ROYAL MILITARY COLLEGE OF CANADA

Department of Civil Engineering

Fluid dynamics – MEE315

Fluid Dynamics – MEE315 - Fall term 2023

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Lectures: Mondays (9-9:50AM), Wednesdays (10-11:50PM), Fridays (12:40-2:30PM)

Tutorials: As indicated by instructor

Labs:

1. Wednesday October 4th 10-12PM
2. Wednesday November 1st 10-12PM

Course Description: This course provides the basic concepts of fluid mechanics. It includes a study of the basic fluid properties, hydrostatics and the fundamental equations of fluid motion. The control volume concept is introduced and applied to the continuity, momentum, and energy equations. Appropriate simplifications result in the Bernoulli equation that is used for practical applications. Students are initiated to dimensional analysis and similitude. An introduction to the concepts of boundary layer for laminar and turbulent flows is given. Viscous flow understanding is then applied to the empirical calculation of incompressible flow in pipes. Finally, the students are exposed to the analysis of open channel flows, as well as an introduction to pumps. The lectures are supplemented by problem assignments and experiments conducted in the laboratory, including measurement of pressure and hydrostatic pressures on submerged surfaces, velocity and flow rates, and weirs.

Mark Distribution:

Assignments (5)	5%
Test 1	30%
Lab 1	7.5%
Lab 2	7.5%
Final Exam	50%

Items in green are course and instructor dependent but must follow ACADEMIC POLICY DIRECTIVE NO: 7 POLICY ON COMMONALITY BETWEEN SECTIONS OF UNDERGRADUATE COURSES and the Faculty of Engineering Policy #1.

Textbooks: Fluid mechanics – White 7th edition by Mcgraw-Hill

Graduate Attributes (GAs)

In this course, we evaluate GAs marked with an X.

1	**A knowledge base for engineering**: Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.	**X**
2	**Problem analysis:** An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.	**X**
3	**Investigation:** An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.	**X**
4	**Design:** An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.	
5	**Use of engineering tools:** An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.	
6	**Individual and team work:** An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.	**X**
7	**Communication skills:** An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.	
8	**Professionalism:** An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.	
9	**Impact of engineering on society and the environment:** An ability to analyze societal and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.	
10	**Ethics and equity:** An ability to apply professional ethics, accountability, and equity.	**X**
11	**Economics and project management:** An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.	
12	**Life-long learning:** An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.	**X**

Learning Outcomes (LOs)

You need to master the following learning outcomes (LO) by the end of this course:

Maximum 12 LOs please

	LEARNING OUTCOME	ACTIVITIES WHERE EVALUATION IS LIKELY TO OCCUR
CLO1	Demonstrate good understanding on the basic terminology, classification, and properties of fluids.	Assignment 1, Test 1, Final exam
CLO2	Calculate pressure and forces on submerged bodies in a static fluid.	Assignment 2, Test 1, Lab 1, Final exam
CLO3	Understand and apply control-volume-based mass and momentum conservation principles to fluid flows.	Assignment 3, Final exam
CLO4	Perform pressure, velocity and drag calculations on canonical internal and external engineering flows.	Assignment 4, Final exam
CLO5	Solve piping system performance problems using Bernoulli with friction, minor losses, pump, and turbine performance curves.	Assignment 5, Lab 2, Final exam
CLO6	Work proficiently and effectively in small teams	Lab 1, Lab 2
CLO7	Present understanding and analysis of problems using methodical and clearly demonstrated worked written solutions.	Assignments 1-5, Test 1, Lab 1-2, Final exam
CLO8	Work professionally in carrying out assignments, laboratory experiments and associated lab reports	Assignments 1-5, Test 1, Lab 1-2, Final exam

COURSE OUTLINE

Chapter 1: Basic Concepts

1. What is a fluid? (Text 1.4)
2. Continuum hypothesis, velocity field, shear stress (Text 1.5, 1.7)
3. Viscosity, Reynolds number and flow between plates (Text 1.9)

Chapter 2: Pressure in Stationary Fluid

1. Pressure, Pascal's law for pressure at a point (Text 2.1)
2. Vertical variation of pressure when density is constant (Text 2.3)
3. Equality of pressure at the same height when density is constant
4. General equation for hydrostatic pressure
5. Absolute pressure, gauge pressure, head
6. Application to manometry (Text 2.4)
    1. pressure tube
    2. barometer
    3. U-tube manometer
    4. U-tube for pressure difference
    5. inverted U-tube
    6. U-tube with multiple fluids
7. Hydrostatic forces on plane surfaces (Text 2.5)
    1. action of fluid pressure on a surface
    2. resultant force and center of pressure on a plane horizontal surface
    3. resultant force and center of pressure on a plane inclined surface
8. Hydrostatic forces on curved surfaces (Text 2.6)
9. Buoyancy, equilibrium of floating objects (Text 2.8)

MID-TERM EXAM I

Chapter 3: Simple Equations for Control Volume

1. Mass, momentum conservation in Lagrangian frame (Text 3.1)
2. Fixed control volume
3. Reynoldstransporttheorem (Text3.2)
4. Mass conservation in fixed control volume (Text 3.3)
    1. special cases
    2. mass flow, average velocity
5. Momentum conservation in fixed control volume (Text 3.4)

    1. the general vector equation
    2. one-dimensional momentum flux
    3. net pressure force on a closed surface
    4. pressure condition at a jet exit
6. The Bernoulli equation (Text 3.7)
    1. general formulation
    2. special case for steady, constant density flow
7. Important dimensionless parameters in fluid mechanics (Text 5.4)

Chapter 6: Pipe Flow

1. Reynolds number regimes (Text 6.1, 6.2)
    1. laminar flow, turbulent flow
    2. volume flow rate Q
    3. average velocity V
    4. entrance region
2. Head loss and friction factor (Text 6.3)
3. Laminar fully developed pipe flow (Text 6.4)
4. Turbulent pipe flow and the Moody chart (Text 6.6)
5. Flow meters (Text 6.12)
    1. Pitot-static tube
    2. Bernoulli obstruction devices

Chapter 7: Flow past Immersed Objects

1. Forces on immersed objects (Text 7.6)
2. Drag force of immersed objects (Text 7.6)
3. Friction drag and pressure drag (Text 7.6)
4. Drag force on surface ship (Text 7.6)
5. Drag force at high Mach number (Text 7.6)

Chapter 10: Open Channel Flow

1. Assumptions (Text 10.1)
2. One dimensional approximation (Text 10.1)
3. Classification of open channel flow (Text 10.1)
4. The Chezy formula for uniform open channel flow (Text 10.2)

Chapter 11: Turbomachinery

1. Basic output parameters of centrifugal pump (Text 11.2)

2. Elementary centrifugal pump theory (Text 11.2)
    1. Ideal velocity diagram
    2. Euler turbmachinery equation
    3. Design point
3. Pump performance curves (Text 11.3)
4. Dimensionless pump performance (Text 11.3)

FINAL EXAM

Pre-requisites and knowledge

PHE205, MAE226

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.