MREN 241 – FLUID MECHANICS & FLUID POWER

Course Syllabus – Fall 2024

This is your course syllabus. Please download the file and keep it for future reference.

Land Acknowledgement

Queen's University is situated on traditional Anishinaabe and Haudenosaunee Territory.
See: http://www.queensu.ca/encyclopedia/t/traditional-territories

Inclusivity Statement

Queen's students, faculty, and staff come from every imaginable background – small towns and suburbs, urban high rises, Indigenous communities, and from more than 100 countries around the world. You belong here: https://www.queensu.ca/inclusive/.

TEACHING TEAM

Course Instructor

Francesco Ambrogi, PhD
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Teaching Assistant

Please visit the OnQ page to know more about the teaching team.

MREN 241 FLUID MECH AND FLUID PWR (F 3-0.25-0.5 3.75)

Course Description

An introductory course in fluid mechanics with application to fluid power systems. Topics include properties of fluids, fluids at rest, dimensional analysis, the laws of conservation of mass and momentum, Bernoulli's equation for incompressible flow and the energy equation, flow measurements, elementary pipe flow problems including losses due to pumps, valves etc. Laboratories will introduce students to pressure and flow measuring devices, pneumatic and hydraulic components and actuators, and circuit analysis of fluid power systems. Upon completion of the course students will be able to:

1. Define a fluid based on its thermodynamic properties.
2. Distinguish between a Eulerian and a Lagrangian approach to fluid mechanics.
3. Compute pressure distribution and forces on submerged bodies in a static fluid.
4. Handle flow problems in an integral framework using the conservation of mass and momentum.
5. Understand the relevance of dimensional analysis and non-dimensional groups.
6. Use Bernoulli's equation to solve simple flow problems involving Pitot probes and Bernoulli's obstacles.
7. Solve pipe flow problems and piping systems involving pumps, minor and major losses.

Prerequisites: APSC 111 (Physics)

(0/0/0/42/0) (Mathematics/Natural Sciences/Complementary Studies/Engineering Science/Engineering Design)

Pre-Requisite Knowledge

This course is a requirement for all second year Mechanical and Materials Engineering students at Queen's University. This course is designed for learners who have successfully completed the first-year program in engineering and a course in differential equations. Learners must have completed the prerequisite course (APSC 111 - Physics) or a similar course.

Course Learning Outcomes (CLO)

By the end of this course, students should be able to:

CLO	Description	Indicator
CLO 1	Define fluid properties and basic concepts of fluid flow and scaling	KB-ES-Fluid Mechanics and Hydraulics
CLO 2	Determine forces applied by fluids at rest	KB-ES-Fluid Mechanics and Hydraulics
CLO 3	Apply energy and momentum balance to analyze fluid power systems using integral equations and balances	KB-ES-Fluid Mechanics and Hydraulics
CLO 4	Solve scaling problems using dimensionless groups.	KB-ES-Fluid Mechanics and Hydraulics

CLO	DESCRIPTION	INDICATOR
CLO 5	Analyze flow through piping systems with friction, minor losses, valves, pumps, and cylinders	KB-ES-Fluid Mechanics and Hydraulics
CLO 6	Identify and assemble components necessary for the design of fluid power systems	KB-ES-Fluid Mechanics and Hydraulics
CLO 7	Solve flow system performance problems using Bernoulli with friction, minor losses, pump, and fan performance curves.	KB-ES-Fluid Mechanics and Hydraulics
CLO 8	Conduct experiments to measure and analyze fluid and fluid power systems	IN-Analyze

COURSE EVALUATION

ASSESSMENT WEIGHTING

Assessment Tool	Due Date (Before 23:59 ET)	Weight	Alignment with CLOs
Assignments (10)	Assigned online via OnQ	10%	1, 2, 3, 4, 5, 6, 7
In-class Tests (3)	** Best 2 out of 3 **	40%	1, 2, 3, 4, 5, 6, 7
Labs (2)	Lab I (week 5 to 8) Lab II (week 9 to 12)	10%	8
Final Exam (Proctored)	**The student MUST pass the final to pass the course.**	40%	1, 2, 3, 4, 5, 6, 7
		100%	

ASSESSMENT DESCRIPTIONS

Assignments

There are 10 assignments in this course (each worth 1%). Each assignment will require students to solve a set of problems regarding topics encountered in class. All the assignments will be posted online via OnQ. A reminder will also be sent via OnQ.

