



Drilling Engineering Practices – Workout Examples and Exercises (Module I – III)

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 Codes	ENG-M-C00296, ENG-M-C00304, ENG-M-C00305
Class Days	Follow posting in NSRIC LMS system
Class Time	Follow posting in NSRIC LMS system
Course Credit Hours	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	Mid-level courses / M

Note: The below classification of courses is related 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
Contact Information	enamulh@nsric.ca ; dr.mehossain@gmail.com
Office Location	NSRIC online platform
Office Hours	10: 30 am – 11:30 am EST (Monday) by email appointment

4.0 Target Audiences

- Diploma and vocational training student.
- University undergraduate level student.

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- Any student who is interested in drilling engineering.
- Students who have completed Basics of Drilling Engineering I (Module 1 – 4) and Drilling Engineering II offered by Prof. M. Enamul Hossain.

5.0 Course Module Descriptions

Module I:

In drilling engineering, there is a clear shortcoming in fundamental understanding of mathematical formulas derived from scientific theories due to the lack of enough practice on mathematical relations in the form of workout examples and exercises in drilling engineering. To date there are several textbooks that explain and cover drilling operations with fundamentals of drilling engineering. Unfortunately, there is no specific book or course so far where enough workout examples and exercises are available as an independent book or course except Prof. Hossain's book in the relevant area. As the first and only complete guide for petroleum engineering students and trainee engineers on basic and in-depth understanding of drilling engineering, this course is the best choice for the oil and gas industry community.

Module I includes all the basic aspects of drilling engineering including an introduction to drilling engineering, rig operations, drilling fluids, and drilling hydraulics. It also covers the types of flow, critical velocity inside the pipe, Equivalent Circulating Density (ECD), pressure losses, total needed pressure to discharge the mud through drilling circulating system, mud flow rate and drilling pipe design for pressure losses. The course covers the fundamental issues for beginners who are interested in learning drilling engineering through enough workout examples in each chapter, exercises, and exercises for self-practices to have a deep understanding on each topic. The answers of exercises are listed at the end of each chapter in a separate document. The course presents the engineering terminologies in a clear manner so that the beginner in drilling engineering would be able to understand the drilling engineering related formulas, mathematical models, correlations etc., with minimum effort. This will make the students interested in enrolling the course. The course used the scientific concepts in the form of mathematical formulations for each topic in a readable fashion very clearly.

This module is a foundation, resource guide and an excellent source for petroleum engineering students and drilling engineers who want to learn concepts through workout examples in each chapter, exercises, and exercises for self-practices mode. The course is designed for audiences/students who have basic knowledge on drilling engineering. The course contains three modules (Module I – III) and each module covers four chapters except Module II (three chapters). Students are strongly advised to complete the course title “Basics of Drilling Engineering I and Drilling Engineering II” by Prof. M. Enamul Hossain at NSRIC Platform to understand this course content.

Keywords: Workout examples and exercises, mathematical formulas, theories, drilling rig, rig components, rig operations, hoisting system, introduction to drilling engineering, drilling fluids, and drilling hydraulics. critical velocity, equivalent circulating density (ECD), pressure losses, drilling circulating system, mud flow rate, drilling pipe design.

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Module II:

In drilling engineering, there is a clear shortcoming in fundamental understanding of mathematical formulas derived from scientific theories due to the lack of enough practice on mathematical relations in the form of workout examples and exercises in drilling engineering. To date there are several textbooks that explain and cover drilling operations with fundamentals and in-depth of drilling engineering. Unfortunately, there is no specific book or course so far where enough workout examples and exercises are available as an independent book or course except Prof. Hossain's book in the relevant area. As the first and only complete guide for petroleum engineering students and trainee engineers on basic and in-depth understanding of drilling engineering, this course is the best choice for the oil and gas industry community.

Module II includes the well control and monitoring system, control of influx and kill mud, type of influx and gradient calculation, kick analysis, kill mud calculations, underground stresses, overburden pressure, pore pressure estimation using Bingham model, Jordan and Shirley model, Rehm and McClendon model, Zamora model, Eaton model, Combs model, estimation of fracture pressure using Hubbert and Willis model, Matthews and Kelly model, Pennebaker model, Eaton model, Christmen model, Anderson et al., model, and Belloti and Giacca model, porosity decline, depth of kick, formation drillability, d-exponent, maximum safe underbalance mud weight, minimum and maximum equivalent mud weight, fracture gradient, drillstring design through collapse and burst pressure, tension load, shock load, stretch of drillpipe, critical rotating speed, bit design, hydraulic horsepower and drilling optimization techniques, bit toot wear, modelling rate of penetration through Maurer method, Galle and Woods method, Bingham model, Bourgoyne and Youngs' method. The course covers the fundamental and in-depth issues for beginners who are interested in learning drilling engineering through enough workout examples in each chapter, exercises, and exercises for self-practices to have a deep understanding on each topic. The answers of exercises are listed at the end of each chapter in a separate document. The course presents the engineering terminologies in a clear manner so that the beginner in drilling engineering would be able to understand the drilling engineering related formulas, mathematical models, correlations etc., with minimum effort. This will make the students interested in enrolling the course. The course used the scientific concepts in the form of mathematical formulations for each topic in a readable fashion very clearly.

