ENVE 3120 Fluid Mechanics (4 credits)

Prerequisites:	CE 2110, MATH 2110, MATH 2410, enrollment in School of Engineering
Recommended preparation:	CE 2120. This course and ME 3250 may not both be taken for credit.
Description:	Statics of fluids, analysis of fluid flow using principles of mass, momentum and energy conservation from a differential and control volume approach. Dimensional analysis. Application to pipe flow and open channel flow.
Lecture Time/Place:	MWF 11:15 - 12:05 pm, ARJ105, with live streaming and WebEx
Lab Time/Place:	Video and live streaming available Tu or Th 11:00-12:15 or 12:30-1:45, CAST 114 (CAST 117 for Lab #4 & #5)
Exam Time/Place:	Exam 1: F 2/19; Exam 2: F 4/2; Exam 3: W 4/28 ; take-home
Instructor:	Dr. Ross Bagtzoglou (**ACB**) – pronouns: he, him, his; CAST 314 Webex: https://uconn-cmr.webex.com/meet/acb02004 email: amvrossios.bagtzoglou@uconn.edu
Graduate TAs:	Mahjabeen F. Mitu (**MFM**) – pronouns: she, her, hers Webex: https://uconn-cmr.webex.com/meet/mfm19004 email: Mahjabeen_fatema.mitu@uconn.edu Christina Feng (**CF**) – pronouns: she, her, hers Webex: https://uconn-cmr.webex.com/meet/ccf13002 email: christina.feng_chang@uconn.edu
Undergrad TA:	Abby Klimowicz (**AK**) – pronouns: she, her, hers Webex: https://uconn-cmr.webex.com/meet/ask15101 email: abby.klimowicz@uconn.edu
Text:	Munson, Young, & Okiishi's Fundamentals of Fluid Mechanics, 8th ed., by Gerhart, Gerhart & Hochstein, John Wiley & Sons, ISBN 978-1-118-84713-8
Office Hours:	Dr. Bagtzoglou: W 3:30-5 pm, or by appointment, via email, Webex, etc. TAs: via Webex; for lab-related issues **MFM** T 10-11 & Th 11-12:15 lab report due weeks, for HWs & recitations **CF** T/Th 12:30-1:30, **AK** T 11-12:30

Course Format:

This is a **flipped/hybrid course**, so this means that part of the class content will be introduced to you through online video lectures, reviews and readings, which should be completed outside class. In-class time will be used for quick material reviews, discussions, step by step problem solving, and team-based learning. You can find the live stream link on https://classrooms.uconn.edu/classroom/ for ARJ105. All video lectures and review sessions have been captioned so that they are accessible to a diverse population of student learners.

Please refer to the **course's HuskyCT webpage** for an introduction to the course and instructions of your weekly activities to be completed before, during and after each class. Every week an announcement will be made with detailed instructions on what will be taking place that week and reminders for all upcoming deadlines. **Please come to class prepared** so that you get the maximum benefits of this learning experience.

Overview of Learning Objectives:

Upon completion of this course, you will be able to:

1. Understand what a fluid is and how to distinguish fluids from solids. Define their properties and describe their fundamental fluid behaviors.
2. Calculate the forces that fluids at rest exert on objects.
3. Understand what causes fluids to move. Learn and apply the methods used to measure fluid flow. Calculate how much force moving fluids exert on objects.
4. Characterize fluid flow and distinguish between Lagrangian and Eulerian flow descriptions
5. Understand and apply the continuity, energy and linear momentum equations.
6. Learn about pumps/turbines and perform relevant calculations in pipe systems using the energy equation.
7. Predict flow behavior in pipes – Understand and calculate energy losses
8. Design pipe systems and solve multiple reservoir problems.
9. Predict flow in open channels. Categorize flows as subcritical or supercritical, gradually varying or rapidly varying.
10. Understand and apply the concepts of specific energy, hydraulic jump, steps and contraction in channels and other design considerations in open channel flow.

