



Fluid Mechanics I (Module I – III)

(**Subtitle:** A comprehensive study of the fundamentals of fluid mechanics to comprehend the diverse properties of fluids, their influence on fluid motion, and their applications to science and engineering)

1.0 Course Faculty Information

Name: Prof. Dr. M. Enamul Hossain

NSRIC Chair Professor in Sustainable Energy

NSRIC Inc., Toronto, Ontario, Canada

2.0 Course Information

Course(s) Codes	ENG-M-C00359, ENG-M-C00363, ENG-M-C00364
Class Days	Follow posting in NSRIC LMS system
Class Time	Follow posting in NSRIC LMS system
Course Credit Hours	1 + 1 + 1 = 3
Class Location	NSRIC online platform
prerequisites and/or co-requisites	n/a
Level /A, E, H, I, K12, M, P, S, T, U, V, W	M

Note: The below classification of courses is related to any areas of knowledge:

A: Advanced level academic level courses; **C:** Canadian immigration and training courses; **E:** Executive courses; **H:** Higher-level courses (i.e., graduate courses); **I:** Intermediate courses (i.e., university preparatory courses – Grade XII+); **K12:** Foundational, and lower-level courses; **M:** Mid-level courses (i.e., undergraduate courses); **P:** Professional courses; **S:** Short/seminar courses; **T:** Training courses; **U:** Tutorial Courses; **V:** Vocational training courses; and **W:** Workshop courses.

3.0 Professor Information

Name	Prof. Dr. M. Enamul Hossain
Title	NSRIC Chair Professor in Sustainable Energy
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Office Location	NSRIC online platform
Office Hours	10: 30 am – 11:30 am EST (Monday) by email appointment

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4.0 Target Audiences

- Science and engineering undergraduate-level student.
- University graduates, early career engineers, scientists, and professional engineers.
- Diploma and vocational training student.
- Any student who is interested in thermal engineering.
- Any student who is interested in automobile engineering.

5.0 Course Modules Descriptions

Module I

This course introduces students to the fundamental concepts of fluids and their properties, fluid statics, kinematics of fluid motion and conservation of mass. This module covers the topics of fluid mechanics such as characteristics of matter, systems of units, viscosity, viscosity measurement, vapour pressure, surface tension and capillarity, absolute and gage pressure, static pressure variation, pressure variation for compressible and incompressible fluids, measurement of static pressure, hydrostatic force on a plane surface, buoyancy, stability, constant translational acceleration, and a steady rotation of a liquid fluid flow descriptions, types and graphical descriptions of fluid flow, fluid acceleration, streamline coordinates, finite control volumes, the Reynolds transport theorem, volumetric flow, mass flow, and average velocity. The course also covers the basics of the fluid mechanics. This module explains each concept in detail and with examples and illustrations. This approach will make the students interested in enrolling in the course.

This module is a foundation, resource guide and an excellent source for science and engineering students, early career professionals, and executives who want to learn concepts, design, and dimensions through enough practice of the theories and examples. This module is designed for individuals and students who need to understand the basics of fluid mechanics. The course contains a total of ten lectures, and each lecture comprises 20 to 35 PowerPoint presentation slides and pdf documents. The course is also designed with two quizzes and two assignments. Students are strongly advised to complete the “Fluid Mechanics I (Module I – III)” course by Prof. M. Enamul Hossain at NSRIC Platform to understand this course content.

Keywords: fluid statics, kinematics of fluid motion, conservation of mass, characteristics of matter, systems of units, viscosity, viscosity measurement, vapour pressure, surface tension and capillarity, absolute and gage pressure, static pressure variation, pressure variation for compressible and incompressible fluids, measurement of static pressure, hydrostatic force on a plane surface, buoyancy, stability, constant translational acceleration, and steady rotation of a liquid fluid flow descriptions, types and graphical descriptions of fluid flow, fluid acceleration, streamline

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coordinates, finite control volumes, the Reynolds transport theorem, volumetric flow, mass flow, and average velocity.

