (e.g. conferences, work-related travel, athletic events) will be permitted to make up the work missed during their absences. Approval of such activities will be granted by the Student Academic and Financial Affairs Committee of the Academic Senate, and statements of the approved absence may be obtained from the Office of the Registrar.

**Honor code** Martin Luther King: "Its always the right time to do what is right." Violations of the GT *Academic Honor Code* and will be dealt with accordingly.

**Diversity & Inclusion Statement:** I strive to create a learning environment that supports and honors the diversity of perspectives, experiences, and thoughts represented among us and beyond the classroom. Please help me do this by:

- Informing me if your name or pronouns differ from those that appear on your official record.
- Informing the instructional team if you feel that your personal experiences outside of class are impacting your performance in class.
- Informing an instructor or TA about anything that was said or done in class that made you feel uncomfortable.
- Giving us suggestions on how we can improve the lecture and project experience to make all participants feel included and valued.

**Additional online material**
David Ancalle videos:
https://www.youtube.com/playlist?list=PLXLUpwDRCVsQzHsd7mCotb4TbLZXrNpdc

Don Webster's videos
https://webster.ce.gatech.edu/fluid-mechanics-cee3040-lecture-videos/

I also recommend videos from the following sources, which have been compiled from John Biddle (Cal Poly Pomona), Michel van Biezen (Loyola Marymount University), Brian Schendt (Rutgers), CPPMechEngTutorials, Victor Ugaz (Texas A&M). To see a longer lecture, watch Don Webster's videos, as he also references problems in the book.

| Topic | Online lectures |
|---|---|
| Calculus Pre-requisites | 1. Derivatives<br>2. Integrals<br>3. Vector calculus<br>4. Ordinary differential equations<br>5. Miscellaneous |

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|---|---|
| Dimensional Analysis | https://www.youtube.com/watch?v=3gxNrc_EEN8 (dimensional analysis, Kamrin)<br><br>Properties of Fluids<br>1. Properties of Fluids – Density<br>2. Properties of Fluids – Viscosity<br>3. Properties of Fluids – Surface Tension<br><br>Dimensional Analysis & Similitude<br>1. Dimensional Analysis & Similitude Example 1 – Building<br>2. Dimensional Analysis & Similitude Example 2 – Venturi Meter<br>Finding Dimensionless Groups<br>1. Finding Dimensionless Groups Example 1 – Surface Waves<br>2. Finding Dimensionless Groups Example 2 – Sphere Flow<br>3. Finding Dimensionless Groups – Pitfalls |
| Hydrostatics | Hydrostatic Pressure<br>Hydrostatic Pressure Variation<br><br>1. Hydrostatic Pressure Variation – Review of Taylor Series Expansion<br>2. Hydrostatic Pressure Variation Example 1 – Swimming Pool<br>3. Hydrostatic Pressure Variation Example 2 – Car Lift<br>Simple Manometers Example 1 – U-tube<br><br>1. Simple Manometers Example 2 – Multifluid<br>Hydrostatic Forces on a Planar Surface<br><br>1. Hydrostatic Forces on a Planar Surface – Line of Action of the Force<br>2. Hydrostatic Forces on a Planar Surface Example 1 – Rectangular Gate<br>3. Hydrostatic Forces on a Planar Surface Example 2 – Inverted Gate<br>Hydrostatic Forces on a Curved Surface<br><br>1. Hydrostatic Forces on a Curved Surface Example 1 – Dam<br>Buoyancy |
| Bernoulli's Equation | Bernoulli Equation<br>1. Bernoulli Equation – Definition of Pressure Terms<br>2. Bernoulli Equation Example 1 – Converging Nozzle<br>3. Bernoulli Equation Example 2 – Pitot Static Tube<br>4. Bernoulli Equation Example 3 – Duct and Manometer<br>https://www.youtube.com/watch?v=VA03j6t5F-8&t=2s (Bernoulli, van Biezen)<br><br>5. |

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| Control volumes, mass and linear momentum | Conservation of Momentum – Reynolds Transport Theorem<br>1. Conservation of Momentum Example 1 – Nozzle Flow<br>2. Conservation of Momentum Example 2 – U elbow<br>3. Conservation of Momentum Example 3 – Windmill<br>4. Conservation of Momentum Example 4 – Drag Force on Model<br>https://www.youtube.com/watch?v=ObKwjK0vU2c&t=12s (Conservation of momentum, CPPMechEngTutorials) |
| Control volumes, angular momentum and energy | Conservation of Angular Momentum<br>1. Conservation of Angular Momentum Example – Sprinkler<br>Conservation of Energy<br>1. Conservation of Energy – Engineering Formulation<br>2. Conservation of Energy Example 1 – Kinetic Energy Correction Factor<br>3. Conservation of Energy Example 2 – Pool<br>4. Conservation of Energy Example 3 – Pump/Turbine<br>5. Conservation of Energy Example 4 – Flow Direction<br>6. Conservation of Energy Example 5 – Steam Turbine<br><br>https://www.youtube.com/watch?v=TTrOdsfELYk (Angular momentum example, Schendt)<br><br>https://www.youtube.com/watch?v=fK-fgHpqSg8 (Angular momentum example 2, Schendt)<br><br>https://www.youtube.com/watch?v=MYF9Wxcb4Ug (Conservation of Energy, CPPMechEngTutorials) |
| Potential Flow | https://www.youtube.com/watch?v=xf_R7RBE8Og at 6:00 (comprehensive lecture)<br>https://www.youtube.com/watch?v=9Of8WCmFGpg (from 11:20) and the follow-up lecture – https://www.youtube.com/watch?v=gLPJAjyiUxA Optional short lectures https://www.youtube.com/watch?v=x8_pfo1-MmI , https://www.youtube.com/watch?v=Zmuq5u9gkX4 , https://www.youtube.com/watch?v=Z7v9soqVS70<br>https://www.youtube.com/watch?v=lzNhSIHBizw , https://www.youtube.com/watch?v=StM6ICd-Yfs , https://www.youtube.com/watch?v=VjyvHjkXCNU |

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|---|---|
| Navier-Stokes | Continuity Equation<br>1. Continuity Equation Example 1 – Diverging Flow<br>2. Continuity Equation Example 2 – Nozzle Flow<br>Navier-Stokes Equations<br>1. Navier-Stokes Equations Example 1 – Couette Flow<br>2. Navier-Stokes Equations Example 2 – Poiseuille Flow<br><br>https://www.youtube.com/watch?v=xLQNqwPUuN4 (Navier Stokes pipe flow, Ugaz)<br><br>https://www.youtube.com/watch?v=pVLCmT5lkw4 (Navier Stokes pipe flow part 2, Ugaz) |