In-Class Tests

There are 3 in-class tests throughout the course. **Only the 2 best marks will contribute to the final grade.** Tests and the final exam will be closed book. You will be permitted a calculator and a single letter sized one-sided handwritten reference sheet for each test and a double-sided sheet of the same format for the final exam. **Rules to follow while preparing the formula sheet will be given by the instructor and posted on OnQ.** Students are responsible for checking their solutions against posted solutions in order to hone their problem-solving skills needed for tests and final exam. All components of this course will receive

numerical percentage marks. The final grade you receive for the course will be derived by converting your numerical course average to a letter grade according to Queen's Official Grade Conversion Scale.

Labs

A pneumatics lab will measure the dynamic response of a pneumatic cylinder and attached mass to a sudden valve opening under various pressure conditions. Acceleration will be recorded and integrated to get velocity and position. Results will be compared to high-speed video captured by a phone, and to predictions based on simple pressure forces. Later assignments will look at system losses to explain the differences. **This lab will be scheduled within weeks 5-8.**

A pipe flow lab will measure velocity profiles and pressure changes in a piping system and compare the results to predictions based on Moody friction and minor loss coefficients. **This lab will be scheduled within weeks 9-12.**

Labs will be carried out in teams and a lab report (to be submitted by each student in the team) will be due at the end of each experience.

Final Exam

The final exam is 3 hours long and is closed book. Students must work individually on the exam and must not cooperate in any way with anyone on the completion of the exam. **Students MUST PASS the final exam (>51%) to pass the course**. Students must write their exam on the day and time scheduled by the University. You should not schedule vacations, travel, etc. during the exam period. The Term and Session Dates will indicate the final exam period session dates in each term.

GRADING

All assessments in this course will receive numerical percentage marks. The final grade you receive for the course will be derived by converting your numerical course average to a letter grade according to the established Grade Point Index.

Feedback on Assessments

The teaching team will provide feedback on graded activities. You can expect feedback on your assessments within seven days of the due date.

Accessing Your Final Grade

Your final grades will show on SOLUS. Official transcripts showing final grades will be available on the Official Grade Release Date. Please note that in official transcripts, a mark of IN (incomplete) is considered a grade, and your transcript is released with this grade.

COURSE MATERIALS

Suggested Textbook

Fundamentals of Fluid Mechanics, Eight Edition, Munson et al. (Wiley)

In the campus bookstore a digital or hard copy of the book can be purchased.

In-class Notes

Students are strongly encouraged to follow the 3-hours/weekly lectures and to take notes.

Other Material

All other course material is accessible via OnQ. Attendance at lectures is strongly recommended as ONLY material covered in class will be included in the tests. The instructor will also post weekly readings (optional for the students) on Connect to help students familiarize with the material and be on track with the course content.

Required Calculator

A Casio 991 is required. **ONLY** this type of non-programmable, non-communicating calculator will be allowed during tests and exams. This calculator sells for around 25 USD at the Queen's Campus Bookstore, Staples and other popular suppliers of school and office supplies.

Suggested Time Commitment

Generally, we expect that students attend all lectures (3hrs/week), review material at home (1 hr/week), complete the weekly assignment problems (1-2 hrs/week - if an assignment takes much more than 1 hr you should be doing additional problems and coming to tutorials and office hours for additional help understanding, about another 2 hours a week). If you keep up your understanding week to week, then a few hours review should be enough to do well on the final exam. An average student will be able to do well in this course by spending about 6 hours a week, over the twelve-week term.