Module II

This course introduces students to the fundamental concepts of work and energy of moving fluids, fluid momentum and differential fluid flow. This module covers the topics of fluid mechanics such as Euler's equations of motion, Bernoulli equation and its applications, energy and hydraulic grade lines, energy equation, linear momentum equation, applications to bodies at rest and bodies having constant velocity. The module also covers the angular momentum equation, propellers and wind turbines, applications for control volumes having accelerated motion, turbojets and turbofans, rockets, differential analysis, kinematics of differential fluid elements, circulation and vorticity, conservation of mass, equations of motion for a fluid particle, stream and potential functions, basic two-dimensional flows, Navier-Stokes equations, and computational fluid dynamics. This module explains each concept in detail and with enough examples and illustrations. This approach will make the students interested in enrolling in the course.

This module is a foundation, resource guide and an excellent source for science and engineering students, early career professionals, and executives who want to learn concepts, design, and dimensions through enough practice of the theories and examples. This module is designed for individuals and students who need to understand the basics of fluid mechanics. The course contains a total of nine lectures, and each lecture comprises 20 to 35 PowerPoint presentation slides and pdf documents. The course is also designed with two quizzes and two assignments. Students are strongly advised to complete the "Fluid Mechanics I (Module I – III)" course by Prof. M. Enamul Hossain at NSRIC Platform to understand this course content.

Keywords: work and energy, moving fluids, fluid momentum, differential fluid flow, Euler's equations, Bernoulli equation, energy grade lines, hydraulic grade lines, energy equation, linear momentum equation, applications to bodies at rest, bodies having constant velocity, angular momentum equation, propellers, wind turbines, control volume, turbojets, turbofans, rockets, differential analysis, kinematics, differential fluid elements, circulation, vorticity, mass conservation, equations of motion, fluid particle, stream function, potential function, two-dimensional flows, Navier-Stokes equation, computational fluid dynamics, CFD.

Module III

This course introduces students to the fundamental concepts of dimensional analysis and similitude, laminar and turbulent flow within pipe, and analysis and design for pipe flow. This module covers the topics of fluid mechanics such as dimensional analysis, important dimensionless numbers, the Buckingham π –theorem, some general considerations related to dimensional analysis, similitude, types of flow regime, viscous flow within enclosed surfaces,

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steady laminar flow between parallel plates and smooth pipe. The course also covers the Reynolds number, fully developed flow from an entrance turbulent flow within a smooth pipe, losses occurring from pipe fittings and transitions, single-pipeline flow, and pipe systems. This module explains each concept in detail and with enough examples and illustrations. This approach will make the students interested in enrolling in the course.

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Keywords: dimensional analysis, similitude, laminar flow, turbulent flow, analysis and design for pipe flow, important dimensionless numbers, Buckingham π –theorem, flow regime, viscous flow, enclosed surfaces, steady state, parallel plates, smooth pipe, Reynolds number, entrance, smooth pipe, losses, pipe fittings, transitions, single-pipeline flow, and pipe systems.

6.0 Course Learning Outcomes

Students who complete this course can achieve the following course learning outcomes (CLOs):

Module I

- CLO1: Ability to understand pressure and show how it varies within a static fluid.
- CLO2: Ability to identify the various ways of measuring pressure in a static fluid using barometers, manometers, and pressure gages.
- CLO3: Ability to understand how to calculate a resultant hydrostatic force and find its location on a submerged surface along with topics of buoyancy and stability.
- CLO4: Ability to calculate the pressure within a liquid subjected to a constant acceleration, and to a steady rotation about a fixed axis.
- CLO5: Ability to define the velocity and acceleration of fluid particles using either a Lagrangian or an Eulerian description.
- CLO6: Ability to classify the various types of fluid flow and to discuss how these flow patterns are visualized experimentally.

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- CLO7: Ability to express the velocity and acceleration of fluid particles in terms of their Cartesian and streamline components.
- CLO8: Ability to define the concept of a finite control volume, and then show how a Lagrangian and an Eulerian description of fluid behavior can be related using the Reynolds transport theorem.
- CLO9: Ability to show how to determine the volume and mass flow, and the average velocity in a conduit.
- CLO10: Ability to use the Reynolds transport theorem to derive the continuity equation, which represents the conservation of mass.
- CLO11: Ability to demonstrate the application of the continuity equation to problems involving finite fixed, moving, and deformable control volumes.

