Mechanical & Materials Engineering
Engineering Bwuilding, Suite 400
www.pdx.edu/mme
503-725-4290

Course Number	ME 322
Title	Applied Fluid Mechanics
Credits	4
Required or Elective	Required
Prerequisite(s)	ME 320, ME 321
Days/Time	Tuesday/Thursday 10-11:50

Instructor	Raúl Bayoán Cal
Email	rcal@pdx.edu
Office Number	402N
Office Hours	Friday 9-10:30

Teaching Assistant	Sarah Smith
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Office Hours	Monday/Wednesday 13-14:30

Required Text or Other Materials: Fundamentals of Fluid Mechanics, 8th Edition - Gerhard, Gerhart and Hochstein

Catalog Course Description: In ME 322, fundamentals established in the first course of fluids mechanics to flow systems encountered in engineering design are applied. Topics covered include viscous flow in pipes, external flow (boundary layers), compressible flow, and turbomachines (pumps) as well as the thermodynamics of gas mixtures, with special emphasis psychrometrics and air-conditioning processes.

Course Learning Objectives

No.	Course Outcomes: Students must demonstrate the ability to:	ABET Program Outcomes*
1	Describe velocity field in vectorial form, derive conservation laws, and introduce stream functions.	A, E, K
2	Analyze internal viscous flows via characteristics of laminar and turbulent flows, Moody charts, metering and conservation laws.	A, E, K
3	Describe external flows by introducing Reynolds number, boundary layer, its derivation, length scales, drag/lift, viscous stress/pressure differentials, order of magnitude analysis, integral analysis.	A, E, K
4	Interpret and apply turbomachinery by pump concepts (internal/external), pump curves, NPSH, scaling laws, and selection of pumps.	A, E, K
5	Dominate compressible flows via classification of Mach numbers, isentropic efficiencies (stagnation properties), speed of sound, and compressible flows in relation to geometry.	A, E, K
6	Understand gas mixtures in relation to humidity, air content, mass/mole fractions. Describe properties of moist air & air conditioning processes as it pertains to humidity and psychrometric charts.	A, E, K

*****More information on ABET Program Outcomes can be found at:

https://www.pdx.edu/mme/program-outcomes

Topics Covered

No.	Topic
1	Overview of differential analysis of fluid motion. General characteristics, laminar and turbulent regimes, exact solution for laminar flow in round pipes.
2	Turbulent, viscous flow in pipes. Darcy-Weisbach equation, Moody Chart. Design procedure for viscous flow in a straight pipe.
3	Minor losses, noncircular ducts, applications.
4	Pipe systems, flow metering.
5	Flow over immersed bodies. Introduction to lift and drag. Flat plate boundary layer.
6	Momentum integral, transition to turbulence.
7	Turbulent boundary layers, separation.
8	Boundary layer stability, terminal velocity.
9	Introduction to turbomachines. Energy and angular momentum considerations. Centrifugal pumps.
10	Pump characteristics. NPSH, matching systems and pumps.
11	Pump characteristics. Turbines. Similarity laws. Axial flow and mixed flow pumps.
12	Ideal gas relationships. Mach number. Speed of sound.
13	Isentropic flow of ideal gases. Converging-diverging nozzle.
14	Non-isentropic flow. Adiabatic flow with friction in constant area ducts. Normal shocks.
15	Introduction to real gases. Mass and mole fractions. P-V-T behavior of ideal and real gases. Properties of real gas mixtures.
16	Gas-vapor and psychometrics. Dry and moist air. Specific and relative humidity. Dew point. Adiabatic saturation temperature. Wet-bulb temperature. Psychometric chart.
17	Fuels and combustion, theoretical and actual combustion processes, enthalpy of formation and combustion.

Course Requirements

Assignment	Points Assigned of % of Total Grade
Homework	15%
Midterm	40%
Final Exam	45%

Incompletes: A grade of "I" is granted by the instructor only with prior approval and consent. Criteria are outlined in the PSU Bulletin. Poor performance in the class is not a valid reason for granting an I (incomplete).

Program requirements: The ME Department requires that junior and senior engineering courses must be completed with a minimum grade of D-, and a student's cumulative PSU GPA must be 2.00 or higher to graduate from the BSME program.

Accommodated Testing: *All accommodated tests should be scheduled during the first week of term* through either the SHAC Testing Services or the CEE & MME (CEME) Testing Center. The CEME Testing Center requires all bookings to be requested at least 7 days prior to the exam date. The center may not be able to proctor your exam if notice is less than 7 days. CEME Testing Center requires a copy of your DRC accommodation letter to complete

your booking. All proctored exam dates and times must be approved by your instructor prior to booking.

