CHEE 223 – FLUID MECHANICS

Course Syllabus – Winter 2021

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

TEACHING TEAM

COURSE INSTRUCTOR

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Please check the course website for an up-to-date list of Teaching Assistants (TAs) and other course personnel.

COURSE INFORMATION

COURSE DESCRIPTION

Principles of momentum and energy transport are applied to the analysis of fluid systems commonly encountered in chemical engineering practice. This approach is via the macroscopic and differential balances of mass, momentum and energy. Topics include fluid statics; incompressible flow in closed conduits; flow and pressure measurement; transportation of fluids; laminar, turbulent and creeping flows; boundary layer effects; sizing of commercial components (piping, tubing, valves, pressure and flow meters and other fittings, as well as pumps) for fluid transport systems in industrial settings. (0/0/0/42/0)
Prerequisites: CHEE 221, MTHE 225

COURSE LEARNING OUTCOMES (CLO)

The objective of the course is to demonstrate the fundamentals of fluid mechanics and their applications in engineering. The course will teach the solution of fluid mechanics problems based on the use of differential and integral mass, momentum and energy balances.

Specific course learning outcomes include:

CLO	DESCRIPTION	INDICATOR
CLO 1	Calculate the pressure distribution in static fluids and the forces on submerged surfaces.	KB-NatSci
CLO 2	Formulate mass, momentum and energy balances using the control volume and differential analysis of fluid flow.	KB-TrPh(a) KB-Math(a)
CLO 3	Identify boundary conditions and solve differential equations describing one-dimensional fluid flow.	KB-TrPh(b) PA-Solve
CLO 4	Determine frictional losses, size pipes and calculate pump power requirements in laminar and turbulent flow for viscous flow in closed conduits.	KB-TrPh(c) KB-Proc(c)
CLO 5	Calculate the drag forces on submerged objects in laminar and turbulent flow.	KB-TrPh(c)
CLO 6	Use dimensional analysis to derive relationships among process or system variables.	PA-Formulate
CLO 7	Demonstrate an understanding of the technical aspects of pressure, flow and viscosity measurement and sizing of pumps and pipes.	CHEE-KB-FM-4 KB-Math(a) EC-Economics

This course assesses the following program indicators at a 2nd year level:

Knowledge base for engineering
KB-NatSci Interpret natural phenomena and relationships through the use of analytical and/or experimental techniques
KB-Math(a) Selects and applies appropriate mathematical tools to solve problems that arise from modeling a real-world problem
KB-Proc(c) Applies engineering principles to do engineering calculations and size various unit operations, including pumps, heat exchangers, separation processes, and reactors
KB-TrPh(a) Formulates and applies integral mass, momentum and energy balances to do engineering calculations
KB-TrPh(b) Formulates and applies differential mass, momentum and energy balances to do engineering calculations
KB-TrPh(c) Analyzes convective transport of fluids in closed conduits and external flows

Problem Analysis
PA-Formulate Develop appropriate frameworks for solving complex engineering problems
PA-Solve Implement solutions for complex engineering problems

Economics and Project Management
EC-Economics Apply economic considerations, such as capital, operating, societal and life cycle costs, to design processes

Relevance to the Program

The course is the first of the suite of courses known as "transport phenomena courses", which deal with the transport properties of matter. Concepts taught in this course are required for 3rd year courses (CHEE 330 – Heat and Mass Transfer, CHEE 331/332/333 – Design and scale-up of unit operations, CHEE 340-Biomedical engineering, CHEE 370 – Wastewater treatment processes) and 4th year courses (CHEE 412-Transport Phenomena in Chemical Engineering, CHEE 452 – Transport Phenomena in Physiological Systems, CHEE 470-Design of Manufacturing processes, CHEE 490-Polymer formulations and polymer technology). The course assumes working knowledge of 1st year mechanics and calculus.

Course Structure and Activities

The course will be delivered through synchronous and asynchronous activities.