COURSE STRUCTURE AND ACTIVITIES

The course is taught in **ONE** section with the following structure:

Lectures:

- Mondays - 4:30 to 5:30pm (Walter Llight 205)
- Wednesdays - 3:30 to 4:30pm (Walter Light 205)
- Fridays - 2:30 to 3:30pm (walter Light 205)

Tutorials:

- Fridays 11:30 to 12:30 (Walter Light 205)

WEEKLY COURSE LEARNING OUTCOMES

Week	Learning Outcomes	Assessment
1	**Introduction** By the end of this week, learners will be able to: • Explain the continuum hypothesis and the dimensions and units used to quantify physical properties. • Identify thermodynamic properties of fluids including viscosity and surface tension.	**[CLO1]** **Assignment 1, Test 1, Final exam**
2	**Pressure** By the end of this week, learners will be able to: • Discuss flow patterns used in fluid mechanics to visualize/describe various fluid flows. • Explain various forms of pressure used in fluid mechanics and solve the problems of manometry.	**[CLO2]** **Assignment 1, Test 1, Final exam**
3	**Pressure on plane and curved surfaces** By the end of this week, learners will be able to: • Determine the pressure on submerged plane surfaces. • Explain the basic laws that are used in fluid mechanics and the Reynolds transport theorem.	**[CLO2]** **Assignment 2, Test 1, Final exam**
4	**Balance of mass and linear momentum** By the end of this week, learners will be able to: • Explain the laws of conservation of mass and balance of linear momentum and their derivation using the Reynolds transport theorem.	**[CLO3]** **Assignement 3, Test 2, Final exam**
5	**Balance of linear momentum and the Bernoulli equation** By the end of this week, learners will be able to: • Use the Balance of linear momentum and the Bernoulli equation to solve related problems in fluid mechanics.	[CLO3] **Assignment 4, Test 2, Final exam**

Week	Learning Outcomes	Assessment
6	**Dimensional analysis** By the end of this week, learners will be able to: • Apply dimensional analysis to the problems of fluid mechanics. • Explain scaling techniques and similarity laws.	**[CLO4]** **Assignment 5, Test 2, Final exam**
7	**Pipe flow** By the end of this week, learners will be able to: • Identify the characteristics of various Reynolds number regimes in pope flows. • Explain the friction factor in internal flows.	**[CLO5]** **Assignment 6, Test 2, Final exam**
8	**Pipe flows ctd.** By the end of this week, learners will be able to: • Explain minor losses in a pipe flow and solve related problems. • Solve pipe flow problems regarding sizing of pipes and desired	**[CLO5]** **Assignment 7, Test 3, Final exam**
9	**Pumps** By the end of this week, learners will be able to: • Identify various types of pumps in fluid flow circuits and their properties. • Explain and use pump performance charts and similarity rules.	**[CLO5][CLO7]** **Assignment 8, Test 3, Final exam**
10	**Pumps ctd. and intro to fluid power** By the end of this week, learners will be able to: • Use pumps' performance charts and similarity rules to select suitable pumps for a piping system. • Identify the characteristics of fluid power systems and important parameters in such systems.	**[CLO6][CLO7]** **Assignment 9 , Test 3, Final exam**

Week	Learning Outcomes	Assessment
11	**Components of fluid power systems** By the end of this week, learners will be able to: • Identify various components and their symbols used in fluid power circuits. • Explain various types of hydraulic (and pneumatic) cylinders and analyze forces, velocity, flow rate, etc. in those components.	**[CLO6]** **Assignment 10, Final exam**
12	**Components of fluid power systems** By the end of this week, learners will be able to: • Explain various types of valves and orifices and analyze their effect on pressure and flow rate in a fluid power system. • Identify miscellaneous components in fluid power circuits and their significance. • Analyze simple fluid power systems in steady state operation.	**[CLO6]** **Final exam**

COURSE COMMUNICATION

QUESTIONS ABOUT COURSE MATERIAL

Questions or comments regarding the course material that can be of benefit to other students should be posted in the Q&A forum on the class website. The instructor, TAs, and students are encouraged to answer these questions directly in the discussion forum for the benefit of everyone in the course.

COURSE ANNOUNCEMENTS

The instructor will routinely post course news in the Announcements section on the main course homepage on OnQ. Please sign up to be automatically notified by email when the instructor posts new information in the Announcements section. Instructions on how to modify your notifications are found in the **Begin Here** section of the onQ course site.