SHAC Testing Services: Schedule through https://www.pdx.edu/shac/testing-services
CEME Testing Center: Email cemetesting@pdx.edu

Note: The CEME Testing Center will only proctor exams for students who have DRC accommodations and/or emergency situations (with instructor approval).

Course Schedule

No	Topic	Reading
W1	Overview of differential analysis of fluid motion. General characteristics, laminar and turbulent regimes, exact solution for laminar flow in round pipes.	6.1 — 6.3 8.1 — 8.2
W2	Turbulent, viscous flow in pipes. Darcy-Weisbach equation, Moody Chart. Design procedure for viscous flow in a straight pipe. Minor Losses, Noncircular ducts, Applications.	8.3 8.4
W3	Pipe systems, Flow metering. Flow over immersed bodies. Introduction to lift and drag. Flat plate boundary layer.	8.5-8.6 9.1-9.2
W4	Momentum integral, transition to turbulence. Turbulent boundary layers. Separation.	9.2 9.2
W5	Boundary layer stability, terminal velocity. **Midterm Exam** Introduction to turbomachines. Energy and angular momentum considerations. Centrifugal pumps.	9.3 February 13 12.1-12.4
W6	Pump characteristics. NPSH, matching systems and pumps Pump characteristics. Turbines. Similarity laws. Axial flow and mixed flow pumps	12.4 12.5 — 12.6
W7	Ideal gas relationships. Mach number. Speed of sound. Normal shocks. Isentropic flow of ideal gases. Converging-diverging nozzles.	11.1 — 11.4 11.5 – 7
W8	Non-isentropic flow. Adiabatic flow with friction in constant area ducts. Introduction to real gases. Mass and mole fractions. p-V-T behavior of ideal and real gases. Properties of real gas mixtures.	11.8 13.1 — 13.3 (Cengel & Boles (CB))
W9	Gas-Vapor and Psychrometrics. Dry and moist air. Specific and relative humidity. Dew point. Adiabatic saturation temperature. Wet-bulb temperature. Psychrometric chart.	14.1 — 14.5 (CB)
W10	Fuels and combustion, theoretical and actual combustion processes, enthalpy of formation & combustion	15.1 — 15.3 (CB)
W11	**Final Exam**	March 17 10:15-12:05

Other policies:
-There will be two tests during the term. All exams are mandatory. Discuss any potential conflicts *well before the exam dates*. **There will be no make-up exams**. Students are allowed to bring a calculator and a single sided sheet of notes for each exam.
-Problems sets will be assigned weekly and solutions will be posted a week after.
-Communication will be done via D2L for homework assignments and solutions.

Computer and E-mail Accounts

- If you haven't done so already, please go to the CADLab located in EB 325 to activate your engineering account. If you need help in using this account, please see the attendant or send an e-mail to support@cat.pdx.edu
- If you choose not to check your MCECS e-mail account regularly (yourname@pdx.edu) then please forward it to an e-mail account that you do check. Important information and announcements are delivered via this e-mail address.

Code of Conduct

The PSU Student Conduct Code prohibits all forms of academic cheating, fraud, and dishonesty. Further details can be found in the PSU Bulletin. Allegations of academic dishonesty may be addressed by the instructor, and/or may be referred to the Office of Student Affairs for action. Acts of academic dishonesty may result in a failing grade on the exam or assignment for which the dishonesty occurred, disciplinary probation, suspension or dismissal from the University. The students and the instructor will work together to establish optimal conditions for honorable academic work. Questions about academic honesty may be directed to the Office of Student Affairs: https://www.pdx.edu/dos/).

Classroom Rules and Behavior Expectations

The classroom is a professional space and professional conduct is expected. Please silence your cell phone and refrain from text messaging during class and exam times. Treat your fellow students and the instructor with respect and please use appropriate language at all times. Additional rules may be added at the instructor's discretion.

Ethics and Professionalism

As future professional engineers you should plan to take the FE Exam (see the Oregon State Board of Examiners for Engineering and Land Surveying at www.osbeels.org), and you should be familiar with the ASME Code of Ethics (https://www.asme.org/getmedia/9eb36017-fa98-477e-8a73-77b04b36d410/p157_ethics.aspx), which includes the following:

Engineers uphold and advance the integrity, honor and dignity of the engineering profession by:

1. *Using their knowledge and skill for the enhancement of human welfare;*
2. *Being honest and impartial, and serving with fidelity their clients (including their employers) and the public; and*
3. *Striving to increase the competence and prestige of the engineering profession.*

Campus Resources

As a PSU student, you have numerous resources at your disposal. Please take advantage of them while you are here. A small sample is listed below:

- MME Website: http://www.pdx.edu/mme
- Career Center: https://www.pdx.edu/careers/
- Center for Student Health & Counseling: https://www.pdx.edu/shac/aboutshac
- The Writing Center: https://www.pdx.edu/writing-center/
- PSU Disability Resource Center: https://www.pdx.edu/drc/
- The PSU Disability Resource Center is available to help students with academic accommodations. If you are a student who has need for test-taking, note-taking or other assistance, please visit the DRC and notify the instructor at the beginning of the term.