Asynchronous: The lectures will be delivered as videos which will include an explanation of concepts, and solutions to problems on specific topics. The videos and resources covered will be equivalent to 3 lecture hours per week.

Synchronous: There will be 1 hour of tutorials per week (through MS Teams or Zoom). Tutorials will include interactive learning activities, including solving problem sets in small working groups, and interacting with TAs and the instructor. Lecture time hours will be allocated as tutorial or Q&A time.

Refer to Solus or OnQ for times and locations.

EXPECTATIONS FOR LECTURES/TUTORIALS

Lecture slides will be posted in advance on the CHEE 223 Learning Management System (LMS) site. Lectures will include information, examples, and problem solutions not contained in the posted slides. Students are expected to read associated sections and study worked examples provided in the textbook and through the course LMS.

Tutorial problems are posted on the course LMS. These are meant to be solved interactively: these problems are broken down to help students get through each step of a question. Solutions will be worked out during tutorial periods with the TAs each week. Maximum benefits from the interactive solutions can be gained only if students come prepared for the tutorial sessions by studying the questions in advance. Solutions will be worked out during tutorial periods. Abbreviated solutions may be posted online following each tutorial session for cases where a problem solution was not presented during tutorial.

In group assignments, each group member is expected to contribute fairly and equitably. In the event of serious deficiencies in the contributions (*e.g.* observed by instructor, through peer assessments, or through complaints from other group members and/or teaching assistants), the student will be issued a written warning, stating the expectations and timeline for remediation and compliance. The student may be assigned individual work to compensate for the lack of contribution. If the student does not comply within the specified time frame, a second written warning will be issued (with a copy to the Associate Head and Undergraduate Chair). Failure to comply will result in automatic expulsion from the group, and possibly a failing mark in the assignment and/or in the course. A peer evaluation form is available through the LMS. This form may be filled out by a group member at any time during the semester. The form must be submitted to the instructor, who will take appropriate action in response to this submission (response may include a request for each group member to fill out a peer evaluation, individual meetings, group meetings, and follow up action as described above).

COURSE MATERIALS

Recommended Textbook

- deNevers, N., "Fluid Mechanics for Chemical Engineers", 3rd Edition, 2004. *Please note that the full 2nd Edition of this textbook is also acceptable, although contents and numbering may be different for chapters, sections, and suggested problems.

Additional Textbooks (Optional)

- Munson, B.R., Young, D.F. and Okiishi, T.H., "Fundamentals of Fluid Mechanics", 3rd Edition, John Wiley and Sons, 1998 (or a more recent edition).
- Giles, R.V., Evett, J.B. and Liu, C., "Fluid Mechanics and Hydraulics", 4th Edition, Schaum's Outline Series of Theory and Problems, McGraw-Hill, 2014.
- White, F. M., "Fluid Mechanics", 8th edition, McGraw-Hill, 2016.

Other Material

- All course material is accessible through the course LMS.

Learning Support

- Instructor and TAs are available by appointment (through e-mail).
- Additional review and help sessions may be scheduled during the term.

COURSE EVALUATION

Deliverable	Week or Date	Weight%	CLOs
Quizzes	Quiz 1, Week 4	15	1, 2, 4
	Quiz 2, Week 9	15	3, 4, 6
Assignments (may be completed individually or in groups of up to 4 students)	Assignment 1, Week 2 or 3	5	1, 7
	Assignment 2, Week 5	5	2, 3
	Assignment 3, Week 8	5	3, 4
	Assignment 4, Week 11	5	2, 3, 7
Final Exam	Exam period	50	All

Students are expected to complete their work on time. The course instructor will provide notification (during lectures and/or on the course LMS) of due dates and any revisions thereof.

Submissions after the due date will not be accepted without prior arrangement and may be penalized at up to 20% per day (24-hour period following due date/time) unless a suitable justification is provided.

Students must pass the individual examination component (combined mark on quizzes + final) to pass the course, as stated in Departmental Policy. Attendance at mid-term (quizzes) and final exam is mandatory. No make-up mid-terms will be provided. Marks assigned to the mid-term may be transferred to the final exam for a medical reason supported with proper documentation following the stipulations of the departmental policy.

