



ESC 301 Fluid Mechanics

Tue, Thu 4:30 – 5:45 pm; FH 267

Spring
2021

Catalog Description:

ESC 301 is the study of fluid properties, hydrostatics, friction loss, dimensional analysis, statics, and dynamics of compressible and incompressible fluids; continuity, energy and momentum principles; laminar and turbulent flow; general concepts of boundary layer flow.

Instructor: Dr. Geyou Ao, Assistant Professor, Chemical and Biomedical Engineering
g.ao@csuohio.edu

Zoom office hours: Tue, Thu 5:50-6:20 pm, and Mon, Wed 4:00-5:00 pm, or by appointment *via* email

Prerequisites: ESC 250 Diffrentl Equatns for Engineers

Textbook: Introduction to Fluid Mechanics, 9th Edition
R. W. Fox, P. J. Pritchard, J. W. Mitchell, and A. T. McDonald, Wiley, New York, NY, 2015.

Course Delivery: *Remote* synchronous, live lectures *via* Zoom:

On-campus midterm and final exams: FH 267, FH 268, FH 202

Teaching Assistant: Venkateswara Rao Kode, v.kode@vikes.csuohio.edu
Office hours: Fri 12:00-1:00 pm, or by appointment *via* email

Course Objectives: This course is designed to

1. Provide junior engineering students with the fundamentals of fluid mechanics.
2. Provide students with an understanding of molecular and convective mechanisms of momentum transport.
3. Demonstrate the differences between laminar flow and turbulent flow from the physical and mathematical points of view.
4. Provide students with an in-depth understanding of integral methods of analysis used to derive the necessary equations of continuity, energy and momentum balances.
5. Demonstrate the application of fluid mechanics principles to solve problems that involve fluids.

Expected Outcomes: Upon completion of the course, students should be able to

1. Apply the mathematical, scientific, and engineering principles of momentum transfer.
2. Use the fluid mechanics principles in engineering design problems.
3. Identify, formulate, and solve fluid mechanics problems using the mathematical expressions of property balance.
4. Understand the prevalence of diffusion vs. convection in processes that involve momentum transport.

Program Outcomes: Fulfills the following engineering program outcomes.

- Knowledge/understanding of application of mathematics, science and engineering principles.
- Knowledge/understanding of engineering design (units and processes).
- Knowledge/understanding of identification, formulation, and solution of engineering problems.

Policies and Procedures: The following policies will be strictly adhered to

Academic honesty: **"Cheating" means intentionally misrepresenting the source, nature, or other conditions of academic work to receive undeserved credit. Cleveland State University affirms that acts of cheating debase the academic degree awarded, have no place in the University, and are severe offenses to academic goals, objectives and the rights of fellow students. CSU does not tolerate any type of cheating and will take disciplinary action up to and including expulsion.**

Students should refer to the University policy concerning academic honesty, plagiarism, and cheating, found in the University Academic Regulations and Procedure, 3344-21-02 Policy on Academic Misconduct. It is the instructor's understanding and expectation that the student's signature on any test or assignment means that the student contributed to the assignment in question and that they neither gave nor received unauthorized aid. Authorized aid on a homework assignment includes discussing the interpretation of the problem statement, sharing ideas or approaches for solving the problem, and explaining concepts involved in the problem. Any other aid would be unauthorized and a violation of the academic integrity policy. This includes directly copying problem solutions from previous offerings of the course or downloaded from the Internet. All cases of academic misconduct will be reviewed by the instructor, the department chairperson or college Dean, and will be submitted to the university review committee. If you are found guilty of academic misconduct in the course, you will be on academic integrity probation for the remainder of your years at CSU and may be required to report your violation on future professional school applications. It is not worth it!

Grading:

	A : 90-100
	A-: 85-89
	B+: 80-84
	B : 75-79
	B-: 70-74
	C+: 65-69
	C : 55-64
	D : 50-54
	F : 0-49
3% Attendance (full points will be given to students attending all classes on time and joining more than 2 office hours)	
10% Homework	
52% Midterm Exams (2)	
35% Comprehensive Final Exam	

*Logical, clear, and consistent problem-solving steps and unit conversions are required for all assignments including homework and exams. Providing correct answers without clearly showing your work will result in zero points. The lower midterm exam grade counts 17%, and the higher one counts 35%. **Note: I do not curve grades in this course.** If you fall into one of the "gray areas" (e.g., A- or B+, B or B-, C+ or C, D or F), your grade will be determined by whether your performance has improved or remained consistent or gotten worse, especially on the final exam. Your performance depends only on how you do, not on how everyone else in the class does.*

- Class material: Students are responsible for all material covered in class whether they are present or not.
- Class participation and attendance: Active participation in discussions is a key part of class performance. Practice problems will be given periodically to assess progress and ensure that students are understanding the lectures. Students are expected to attend all scheduled classes. College work requires regular class attendance as well as careful preparation.
- Homework: Homework will be assigned periodically throughout the semester. Students are permitted to form virtual study groups to discuss homework, however students must submit their own work and solutions. Do not give away your work!
- Homework format: Submit scans (e.g., using Microsoft Lens) of homework in a single PDF file on Blackboard. Homework must be neatly written with no pages torn from notebooks. Begin each problem on a new page and box all final answers. If the homework problems require work with spreadsheets and graph creating software, you must use computer tools to create graphs. The problem should be submitted in the same order as in the homework assignment. Include your name and problem set number. Standard point deductions will be assigned for failure to submit legible work, not plotting graphs using computer tools, not combining in a single PDF file, no names on assignments, torn pages, etc.
- Late homework: Homework is due on the date and time marked on each assignment. Deadlines will be strictly enforced with a grace of one late day and a 20% grade deduction. *However, once an individual hands in two late assignments, no more late assignments will be accepted.*
- On-campus exams: Follow strict safety protocols for COVID-19. More information can be found at <https://engineering.csuohio.edu/dean/covid-19-and-re-opening-campus>
- There will be two midterm exams and a comprehensive final exam;
- 1) Each exam is closed notes and closed book with no Wi-Fi enabled electronic devices allowed including but not limited to cell phones, smart watches, cameras, and earphones. Bring your calculators. However, calculator cases must be removed. *If you forget your calculator, then you will be asked to proceed without one.*
 - 2) Exams must be taken when scheduled. There will be no exceptions. If you miss one midterm due to verifiable sickness or family emergencies, your final exam grade will be assigned to the missing midterm. A second missed midterm will result in zero for that exam.
 - 3) Please keep your cell phones turned off during exams. Unauthorized use of your cell phone during an exam will result in a grade of zero and may even failing the course.