Student Groups and Professional Organizations

Participation in student and professional groups can be a valuable part of your education experience. Membership gives students opportunities to get to know fellow students better, meet and network with professionals, collaborate in solving real engineering problems, learn about internship or job possibilities, socialize and have fun. Consider becoming active with a student organization, such as the following:

- Viking Motorsports (VMS): https://www.pdx.edu/mme/viking-motorsports
- ASHRAE: https://www.pdx.edu/mme/ashrae

Most professional organizations have monthly meetings and encourage student participation by providing discounts for lunch and dinner meetings. These meetings provide opportunities to network with potential future employers, learn about scholarships, and increase your technical knowledge. Take a look at these organizations as a starting point:

- American Society of Mechanical Engineers (ASME): https://www.asme.org/
- Society of Women Engineers (SWE) Columbia River Section: http://www.swe-columbia-river.org

Library and Literature Research

With the advent of the Internet it is very tempting to think that all necessary resources for a term project will be available in full text after typing in a few words at Google.com. This is not the case. You will often need to go to the library, use real library search tools and access real books and articles contained in refereed/archival journals.

Be sure to make use of the library catalog accessed via the PSU library home page at http://library.pdx.edu/. Also available on the library home page are Full Text Electronic Journals and a list of on-line Databases. Databases to try are Engineering Village (http://www.ei.org/ev2/ev2.home) and Lexis-Nexis (http://www.lexisnexis.com/hottopics/lnacademic/?) Note that access to these databases is free for PSU students, but you must be using a computer on campus or via a dial-in service.

Access and Inclusion for Students with Disabilities

PSU values diversity and inclusion; we are committed to fostering mutual respect and full participation for all students. My goal is to create a learning environment that is equitable, useable, inclusive, and welcoming. If any aspects of instruction or course design result in barriers to your inclusion or learning, please notify me. The Disability Resource Center (DRC) provides reasonable accommodations for students who encounter barriers in the learning environment.

If you have, or think you may have, a disability that may affect your work in this class and feel you need accommodations, contact the Disability Resource Center to schedule an appointment and initiate a conversation about reasonable accommodations. The DRC is located in 116 Smith Memorial Student Union, 503-725-4150, drc@pdx.edu.

If you already have accommodations, please contact me to make sure that I have received a faculty notification letter and discuss your accommodations. Students who need accommodations for tests and quizzes are expected to schedule their tests to overlap with the time the class is taking the test. Please be aware that the accessible tables or chairs in the room should remain available for students who find that standard classroom seating is not useable.

For information about emergency preparedness, please go to the Fire and Life Safety webpage: https://www.pdx.edu/environmental-health-safety/fire-and-life-safety

Title IX Reporting Obligations
Portland State is committed to providing an environment free of all forms of prohibited discrimination and sexual harassment (sexual assault, domestic and dating violence, and gender or sex-based harassment and stalking). If you have experienced any form of gender or sex-based discrimination or sexual harassment, know that help and support are available. PSU has staff members trained to support survivors in navigating campus life, accessing health and counseling services, providing academic and on-housing accommodations, helping with legal protective orders, and more. Information about PSU's support services on campus, including confidential services and reporting options, can be found on PSU's Sexual Misconduct Prevention and Response website at: https://www.pdx.edu/sexual-assault/ or you may call a confidential IPV Advocate at 503-725-5672. You may report any incident of discrimination or discriminatory harassment, including sexual harassment, to either the Office of Equity and Compliance or the Office of the Dean of Student Life.

Please be aware that all PSU faculty members and instructors are required to report information of an incident that may constitute prohibited discrimination, including sexual harassment and sexual violence. This means that if you tell me about a situation of sexual harassment or sexual violence that may have violated university policy or student code of conduct, I have to share the information with my supervisor, the University's Title IX Coordinator or the Office of the Dean of Student Life. For more information about Title IX please complete the required student module Creating a Safe Campus in your D2L.

Campus Safety
The University considers student safety paramount. The Campus Public Safety Office is open 24 hours a day to assist with personal safety, crime prevention and security escort services. Call 503-725-4407 for more information.

For Campus Emergencies call 503-725-4404