OFFICE HOURS

In addition to interaction in the Q&A discussion forums, you will have the opportunity to interact with either a TA or the instructor through office hours. The instructor will provide a schedule of availability at the beginning of the term.

CONFIDENTIAL MATTERS

If you have a confidential matter you would like to discuss with your instructor, their contact details are on the first page of this document. Expect email replies within 48 hours.

ABSENCES (ACADEMIC CONSIDERATIONS)

For information on academic considerations due to extenuating circumstances, please review the information on the FEAS website. Note that unacceptable reasons include extra-curricular activities, travel plans, generally behind on schoolwork, etc. Do not schedule travel during midterms and final exams, as travel is not an acceptable reason for granting academic considerations.

Because there are 3 in-class tests where only the 2 best outcomes are selected for the final grade, there will be NO make-up exams in case students miss a test.

LATE POLICY

In the event of extenuating circumstances, you must follow the policies for requesting an academic consideration (as described above). In the absence of an approved consideration request, the normal late penalty will apply as described in the assignment or any course/departmental policies.

STANDARD QUEEN'S AND SMITH ENGINEERING POLICIES

NETIQUETTE

In this course, you may be expected to communicate with your peers and the teaching team through electronic communication. You are expected to use the utmost respect in your dealings with your colleagues or when participating in activities, discussions, and online communication.

Following is a list of netiquette guidelines. Please read them carefully and use them to guide your online communication in this course and beyond.

1. Make a personal commitment to learn about, understand, and support your peers.
2. Assume the best of others and expect the best of them.
3. Acknowledge the impact of oppression on the lives of other people and make sure your writing is respectful and inclusive.
4. Recognize and value the experiences, abilities, and knowledge each person brings.
5. Pay close attention to what your peers write before you respond. Think through and re-read your writings before you post or send them to others.
6. It's alright to disagree with ideas, but do not make personal attacks.
7. Be open to be challenged or confronted on your ideas and challenge others with the intent of facilitating growth. Do not demean or embarrass others.
8. Encourage others to develop and share their ideas.

Student Code of Conduct

Queen's University values maintaining an environment free of, and will not tolerate, harassment, discrimination, and reprisal. The Student Code of Conduct applies to all students at Queen's. It outlines the activities and behaviours that could be considered Non-Academic Misconduct (NAM). The Code also describes the NAM process and the sanctions that could be imposed on a student found responsible for a violation.
All students should be familiar with the Student code of conduct and related policies on sexual violence prevention and response and harassment and discrimination prevention and response.
https://www.queensu.ca/nonacademicmisconduct/policies

Copyright

Course materials created by the course instructor, including all slides, presentations, synchronous and asynchronous course recordings, handouts, tests, exams, and other similar course materials, are the intellectual property of the instructor. It is a departure from academic integrity to distribute, publicly post, sell or otherwise disseminate an instructor's course materials or to provide an instructor's course materials to anyone else for distribution, posting, sale or other means of dissemination, without the instructor's ***express consent***. A student who engages in such conduct may be subject to penalty for a departure from academic integrity and may also face adverse legal consequences for infringement of intellectual property rights and, with respect to recordings, potentially privacy violations of other students.

Academic Integrity

As an engineering student, you have made a decision to join us in the profession of engineering, a long-respected profession with high standards of behaviour. As future engineers, we expect you to behave with integrity at all times. Please note that Engineers have a duty to:

- Act at all times with devotion to the high ideals of personal honour and professional integrity.
- Give proper credit for engineering work

The standard of behaviour expected of professional engineers is explained in the Professional Engineers Ontario Code of Ethics. Information on policies concerning academic integrity is available in the Queen's University Code of Conduct, in the Senate Academic Integrity Policy Statement, on the Smith Engineering website, and from your instructor.

Departures from academic integrity include plagiarism, use of unauthorized materials or services, facilitation, forgery, falsification, unauthorized use of intellectual property, and collaboration, and are antithetical to the development of an academic community at Queen's. Given the seriousness of these matters, actions which contravene the regulation on academic integrity carry sanctions that can range from a warning or the loss of grades on an assignment to the failure of a course to a requirement to withdraw from the University.