Course expectations:

The students will:

- review important standards, policies and resources, including the Student Code (Academic Integrity, Resources on Avoiding Cheating and Plagiarism), Copyrighted Materials, Credit Hours and Workload, Netiquette and Communication, Adding or Dropping a Course, Academic Calendar, Policy Against Discrimination, Harassment and Inappropriate Romantic Relationships, Sexual Assault Reporting Policy
- get familiar with the course's HuskyCT website
- come to class fully prepared (view instructional videos and presentation slides, do the assigned readings and participate in group discussion forum before coming to class)
- work on assigned homework problems with your group and hand them in when due
- work on online quizzes and submit them when due
- participate in laboratory assignments and work with your group to perform analysis and write lab or project reports
- evaluate each other anonymously in order to ensure that proper credit is given to all members of the group
- introduce yourselves to the rest of the class the first day you meet in a lab setting
- participate in ALL exams; notify the professor BEFORE missing any exams, or get a ZERO on the exam

The instructor will:

- introduce himself and the TA team to the students using HuskyCT and in person the first day in class

- provide instructional videos, presentation slides and worked out example problems
- assign challenging and pertinent homework problems and lab exercises
- oversee homework and lab report grading / critically and fairly grade exams
- be available to answer student's questions inside and outside class
- conduct online Webex meetings to answer questions and solve example problems
- provide feedback on student's performance in a timely fashion, by assigning numerical grades via HuskyCT and a narrative indicating how is the student progressing overall on a per topical unit basis
- conduct extra review sessions for students that are facing challenges in the course

Inclusion Statement:

Professor Bagtzoglou is a key member of the INCLUDE program team, a NSF-funded neurodiversity initiative that aspires to create an inclusive learning environment in which *all* students can thrive. Emphasis is given to providing a strengths-based approach to education that encourages students to identify, develop, and leverage their unique abilities to address complex engineering problems. This course was designed to address the diverse thinking and learning styles that neurodiverse students possess. Several pedagogical innovations will be implemented in this course including, but not limited to peer-learning, alternative examination modalities, project-based learning, etc.

Accessibility Statement:

The University of Connecticut is committed to protecting the rights of individuals with disabilities and assuring that the learning environment is accessible. If you anticipate or experience physical or academic barriers based on disability or pregnancy, please let me know immediately so that we can discuss options. Students who require accommodations should contact the Center for Students with Disabilities, Wilbur Cross Building Room 204, (860) 486-2020 or http://csd.uconn.edu/.

Software/Technical Requirements (with Accessibility and Privacy Information):

The software/technical requirements for this course include:

- HuskyCT/Blackboard (HuskyCT/ Blackboard Accessibility Statement, HuskyCT/ Blackboard Privacy Policy)
- Adobe Acrobat Reader (Adobe Reader Accessibility Statement, Adobe Reader Privacy Policy)
- Google Apps (Google Apps Accessibility, Google for Education Privacy Policy)
- Microsoft Office (free to UConn students through uconn.onthehub.com) (Microsoft Accessibility Statement, Microsoft Privacy Statement)
- Dedicated access to high-speed internet with a minimum speed of 1.5 Mbps (4 Mbps or higher is recommended)
- WebCam
- Bentley Water CAD and Water Gems (free to students taking the course).

For information on managing your privacy at the University of Connecticut, visit the University's Privacy page.

NOTE: This course has NOT been designed for use with mobile devices.

Minimum Technical Skills:

To be successful in this course, you will need the following technical skills:

- Meet all prerequisite requirements
- Use electronic mail with attachments.
- Save files in commonly used word processing program formats.
- Copy and paste text, graphics or hyperlinks.

- Work within two or more browser windows simultaneously.
- Open and access PDF files.

University students are expected to demonstrate competency in Computer Technology. Explore the Computer Technology Competencies page for more information.

Course Evaluation:

Students will be provided an opportunity to evaluate instruction in this course using the University's standard procedures, which are administered by the Office of Institutional Research and Effectiveness (OIRE). Additional informal formative surveys will be administered within the course as an optional evaluation tool and as a feedback mechanism to the instructor.

Grading:

Three Exams:	75%,	Final Exam:	0 - 75%,
Homework:	5%,	Quizzes:	5%,
Lab/Project Reports:	15%		

Students are required to take **all quizzes, mid-term exams and the final exam as appropriate**.

Exam Policies:

- Exams will be take-home, so they are open book and notes
- However, you are strongly encouraged to develop **one sheet** (8.5x11 inch letter size or engineering paper) of your own notes for the mid-terms and **two sheets** for the Final exam as quick review sheet
- if done properly, one should have to refer only **t**o their "crib sheet" during the exam
- all work to be graded will be submitted on the exam papers, using backs of pages if necessary
- Students may elect to take some exams in alternative formats, such as an **oral exam**, or a comprehensive **design project**. Grading criteria and exemplars will be provided at a later time.