Module II

- CLO12: Ability to develop Euler's equations of motion and the Bernoulli equation for streamline coordinates and illustrate some important applications.
- CLO13: Ability to show how to establish the energy grade line and hydraulic grade line for a fluid system.
- CLO14: Ability to develop the energy equation from the first law of thermodynamics, and to show how to solve problems that include pumps, turbines, and frictional loss.
- CLO15: Ability to develop the principles of linear and angular impulse and momentum for fluid so that the loadings the fluid exerts on a surface can be determined.
- CLO16: Ability to illustrate specific applications of the momentum equation to propellers, wind turbines, turbojets and rockets.
- CLO17: Understanding basic kinematic principles as they apply to a differential fluid element.
- CLO18: Ability to develop the Bernoulli equation for ideal fluid flow.
- CLO19: Analyze the idea of the stream function and potential function and show how they can be used to solve various types of ideal fluid flow problems including uniform flow, flow from a source, flow into a sink, and free-vortex flow.

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CLO20: Ability to develop the Navier-Stokes equations, which apply to a differential element of viscous incompressible fluid.

CLO21: Examine how to solve complex fluid flow problems using computational fluid dynamics.

Module III

CLO22: Ability to show how to use dimensional analysis to specify the least amount of data needed to study the behaviour of a fluid experimentally.

CLO23: Ability to analyze how flow behavior depends on the types of forces that influence the flow, and to present an essential set of dimensionless numbers that involve these forces.

CLO24: Ability to analyze the dimensional analysis procedure by obtaining groups of dimensionless numbers using the Buckingham π –theorem.

CLO25: Ability to analyze the prototype and model to scale up or scale down.

CLO26: Ability to understand how the forces of gravity, pressure, and viscosity affect the laminar flow of an incompressible fluid contained between parallel plates and within a pipe.

CLO27: Ability to classify how to classify the flow using the Reynolds number.

CLO28: Ability to understand how to analyze and design pipe systems having various fittings and connections.

7.0 How the course supports the attainment of the student outcomes

Student Learning Outcomes (1-6)						
1	2	3	4	5	6	7
Moderate	Moderate	Moderate	Low	Moderate	Moderate	Excellent

8.0 Course Materials

Online course materials

- Online presentation documents in pdf form.
- Audio/visual recording of lectures (Optional).
- Online tutorial and meeting with students upon request.
- Workout examples for hands-on experience.

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- Assignments and MCQs in the form of evaluation at the NSRIC online MLS system
- Reading materials, if any, in pdf form

Textbook and resources (If any)

1. Fluid Mechanics, R.C. Hibbeler, Pearson Education Canada.

References:

- 1) Fluid Mechanics, 6/E, Swaffield, Jack, Douglas & Gasiorek, Pearson Education Canada, 2011
- 2) Course Notes of Prof. Hossain (Lectures 1 – 31)

9.0 Academic Integrity

Students are encouraged to have a look at the NSRIC's statement of academic integrity on the NSRIC website. It is noted that by signing this syllabus, you will acknowledge that you have understood that any detected plagiarism should be reported.

10. Assessment for Grade

This course is a professional course not an academic course (i.e., K12, and university level courses). Therefore, there will not be any assessment based on individual and team performance as shown in Table 1. However, the course contains four quizzes and assignments to make the assessment. Students will receive a "**Certificate of completion**" after successful completion of the course.

Table 1: NSRIC grading system.

Type of Assessment	Grade %
Participation/Engagement/Performance	10%
Assignments (For Module III – 40%)	60%
Quizzes (For Module III – 20%)	30%
Research Project	0%
Midterm Exam I	0%
Midterm Exam II	0%
Final Exam (Module III – 30%)	0%
Total	100%

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Important Note:

- i) The below classified courses (i.e., academic courses) will only be evaluated based on the grade system shown in Table 2. A grade and certificate will be issued for the student(s) and participant(s).
A: Advanced level academic level courses; **H:** Higher-level courses (i.e., graduate courses); **I:** Intermediate courses (i.e., university preparatory courses – Grade XII+); **K12:** Foundational, and lower-level courses; **M:** Mid-level courses (i.e., undergraduate courses).
- ii) The below-classified courses will **not** be evaluated based on the grading system shown in Table 2. A certificate will be issued for the student(s) and participant(s).

E: Executive courses; **P:** Professional courses; **S:** Short/seminar courses; **T:** Training courses; **U:** Tutorial Courses; **V:** Vocational training courses; and **W:** Workshop courses.

