**ME 320: Fluid Mechanics Fall 2019**

Portland State University, Maseeh College of Engineering and Computer Science

**Course Objectives**

To provide mechanical engineering students with the basic knowledge of fluid properties, fluid statics and fluid dynamics through differential analysis and conservation laws.

**Instructor**

Derek Tretheway

Associate Professor

Department of Mechanical and Materials Engineering

EB 402H

Phone: 725-8760

Email: [tretdc@pdx.edu](mailto:tretdc@pdx.edu)

Website: <file://unix.cecs.pdx.edu/common/public_html/Classes/classes.html>

Office hours: Tuesday 11am-12pm and by appointment

(note, at any time, if my office door is open, I may be able to answer questions. If I don’t have time at that moment, I will arrange a time to meet with you.)

**Teaching Assistants**

Grader:

Laboratory: Suhyun Lee, Jesse Goodman

**Prerequisites:** EAS 215 (Dynamics), Math 256 (Applied Differential Equations)

**Textbooks:**

Munson, Okiishi, Huebsch, and Rothmeyer, “Fundamentals of Fluid Mechanics” 7th edition, John Wiley and Sons ISBN#978-1-11811613-5.

or any newer or older editions

Lab Manual for ME 320, Mechanical and Materials Engineering Department, Portland State University, Fall 2008. Manual can be downloaded from class website.

**ME 320L:** Laboratory exercises are meant to demonstrate and reinforce concepts discussed in lecture. Attendance is required for each laboratory exercise. Lab reports and other assignments are due the following week unless otherwise noted by the instructor. The scheduled laboratory sections are

11849 Thursday 2-4:30pm

11850 Friday 8-10:30am

11851 Friday 11am-1:30pm

11852 Friday 3-5:30pm

Tentative Laboratory Exercise Schedule

Week 1 Orientation and Tank filling (worksheet)

Week 2 Viscometer A/B (report due week 10)

Week 3 Submerged Surface (results/discussion)

Week 4 Bernoulli Equation, (methods report and summary/conclusion)

Week 5 Tank Draining (worksheet)

Week 6 Viscometer B/A (report due week 10)

Week 7 Impact of a Jet (Introduction and summary/conclusion)

Week 8 Sudden Expansion of a Jet (worksheet)

Week 9 No laboratory

Week 10 No laboratory

**Policies**

There will be two, no longer than thirty minute in-class quizzes. Exams 1 and 2 will last one class period. The final exam will be comprehensive. All quizzes and exams are mandatory. Discuss any potential conflicts *well before the exam dates*. Quiz dates TBA in prior lecture. **There will be no make-up quizzes or exams**.

Students are expected to turn in laboratory assignments and homework problems that are substantially the result of their own work. Study groups, discussion of assignments among students, collective brainstorming for solutions, and sharing of advice are encouraged. Copying of assignments, computer files, graphs, or other means of duplicating material that is turned in for grading is *expressly* forbidden.

If you have a disability, are registered with the Disability Resource Center, and are in need of academic accommodations, please notify me (D. Tretheway) immediately to arrange needed supports. If you are unregistered or need information about disabilities, please contact the Disability Resource Center on campus at 725-4150.

Cumulative grades will be based on the following weights

Homework 10% assigned/collected on Wednesday

Quizzes 10%

Laboratory 15%

Exam 1 and 2 25% and 20%

Final Exam 20% (Wed. Dec. 11, 10:15am)

**Course Learning Objectives**

At the end of the term, students taking ME320 should be able to demonstrate the ability to:

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| --- | --- |
|  | Program Outcomes\* |
| 1. Analyze fluid problems in SI and English units and properly convert between SI and English Engineering units. 2. Identify basic fluid properties and obtain numerical values for these properties from reference tables. 3. Apply Newton’s Law of viscosity to analyze simple shear flows of liquids and gases. Given an analytical expression for the velocity profile, compute the shear stress on a solid-fluid interface. 4. Use the hydrostatic pressure equation to predict pressure variations in fluid columns (e.g. manometers), and predict forces and moments on submerged surfaces. 5. Compute fluid acceleration at a point given a mathematical formula for the velocity field. 6. Correctly apply the Bernoulli equation to flow analysis and to distinguish cases where the energy equation must be used instead of the Bernoulli equation. 7. Apply control volume analysis to determine forces, flow rates and flow property changes in free jets and confined flows. 8. Give appropriate definitions of the Reynolds number, Froude number, and Mach number, and to compute values of these dimensionless numbers given appropriate length and velocity scales for a flow situation. 9. Convert dimensional data to dimensionless form, and to develop dimensionless groups from a list of related dimensional variables. 10. Apply differential analysis to derive velocity fields, fluid stresses, and flows rates from the Navier-Stokes equations. 11. Perform simple measurements and convert the raw data to quantities of engineering significance. 12. Estimate uncertainties in basic measurements and to estimate their impact on engineering data obtained from laboratory measurements. 13. Document laboratory observations with brief technical reports. | a,k  b,d  a,e  b,d,e  a,e  b,d,e,k  b,e,d  e  b  a, e  b,d,k  a,b  g, k |
| \*Program Outcomes are Learning Outcomes for the entire BSME Program. Refer to the standard ABET learning outcomes listed at http://www.me.pdx.edu/programs/undergrad/objectives.php. | |

**ME 320 Course Outline** (tentative\*)

Class Date Subject Reading

1 9/30 Overview, problem solving, units, fluid properties 1.1-1.3

2 10/2 Introduction to fluid statics 2.1-2.5

3 10/7 Fluid statics: manometers, hydrostatic forces 2.6-2.9

4 10/9 Fluid statics: curved surfaces, buoyancy. Data Presentation 2.10-2.12

5 10/14 Rigid body rotation, elementary fluid kinematics 4.1-.2, 3.1-3.4

6 10/16 Bernoulli equation derivation and applications 3.5-3.8

7 10/21 Technical Writing, Reynold Transport Theorem 4.3-4.4

8 10/23 Reynolds Transport Theorem cont.

9 10/28 Conservation of mass 5.1

10 10/30 Conservation of Momentum 5.2

11 11/4 Conservation of Energry 5.3

12 11/6 Exam #1

13 11/11 *No class, Veterans Day*

14 11/13 Energy equation applications, More technical writing?

15 11/18 Differential Analysis, Derivation of the governing eqns. 6.1-6.3

16 11/20 Solns to the differential governing equations

17 11/25 Simplifying the governing eqns by dimensional analysis 7.10, 6.4-6.9

18 11/27 Dimensional Analysis: dimensionless grps, Buckingham Pi 7.1-7.8

19 12/2 Solutions to the Navier Stokes Eqn.

20 12/4 Exam #2

\* note: This is a tentative course outline. Lecture topics and reading assignments may vary depending on lecture progress. The exam dates may change! The date will be confirmed by an announcement in lecture. Do not claim that you missed the midterm exam because it did not occur at the date implied by this outline!

ME 320 Homework Format:

1. Name and date in upper right hand corner on every page. Please staple pages together.
2. Homework assignment number on upper left.
3. Please write legibly in dark pencil or pen. Print (no cursive) with decent size.
4. Identify each problem clearly.
5. Please box the results using proper significant digits and show the units.
6. For solving problems follow the format in the textbook.
7. State the problem (what’s given).
8. State the required results.
9. List the assumptions employed – only state the assumptions that can potentially cause the answer to differ significantly from the real answer.
10. In the analysis, clearly identify what you are doing. Do not string together formulas without connecting them properly with explanation text. Justify the use of formulas.
11. Add comments to results when appropriate. Do the results appear reasonable? Are the assumptions reasonable? Is there additional relevant material not reflected in the analysis?

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](mailto:support@cat.pdx.edu)
* If you choose not to check your MCECS e-mail account regularly ([yourname@pdx.edu](mailto: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](http://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](mailto: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**.