Any communication with individuals in the classroom or outside of the classroom is forbidden during the exam. The use of materials not authorized by the instructor is also forbidden.

Re-grade policy: A typed explanation for why a re-grade is warranted together with a photocopy of the graded work (homework and exam) must be submitted to the Teaching Assistant and the instructor *via* email within *three days* of receiving the graded work.

Health and Safety syllabus statement: The COVID-19 pandemic is still present and serious. Before entering class, you should have completed your daily health assessment. While you are in class on campus, you are required to: sit in your designated seat, maintain physical distance, wear your facial covering (e.g., masks), always cough or sneeze into your elbow or tissue, use the materials provided to clean your desk and chair before and after use, and adhere to other public safety protocols and directives for your specific classroom/lab/studio. Students who do not follow these health and safety requirements will be instructed to leave class immediately. Students who violate this protocol will need to leave the classroom and MAY be marked absent. Repeated violations of these health-saving protocols may lead to sanctions under the [Student Code of Conduct \(3344-83-04 \[E\] and \[Z\]\)](#) up to and including suspension or expulsion. The CSU community thanks you for your cooperation!

Syllabi statement that students are required to pull back all head coverings to display their ears during exams to prevent academic misconduct: As part of the University's ongoing efforts to prevent cheating, and based on evidence of increased use of headphones and ear piece devices to permit cheating on exams, all students are required to display their ears for the duration of any exam. The policy may require adjustment to hair or clothing. Any student not complying with this policy will, after a warning, be issued a zero on the exam. Students with concerns about their compliance with this policy please contact the Office for Institutional Equity at OIE@csuohio.edu or 216-687-2223.

Accommodations for students with disabilities: In accordance with federal law, if you have a documented disability, you may be eligible to request accommodations from The Office of Disability and Testing Services. For more information regarding available accommodations and registration, please call 216-687-2015 or stop by their office in Rhodes West 210. Please keep in mind that accommodations are not retroactive.

ESC 301 Schedule of Topics (Tentative):

Ch. 1. Introduction - 1 week.

- Definition of a fluid, equation literacy (mass vs. weight), the ideal gas law, units & dimensions, system vs. control volume

Ch. 2. Fundamental Concepts - 2 weeks.

- Fluid as a continuum, density field, velocity field, classification of dimensional flow, graphical description of fluid flow (streamlines, pathlines, streaklines), element area, stress field, viscosity, boundary conditions, couette flow

Ch. 3. Fluid Statics - 2 weeks.

- Pressure, Pascal's law, pressure field, absolute and gage pressure, pressure variation in a static fluid, pressure gradient, pressure head, manometer, hydrostatic force on plane/curved surfaces (resultant force), buoyancy

Ch. 4. Basic Equations in Integral Form for a Control Volume - 2 weeks.

- Reynolds transport theorem, extensive and intensive properties, conservation of mass, Newton's second law of motion, body vs. surface forces, the first law of thermodynamics, volumetric flow, average velocity, mass flow

Ch. 6. Incompressible Inviscid Flow - 2 weeks.

- Bernoulli equation (application & limitation), static/stagnation/dynamic pressures, venturi meter, energy and hydraulic grade lines, power and efficiency

Ch. 7. Dimensional Analysis and Similitude - 2 weeks.

- Important dimensionless numbers, dimensional homogeneity, Buckingham Pi Theorem, flow similarity (geometric/kinematic/dynamic similitude) and model studies

Ch. 8. Internal Incompressible Flow - 2 weeks.

- Fully developed laminar flow, derivation of velocity field, pressure gradient, pressure drop, Continuity equation (EOC), Navier-Stokes equation (Equation of Motion, EOM), flow in pipes and ducts, energy consideration in a pipe flow, major & minor head losses, friction factor for laminar (Darcy) and turbulent (Darcy-Weisbach) flows, Moody diagram, pumps/fans/blowers in fluid systems, flow measurement (venturi/nozzle/orifice meters)

Ch. 9. External Incompressible Flow - 2 weeks.

- The Concept of the Boundary Layers (disturbance/displacement/momentum thickness), laminar boundary layers, friction drag coefficient/force

Notable Dates

<https://www.csuohio.edu/registrar/spring-semester-2021>

Martin Luther King Day (1/18/2021)

President's Day (2/15/2021)

Last Day to Withdraw (3/26/2021)

Reading Day (3/10/2021 and 4/8/2021)

Exam 1 (Tuesday 2/23/2021, time 4:30 – 5:45 PM)

Exam 2 (Tuesday 4/6/2020, time 4:30 – 5:45 PM)

Final Exam (Tuesday 5/4/2021, time: 4:00-6:00 PM)