Participation/Engagement/Performance

Your participation in every aspect of the course is important for the learning process. Your engagement in every discussion in the course, and due delivery of all practices will be fruitful. These efforts from your side will reflect your performance in the course delivery and your commitments. This performance is the reflection of your dream grade!!

At the end of the term, below Table 2 will be used for translating your marks into a “Latter Grade” based on the NSRIC grading policy.

11.0 Advice and additional requirements

I advise you to:

- Please contact me if you need any help.
- Students are expected to attend all scheduled online lecture classes.
- Students are expected to study from the course materials and/or textbooks which will help to easily read and understand.
- Students are encouraged to write their own notes during lectures/presentations (pdf PowerPoint presentations, and additional materials if any).
- Students are encouraged to attend online platform classes on time because late attendee disrupts the flow of the class for both the instructor and the other students.

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Table 2: NSRIC grading system.

Marks	Letter Grade	Points	Description
≥ 93	A+	4.00	Outstanding
≥ 90	A	3.75	
≥ 87	A-	3.50	Excellent
≥ 84	B+	3.25	Very good
≥ 81	B	3.0	
≥ 78	B-	2.75	Moderately Good
≥ 75	C+	2.50	Good
≥ 72	C	2.25	
≥ 69	C-	2.0	Moderately Good
≥ 66	D+	1.75	Pass
≥ 63	D	1.50	
≥ 60	D-	1.25	Poor Pass
< 60	F	0	Failing

Additional information (During the Online Course offering Period)

- The PowerPoint course materials and video lectures will be available on the NSRIC Platform.
- There will be scheduled discussion/tutorial sessions based on the request at the class scheduled time. All students must attend this session (Need the student's email request).
- There will be an office hour for students on Monday from 10:30 am to 11:30 am EST (Toronto, Canada time). Students need to send an email request so that a Zoom meeting can be arranged. In addition, any time students can set up an online appointment (i.e., phone, zoom, or other mode of communication) based on the availability of the course instructor. However, students should request an email to set up this type of meeting.

12.0 Course Topics

- Properties of the pure substances
- Fundamental concepts: fluids and their properties
- Fluid Statics: pressure and head, static forces on surfaces, buoyancy
- Kinetics of fluid motion: motion of fluid particles and streams
- Conservation of mass: transport theorem, volumetric and mass flow
- Work and energy of moving fluids: Bernoulli equation, Energy equation
- Fluid Momentum: linear and angular momentum equation

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- Dimensional analysis and similitude
- Laminar and turbulent flow within a pipe
- Analysis and design for pipe flow

Requirements/Instructions

Students are advised to register for all drilling engineering modules courses to become a master in the subject area.

13. Bundled Courses Program Description

The objectives of fluid mechanics are to help us understand the behavior of fluid under various forces and at different atmospheric conditions, to select the proper fluid for various applications and to understand the nature of fluid statics, in particular, dealing with problems related to hydrostatic forces. Fluid mechanics is a branch of physics that studies fluids and their behaviors in response to different forces. The bundled courses program begins with an overview of the fundamentals of fluid mechanics concepts step-by-step with specific workout examples to address the above objectives. The bundled courses program covers three modules. A complete discussion is presented on different concepts, as highlighted in the section below.

Fluid mechanics (Module I) introduces students to the fundamental concepts of fluids and their properties, fluid statics, kinematics of fluid motion and conservation of mass. This module covers the topics of fluid mechanics such as characteristics of matter, viscosity, viscosity measurement, surface tension and capillarity, pressure variation for compressible and incompressible fluids, measurement of static pressure, hydrostatic force on a plane surface, buoyancy, stability, constant translational acceleration, and a steady rotation of a liquid fluid flow descriptions, types and graphical descriptions of fluid flow, fluid acceleration, streamline coordinates, finite control volumes, the Reynolds transport theorem, volumetric flow, mass flow, and average velocity.