In the case of online or remotely proctored exams, impersonating another student, copying from another student, making information available to another student about the exam questions or possible answers, posting materials to online services, communicating with another person during an exam or about an exam during the exam window, or accessing unauthorized materials, including internet sources and using unauthorized materials, including smart devices, are actions in contravention of academic integrity.

Generative Artificial Intelligence (AI) Tools, like ChatGPT

Using generative AI writing tools such as ChatGPT in your submitted work is prohibited in this class. This type of use constitutes a Departure from Academic Integrity.

Invalid Exams

An exam may be declared invalid in case of an interruption in an in-person examination; if the instructions in a remote or online exam were not followed; if the student uploads wrong materials; or if a situation arises where the integrity of the exam cannot be verified. If an exam is declared invalid, the student may be granted a re-write.

ACADEMIC AND STUDENT SUPPORT

Queen's has a robust set of supports available to you including the Library, Student Academic Success Services (Learning Strategies and Writing Centre), and Career Services. Learners are encouraged to visit the Smith Engineering Current Students web portal for information about various other policies such as academic advisors, registration, student exchanges, awards and scholarships, etc. Students are also encouraged to review the information that is available in the EngQ Hub, posted in onQ.

Absences (Academic Considerations) and Academic Accommodations

For academic accommodations and considerations please review the information on the Smith Engineering website.

Accommodations for Disabilities

Queen's University is committed to working with students with disabilities to remove barriers to their academic goals. Queen's Student Accessibility Services (QSAS), students with disabilities, instructors, and faculty staff work together to provide and implement academic accommodations designed to allow students with disabilities equitable access to all course material (including in-class as well as exams). If you are a student currently experiencing barriers to your academics due to disability related reasons, and you would like to understand whether academic accommodations could support the removal of those barriers, please visit the QSAS website (https://www.queensu.ca/studentwellness/accessibility-services) to learn more about academic accommodations. To start the registration process with QSAS, click the ***Access Ventus*** button found on the Ventus student portal: https://www.queensu.ca/studentwellness/accessibility-services/ventus

Ventus is an online portal that connects students, instructors, Queen's Student Accessibility Services, the Exam's Office, and other support services in the process to request, assess, and implement academic accommodations. To learn more about Ventus, visit A Visual Guide to Ventus for Students: https://www.queensu.ca/ventus-support/students/visual-guide-ventus-students

For questions or assistance with requesting Academic Consideration or Accommodation, contact the Smith Engineering Program Advisor (Accommodations and Considerations) at engineering.aac@queensu.ca

Every effort has been made to provide course materials that are accessible. For further information on accessibility compliance of the educational technologies used in this course, please consult the links below.

Educational Technology	Accessibility Compliance Information
onQ (Brightspace Learning Management System by D2L)	https://www.d2l.com/accessibility/standards/
MS-Teams	https://support.microsoft.com/en-us/office/accessibility-support-for-microsoft-teams-d12ee53f-d15f-445e-be8d-f0ba2c5ee68f
Zoom	https://zoom.us/accessibility

If you find any element of this course difficult to access, please discuss with your instructor how you can obtain an accommodation.

Religious Observance

Students in need of accommodation for religious observance are asked to speak to their professor within a week of receiving their syllabus. Note also that alternative assignments are considered a "reasonable accommodation" under the Ontario Human Rights Code. Students with questions about their rights and responsibilities regarding religious accommodation should contact the Chaplain Chaplain@queensu.ca.

OTHER HUMAN-RIGHTS BASED ACCESSIBILITY NEEDS

Students who have accessibility needs based on human-rights covered grounds, should inform their instructors within a week of receiving their syllabus. Student can also contact the contact the Smith Engineering Program Advisor (Accommodations and Considerations) at engineering.aac@queensu.ca for guidance.

TECHNICAL SUPPORT

Some basic comfort level with basic hardware and software skills are required for this course. If you require technical assistance, please contact Technical Support.

SUPPORTIVE PERSONAL COUNSELLING

If at any time you find yourself feeling overwhelmed, anxious, sad, lonely, or distressed, consider confidential personal counselling and wellness services offered by Smith Engineering and the Queen's student wellness services.