Problem and design assignments will be completed during the term. The aim of these projects is to apply the theory presented in the course. Submissions must be handed in through the LMS (see detailed schedule below). Only one submission per group, with the name of each group member clearly indicated. Assignment solutions and reports may be hand-written (pen or pencil), or typed, but must be complete and fully support the answers.

To be eligible for mark reassessment (of assignments or tests), all work must be written in permanent ink, and a request must be submitted within two weeks of the initial return date along with a mark reassessment form (available on the course LMS) and the complete original submission. Please note that a selection of marked assignments and quizzes will be photocopied and archived.

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

Final Exam

The final exam is closed book. 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.

Remote Proctoring - Proctortrack

The final exam in this course will use remote proctoring provided by a third-party, cloud-based service that enables the completion of a proctored exam or test from an off-campus location, through onQ or Elentra. This online proctoring solution was chosen as part of the approach to maintaining academic integrity in online assessment. Precise details about how remote proctoring will be used in this course can be found in the "Getting Started with Remote Proctoring" content module in onQ. When writing tests/exams using remote proctoring, you are connecting to the third-party service. Queen's has conducted a privacy and security review of the service and has entered into a binding agreement with terms that address the appropriate collection, use and disclosure of personal information in accordance with Ontario's privacy legislation. You should also take measures yourself to protect your information by keeping your NetID, password and challenge questions private, closing all applications prior to starting an exam/test, and ensuring your device is updated and safeguarded against malware. For more information about remote proctoring, see the Student FAQs on the VPTL/ITS Resource page for remote proctoring.

HOW TO DO WELL IN THIS COURSE

This course introduces important engineering concepts that are fundamental to the understanding and applications of advanced topics taught in upper years of your undergraduate program. The concepts range in difficulty from fundamental and straight-forward to a certain level of complexity associated with non-ideal systems. As such, significant practice is required to formulate and solve problems efficiently and correctly. Students should plan on attending lectures and tutorials having prepared for the session as detailed on the course LMS. Students are expected to assimilate new concepts and methodologies in the lectures, to practice by solving suggested problem set questions, and to seek help outside the course when they do not understand the concepts. They are expected to remember and apply concepts and problem-solving methodologies from previous courses.

Students are expected to apply the concepts and to implement the methods taught in class and presented in the textbook. These concepts will be tested in assignments, quizzes, and exams, and students must be capable of extrapolating the applications to a variety of problems in fluid mechanics.

To obtain full marks, the complete methodology must be clearly and logically presented; where appropriate, clearly labeled diagrams must be included with the solution. For questions involving multiple parts, partial credit may be given for correct methodology, but the final answer must also be correct. If the answer does not reflect the expected outcome, or if it is not physically representative, then the student is encouraged to provide comments, using critical analysis skills, to point out any outstanding issue. All relevant assumptions must be stated, and proper units must always be included.

COURSE POLICIES

Please review the following policies concerning copyright, academic integrity, absences and academic accommodations:

COPYRIGHT

Unless otherwise stated, the material on the course website is copyrighted and is for the sole use of students registered in this course. The material on the website may be downloaded for a registered student's personal use but shall not be distributed or disseminated to anyone other than students registered in this course.

ACADEMIC INTEGRITY

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 Faculty of Engineering and Applied Science website, and from your instructor.

ABSENCES (ACADEMIC CONSIDERATION) AND ACADEMIC ACCOMMODATIONS

For absences and academic accommodations please review the information on the FEAS website.

TECHNICAL SUPPORT

No specialized computer-related technical skills are required for this course. If you require technical assistance, please contact Technical Support.

PERSONAL SUPPORTIVE COUNSELLING

If at any time you find yourself feeling overwhelmed, anxious, sad, lonely, or distressed, consider confidential supportive counselling offered by the Faculty of Engineering and Applied Science.