Module II introduces the basic concepts of work and energy of moving fluids, fluid momentum and differential fluid flow. This module covers the topics of fluid mechanics such as Euler's equations of motion, Bernoulli equation and its applications, energy and hydraulic grade lines, energy equation, linear momentum equation, applications to bodies at rest and bodies having constant velocity. Students will be able to analyze the problems related to elementary fluid dynamics, especially for incompressible flows using the Bernoulli equation in particular. The module also covers the angular momentum equation, propellers and wind turbines, applications for control volumes having accelerated motion, turbojets and turbofans, rockets, differential analysis, kinematics of differential fluid elements, circulation and vorticity, conservation of mass, equations of motion for a fluid particle, stream and potential functions, basic two-dimensional flows, Navier-Stokes equations, and computational fluid dynamics.

Module III introduces the fundamental concepts of dimensional analysis and similitude, laminar and turbulent flow within pipe, and analysis and design for pipe flow. This module

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covers the topics of fluid mechanics such as important dimensionless numbers, the Buckingham π –theorem, some general considerations related to dimensional analysis, similitude, types of flow regime, viscous flow within enclosed surfaces, steady laminar flow between parallel plates and smooth pipe. The course also covers the Reynolds number, fully developed flow from an entrance turbulent flow within a smooth pipe, losses occurring from pipe fittings and transitions, single-pipeline flow, and pipe systems. This module explains each concept in detail and with enough examples and illustrations. This approach will make the students interested in enrolling in these courses.

Upon successful completion of this bundled course the students will be able to (i) understand the various properties of fluids and their influence on fluid motion, (ii) analyse a variety of problems in fluid statics and dynamics including dimensional analysis and (iii) calculate the forces that act on different planes and curves.

This program is a foundation, resource guide and an excellent source for science and engineering students, early career professionals, and executives who want to learn concepts, design, and dimensions through enough practice of the theories and examples. The different modules are designed for individuals and students who need to understand the basics of fluid mechanics where Euler's equation, Bernoulli equation, dimensional analysis, important dimensionless numbers, and Buckingham π –theorem are the main focus. Each bundled course (Module I, II and III) contains a total of 10, 9 and 11 lectures respectively. Each lecture comprises 20 to 35 PowerPoint presentation slides and pdf documents. The courses are also designed with two quizzes, two assignments and one final exam in Module III. Students are strongly advised to complete the “Fundamentals of Thermodynamics (Module I – III)” course by Prof. M. Enamul Hossain at NSRIC Platform to understand this course content.

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14.0 Course Contents and Schedule

Lec. No.	Module	Topics	Remarks
Module I			
01	Introduction	Introduction of fluids and their properties 1	
02	Fluid properties	Fluids and their properties 2	Quiz 1
03	Fluid statics	Fluid statics 1	Assignment 1
04	Fluid statics	Fluid statics 2	
05	Fluid statics	Fluid statics 3	Quiz 2
06	Kinematics	Kinematics of fluid motion 1	Assignment 2
07	Kinematics	Kinematics of fluid motion 2	
08	Cons. of mass	Conservation of mass 1	
09	Cons. of mass	Conservation of mass 2	
10	Review session	Review session 1	
Module II			
11	Work and energy	Work and energy 1	
12	Work and energy	Work and energy 2	Quiz 3
13	Fluid momentum	Fluid momentum 1	Assignment 3
14	Fluid momentum	Fluid momentum 2	
15	Fluid momentum	Fluid momentum 3	Quiz 4
16	Fluid momentum	Fluid momentum 4	Assignment 4
17	Diff. fluid flow	Differential fluid flow 1	
18	Diff. fluid flow	Differential fluid flow 2	
19	Review session	Review session 2	
Module III			
20	Dimensional analysis	Dimensional analysis 1	
21	Dimensional analysis	Dimensional analysis 2	Quiz 5
22	Dimensional analysis	Dimensional analysis 3	Assignment 5
23	Dimensional analysis	Dimensional analysis 4	
24	Dimensional analysis	Dimensional analysis 5	Quiz 6
25	Viscous flow	Laminar and turbulent flow 1	Assignment 6
26	Viscous flow	Laminar and turbulent flow 2	
27	Viscous flow	Laminar and turbulent flow 3	
28	Viscous flow	Laminar and turbulent flow 4	
29	Pipe flow	Analysis and design for pipe flow	
30	Review session	Review session 2	
31	Final Exam – Online after completion of the course requirements		

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Prepared by Prof. M. Enamul Hossain, NSRIC Chair Professor in Sustainable Energy, Dept. of Petroleum Engineering, OE Division, NSRIC Inc., Toronto, ON, Canada.



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