The exam schedule and the material each exam covers are as follows:

Exam 1: slides 1-129
Friday, February 19th

Exam 2: slides 130-233
Friday, April 2nd

Exam 3: slides 234-322
Wednesday, April 28th

Final Exam (if needed): slides 1-322
TBA

Homework Format:

- new page for each problem (or reasonable spacing between problem solutions)
- name on each page
- scan or take good quality picture of the HW and submit **via HuskyCT** as **single file (PDF or image)**

Homework is assigned **on HuskyCT** and will be **due in 3 batches before the exams**. Some of these problems may be solved in class and will be excluded from submission. No late homework will be accepted. Homework will be graded on the following basis: 0 for problem not attempted, 1 for problem attempted, 2 for problem attempted and correctly solved. You are **encouraged** to work with your team for HWs and learn from each other.

The HW problems are due as follows:

Batch 1 (due on **February 17th 5pm**): HW 1, 2, 3, 4
Batch 2 (due on **March 31st 5pm**): HW 5, 6, 7, 8
Batch 3 (due on **April 26th 5pm**): HW 9, 10

Quizzes:

An online Quiz will be given after each Chapter. Please refer to the tentative schedule at the end of this document as well as your weekly activities on HuskyCT to see if you have an online Quiz to complete that week.

Quizzes will guide your learning and keep you at an appropriate pace. The Quizzes are due as follows:

Quiz 1 (due on **January 29th 5pm**)
Quiz 2 (due on **February 5th 5pm**)
Quiz 3 (due on **February 19th 5pm**)
Quiz 4 (due on **February 26th 5pm**)
Quiz 5 (due on **March 5th 5pm**)
Quiz 6 (due on **March 19th 5pm**)
Quiz 7 (due on **March 26th 5pm**)
Quiz 8 (due on **April 23rd 5pm**)

Labs and Projects:

This year the labs and recitations will be made available via video and live streaming. Laboratory instruction, taking place approximately one afternoon every week, consists of discussion and experimental sessions. The discussion/recitation sessions involve solution of typical homework-like and design problems with the teaching assistants (TAs), and/or Professor Bagtzoglou. More important than that, however, this session provides the students with an opportunity to collectively engage in a fruitful discussion and question-answer session where exciting new and helpful ideas are exchanged.

The experimental session involves experimentation, computational work, and report writing. The members of each laboratory group are required to have reviewed thoroughly the laboratory manual pages pertaining to the experiment under question prior to their lab session. This will allow last minute organization and planning for an efficient lab session. The TA, lab supervisor, and lab instructor will be there to assist but **not** to conduct the experiment for the members of the group.

Students will form groups of 3-5 students each. Each experiment will be performed under the direction of a group leader who is elected by the members of the group (or on a rotating basis) and who will be responsible for:

- obtaining necessary and correct experimental readings
- assignment of specific duties
- general conduct of his/her group during lab sessions
- the well-being and cleaning of all instruments and apparatus used
- collection of complete data set for the group

Lab and Project reports are group reports, which depend on a team effort. You will be grading each other's participation and contribution towards the final product. Submission of the confidential group evaluation (included in the lab manual packet for all assignments) from each group member is mandatory. Each group leader must collect, in a manner that ensures confidentiality, his/her group members' evaluation and turn it in together with the corresponding report. Reports **will not be graded** without the accompanying group evaluation forms.

All lab & project reports **must** be typed, with all graphics produced using computer software and should be professionally looking. The reports will be due a week after the completion of the corresponding laboratory session. Reports are to be submitted **via HuskyCT portals**.

Final Grade Scale:

Grade Scale							
A	= 93 – 100%	**A-**	= 89 – 92%	**B+**	= 86 – 89%	**B**	= 82 – 86%
B-	= 79 – 82%	**C+**	= 76 – 79%	**C**	= 72 – 76%	**C-**	= 69 – 72%
D+	= 66 – 69%	**D**	= 62 – 66%	**D-**	= 59 – 62%	**F**	= 0 – 59%

This grade scale is guaranteed. The instructor reserves the right to bump students **up** to the next-higher grade when deemed appropriate (as determined by the instructor). PLEASE NOTE: There will be no extra assignments to improve students' perceived grade deficiencies.

The instructor will make every effort to provide feedback and grades within a week from the exam or lab report submission. To keep track of your performance in the course, refer to My Grades in HuskyCT.

Code of Conduct and Collaboration Policy:

Students who come to the class must respect other students' right to learn. No distracting behavior will be tolerated. Students are encouraged to discuss homework assignments in the interest of gaining better understanding of the material. However, direct copying is discouraged and may result in point deductions for all involved parties. Students are expected to collaborate with their group members to complete lab and project assignments; they will evaluate each other anonymously in order to ensure that proper credit is given to all members of the group. Collaborating on exams will result in a ZERO exam grade for all parties involved.