COURSE OVERVIEW

CHEE 223 || Module overview

Course learning outcomes (CLO): Students will be able to:

1. Calculate pressure distribution in static fluids and forces on submerged surfaces.
2. Formulate mass, momentum, and energy balances using the control volume and differential analysis of fluid flow.
3. Identify boundary conditions and solve differential equations describing one-dimensional fluid flow.
4. Determine frictional losses, pipe size, and pump power requirements in laminar and turbulent flow for viscous flow in closed conduits.
5. Calculate the drag forces on submerged objects in laminar and turbulent flow.
6. Use dimensional analysis to derive relationships among process or system variables.
7. Demonstrate an understanding of the technical aspects of pressure, flow and viscosity measurement and sizing of pumps and pipes.

Students are expected to augment lecture material through reading of associated sections of the textbook, and to practice execution of course principles by completing posted problem sets

Module	Lecture approach* and content	Tutorial approach** and content	Notes and assessment (CLO)
Module 1 (Weeks 1-2)	**Introduction to Fluid Mechanics** **Fluid Statics (CLO1)** • Definition of pressure • Pressure distribution for a fluid at rest • Hydrostatic forces on plane surfaces • Buoyancy • Measurement of pressure	Tutorials 1, 2, 3 (CLO1)	*Textbook Ch. 1, 2* Material is included in Quiz 1 (CLO1) Assignment 1 (CLO1, CLO7) due end of Week 2 or 3
Module 2 (Weeks 3-6)	**Finite Control Volume Analysis (CLO2, CLO3, CLO7)** • The general balance equation • Conservation of Mass -Continuity equation • Energy balance • Bernoulli's equation (mechanical energy balance) • Applications: Flow measurement • Momentum balance	Tutorials 4, 5, 6 (CLO2, CLO3, CLO7)	*Textbook Ch. 3, 4, 5, 7* Material is included in Quizzes 1 and 2 (CLO2, CLO3, CLO7) Assignment 2 (CLO2, CLO3) due end of Week 5

Module	Lecture approach* and content	Tutorial approach** and content	Notes and assessment (CLO)
Quiz 1 (Week 4)	**Covers Module 1 and parts of Module 2**		3-4 questions (CLO1, CLO2, CLO3, CLO7)
Module 3 (Weeks 7-9)	**Viscous flow in closed conduits/fluid friction in steady- one dimensional flow (CLO4, CLO7)** • Definitions of viscosity and stresses • Laminar flow • Turbulent flow • Friction factors, major and minor losses • Economic pipe diameter • Pumps and pump sizing	Tutorials 7, 8, 9 (CLO4, CLO7)	*Textbook Ch. 6, 10* Material is included on Quiz 2 (CLO4, CLO7) Assignment 3 (CLO4, CLO7) Due end of Week 8
Quiz 2 (Week 9)	**Covers Modules 2 and 3**		3-4 questions (CLO2, CLO3, CLO4, CLO7)
Module 4 (Week 10)	**Dimensional Analysis/Modeling (CLO6)**	Tutorial 10 (CLO6)	*Textbook Ch. 9* Material is included on Final Exam (CLO6)
Module 5 (Week 11)	**Differential methods of analysis (CLO2,CLO3)** • Differential mass and momentum balances • Equations of motion, Navier-Stokes equations • One-dimensional, steady-state problems	Tutorial 11 (CLO2, CLO3)	*Textbook Ch. 15* Material is included on Final Exam (CLO2, CLO3) Assignment 4 (CLO2, CLO3, CLO7) due end of Week 11
Module 6 (Week 12)	**Flow over immersed bodies (CLO5)** • Flow past an object • Introduction to boundary layers • Estimation of drag coefficients	Tutorial 12 (CLO5)	*Textbook Ch. 6 (section 6.13)* Material is included on Final Exam (CLO5)
FINAL EXAM			5-7 questions (All CLOs)

*Delivery through lecture materials, in-class examples and solutions, true or false trivia, video clips.
**Tutorials are solved interactively in class