Detailed Learning Objectives

Unit 1: Fundamentals, Statics, and Idealized Fluid Motion

Chapter 1. Fluid Properties.

At the end of this topic, you will be able to:

- Understand what a fluid is and how to distinguish fluids from solids.
- Learn about dimensions and primary unit systems. Perform unit conversions
- Identify and calculate key fluid properties. Look up fluid properties from tables in the text.
- Learn about and understand the property of viscosity. Define and apply Newton's law of viscosity.
- Learn about and be able to use the concepts of compressibility, vapor pressure, cavitation, surface tension and capillary rise.

Chapter 2. Fluid Statics.

After successful completion of this topic, you will be able to:

- Understand how pressure is generated in fluids at rest. Define pressure for incompressible fluids.
- Understand and apply the "manometer rule" to measure differences in pressure. Learn about pressure measuring devices.
- Calculate the magnitude and direction of hydrostatic forces on planar surfaces of various shapes
- Calculate the magnitude and direction of hydrostatic forces on curved surfaces

- Calculate the buoyant force and determine the stability of floating and submerged objects.

Chapter 3. Idealized Fluid Motion.

At the end of this topical section you will be able to:
- Understand what causes fluids to move.
- Understand and apply Bernoulli's equation for flow without losses along a streamline
- Compute the static, dynamic, and total (stagnation) pressure in a moving fluid at a point using Bernoulli's equation. Understand the principle behind a pitot tube and solve relevant problems
- Use Bernoulli's equation to solve problems involving free jets and confined flows
- Learn and apply the methods for measuring fluid flow based on the Bernoulli's equation (orifice, nozzle, venturi meters).
- Learn about, compute and draw the hydraulic grade line (HGL) and energy line (EGL).

1st Mid-Term Exam (Chapters 1, 2 and 3; slides 1-129) – Friday, February 19

Unit 2: Fluid Dynamics and Pipe Flow

Chapter 4. Fluid Kinematics.

When you finish this topic, you will be able to:
- Distinguish between the Lagrangian and Eulerian flow descriptions.
- Learn about, distinguish and draw streamlines, streaklines and pathlines.
- Categorize flows as steady or unsteady
- State Reynolds Transport Theorem for flow through a control volume and apply to flow situations.

Chapter 5. Finite Control Volume Analysis.

After successful completion of this topic, you will be able to:
- Understand and apply the conservation of mass (continuity) equation
- Understand and apply the conservation of linear momentum equation. Analyze and solve problems combining the continuity and momentum equations
- Understand and apply the conservation of energy equation.
- Learn about pumps/turbines and perform relevant calculations in pipe systems using the energy equation. Understand what cavitation is and how we avoid it.

Chapter 6. Differential Analysis of Fluid Flow.

After successful completion of this topic, you will be able to:
- Understand the Navier-Stokes equations: Steady laminar flow
- Apply the Navier-Stokes equations to various flow problems in Cartesian and cylindrical coordinates
- Solve flow problems in parallel plates (Couette flow)
- Solve flow problems in tubes (Poiseuille flow)

Chapter 8. Viscous Flow in Pipes.

At the end of this topic, you will be able to:
- Understand velocity profiles for laminar and turbulent flow in circular pipes

- Identify entrance regions and fully-developed pipe flow
- Use the Darcy-Weisbach equation for calculating head losses in pipes. Use the Moody diagram to obtain the friction factor f for a given flow. Identify major and calculate major and minor head losses
- Solve for head losses in laminar and turbulent pipe flow
- Solve for discharge or pipe diameter in turbulent flow problems.

2nd Mid-Term Exam (Chapters 4, 5, 6 and 8; slides 130-233) – Friday, April 2

Chapter 8.5.2. Multiple Pipe Systems.

At the end of this topic, you will be able to:
- Analyze and solve three reservoir problems
- Analyze and solve multiple pipe problems (in series or parallel)
- Understand and apply the Hardy Cross method to simple pipe networks with/without reservoirs

Unit 3: Open Channel Flow

Chapter 10. Open Channel Flow.

In this topic area, you will learn to:
- Understand the characteristics of open channel flow. Categorize flows as subcritical or supercritical, gradually varying or rapidly varying
- Calculate the specific energy and draw a Specific Energy Diagram.
- Understand and categorize hydraulic jumps. Compute related values.
- Calculate the velocity and volumetric flow rate in open channels using Manning's Equation
- Explore flow over steps and through constrictions in open channels
- Understand the differences between types of weirs. Compute relevant parameter/values.

3rd Mid-Term Exam (Chapters 8 and 10; slides 234-322) – Wednesday, April 28

Final Exam (Comprehensive & if appropriate) – TBD

Midterm & Final Exams:

In an effort to create an inclusive/engaging environment for students with different learning styles, the 3 Midterm Exams (scheduled) and Final exam (Schedule TBA) will be made available in three alternative formats, such as **written exam**, an **oral exam**, or a comprehensive **design project**. Grading criteria and exemplars will be provided at a later time.

If you are satisfied with your midterm exam grades you do not have to take the Final Exam. If you wish to improve any, or all your grades you can take 1, 2, or all 3 parts of the final exam. Therefore, the final exam may count for 0, 25, 50, or 75% of your grade. An explicit declaration will be required by each student by the last day of classes on which (if any) parts of the final you will be taking. If no declaration is submitted it will be assumed that you are satisfied with your midterm grades and are NOT taking the final exam.

Students are required to be available for their exams during the stated time. If you think that your situation warrants permission to reschedule, please give the professor plenty of notice and, if necessary, contact the Office of Student Services and Advocacy with any questions. Thank you in advance for your cooperation.

ENVE 3120: Tentative Course Schedule/Calendar

Week	Dates	Topic	Chapter
Week 1	January 18 - 22	Introduction / Fluid Properties ***No Laboratory***	Chapter 1
Week 2	January 25 - 29	Pressure / Manometry / Hydrostatics **LAB #1: Viscosity (CAST 114)** ***Quiz 1 (Friday Jan 29)***	Chapter 2
Week 3	February 1 - 5	Hydrostatics / Buoyancy / Stability ***No Laboratory; T/Th Recitations*** ***Quiz 2 (Friday Feb 5)***	Chapter 2
Week 4	February 8 - 12	Bernoulli Equation ***No Laboratory; T/Th Recitations***	Chapter 3
Week 5	February 15 - 19	Flow Measurements / EGL and HGL ***No Laboratory; T/Th Reviews*** ***Quiz 3 (Thursday Feb 18); HW Batch 1 (Wednesday Feb 17)*** **EXAM 1 (Chapters 1, 2, 3); Friday, Feb 19**	Chapter 3
Week 6	February 22 - 26	Fluid Kinematics / Conservation of Mass **LAB #2: Flow Measurements (CAST 114)** ***Quiz 4 (Friday Feb 26)***	Chapters 4, 5
Week 7	March 1 - 5	Conservation of Momentum and Energy ***No Laboratory; T/Th Recitations*** ***Quiz 5 (Friday Mar 5)***	Chapter 5
Week 8	March 8 - 12	Viscous Flow in Pipes **LAB #3: Impact of Jet (CAST 114)**	Chapter 8
Week 9	March 15 - 19	Multiple Pipe Systems ***T/Th Recitations*** **LAB #4 3-Reservoir Problem Analysis (CAST 117)** ***Quiz 6 (Friday Mar 19)***	Chapter 8
Week 10	March 22 - 26	Multiple Pipe Systems / Navier-Stokes Equations **LAB #5 Hardy-Cross Analysis (CAST 117)** ***Quiz 7 (Friday Mar 26)***	Chapters 8, 6
Week 11	March 29 - April 2	Open Channel Flow ***No Laboratory; T/Th Reviews*** ***HW Batch 2 (Wednesday Mar 31)*** **EXAM 2 (Chapters 4, 5, 6, 8); Friday, Apr 2**	Chapter 10
Week 12	April 5 - 9	Open Channel Flow / Hydraulic Jump & Specific Energy ***No Laboratory; T/Th Recitations***	Chapter 10
	April 12 - 16	**SPRING BREAK**	
Week 13	April 19 - 23	Open Channel Flow / Manning's Eqn & Steps & Weirs **LAB #6: Hydraulic Jump & Specific Energy (CAST 114)** ***T/Th Recitations & Sunday Review*** ***Quiz 8 (Friday Apr 23)***	Chapter 10
Week 14	April 26 - 28	***HW Batch 3 (Monday Apr 26)*** **EXAM 3 (Chapter 8, 10)** **Wednesday, Apr 28**	Chapter 10
Reading Days	April 29 – May 2	**Optional Final Design Project** ***T/Th Reviews***	