This module is a foundation, resource guide and an excellent source for petroleum engineering students and drilling engineers who want to learn concepts through workout examples in each chapter, exercises, and exercises for self-practices mode. The course is designed for audiences/students who have basic knowledge on drilling engineering. The course contains three modules (Module I – III) and each module covers four chapters except this module (three modules). Students are strongly advised to complete the course title “Basics of Drilling Engineering I and Drilling Engineering II” by Prof. M. Enamul Hossain at NSRIC Platform to understand this course content.

Keywords: mathematical formulas, theories, well control and monitoring system, influx and kill mud, kick analysis, kill mud calculations, underground stresses, overburden pressure, pore pressure estimation, Rehm and McClendon model, Zamora model, Eaton model, Combs model, Hubbert and Willis model, Matthews and Kelly model, formation drillability, d-exponent, collapse and burst pressure, tension load, shock load, stretch of drillpipe, critical rotating speed, bit design, hydraulic horsepower toot wear, modelling ROP

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Module III:

In drilling engineering, there is a clear shortcoming in fundamental understanding of mathematical formulas derived from scientific theories due to the lack of enough practice on mathematical relations in the form of workout examples and exercises in drilling engineering. To date there are several textbooks that explain and cover drilling operations with fundamentals of drilling engineering. Unfortunately, there is no specific book or course so far where enough workout examples and exercises are available as an independent book or course except Prof. Hossain's book in the relevant area. As the first and only complete guide for petroleum engineering students and trainee engineers on basic and in-depth understanding of drilling engineering, this course is the best choice for the oil and gas industry community.

Module III includes the casing design through collapse pressure, burst pressure, collapse strength, collapse pressure with axial stress, burst loading estimate using Barlow model, estimating yield strength, biaxial and triaxial loading, torsion and bending effects. The cementing design includes finding out the density, thickening time, viscosity and yield point, permeability, compressive strength, cement volume calculation such as number of sacks, additives, mixwater, mud volume and pumping duration. In horizontal and directional drilling, the module covers buckling models in coiled tubing, horizontal departure, directional patterns, principles of surveying, radius of curvature and minimum curvature. Finally, drilling cost analysis includes the Authorization for Expenditure (AFE), drilling cost estimation, well drilling time estimation, trip time estimation, number of bit estimation, connection time estimation, coring cost estimation, future value estimation, and price elasticity.

This course covers the fundamental issues for beginners and practicing engineers who are interested in learning drilling engineering through enough workout examples in each chapter, exercises, and exercises for self-practices to have a deep understanding on each topic. The answers of exercises are listed at the end of each chapter in a separate document. The course presents the engineering terminologies in a clear manner so that the beginner in drilling engineering would be able to understand the drilling engineering related formulas, mathematical models, correlations etc., with minimum effort. This will make the students interested in enrolling the course. The course used the scientific concepts in the form of mathematical formulations for each topic in a readable fashion very clearly.

This module is a foundation, resource guide and an excellent source for petroleum engineering students and drilling engineers who want to learn concepts in-depth through workout examples in each chapter, exercises, and exercises for self-practices mode. The course is designed for audiences/students who have basic knowledge on drilling engineering. The course contains three modules (Module I – III) and each module covers four chapters except Module II (three chapters). Students are strongly advised to complete the course title “Basics of Drilling Engineering I and Drilling Engineering II” by Prof. M. Enamul Hossain at NSRIC Platform to understand this course content.

Keywords: Workout examples and exercises, mathematical formulas, theories, collapse pressure, burst pressure, collapse strength, collapse pressure with axial stress, burst loading estimate using Barlow model, estimating yield strength, biaxial and triaxial loading, torsion and bending effects, cement density, thickening time, viscosity and yield point, permeability, compressive strength, cement volume calculation, number of sacks, additives, mixwater, mud volume and pumping duration, horizontal and directional drilling, buckling models, coiled tubing, horizontal departure, directional patterns, principles of surveying, radius of

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curvature, minimum curvature, drilling cost analysis, Authorization for Expenditure (AFE), drilling cost estimation, well drilling time estimation, trip time estimation, number of bit estimation, connection time estimation, coring cost estimation, future value estimation, and price elasticity.

6.0 Course Learning Outcomes

Upon successful completion of this course, students will be able to:

- CLO1: Become familiar with drilling rigs and mud pump design components through enough workout examples and exercises.
- CLO2: Understand the well control and monitoring system, calculations of kill mud, mud program, kick control through workout examples and exercises.
- CLO3: Ability to understand drilling fluids rheological properties, and mud design through enough workout examples and exercises.
- CLO4: Understand the basics of cementing concepts by employing cement volume calculations, thickening time, number of sacks etc. through enough workout examples and exercises.
- CLO5: Ability to understand hydrostatic and formation pressure and pressure loss calculation to design the mud pump concepts through enough workout examples and exercises.
- CLO6: Understand the Bottom-hole assembly (BHA), drilling bit design, drillstring design through enough workout examples and exercises.
- CLO7: Understand the drilling bit tooth wearing, design, selections, and evaluation through enough workout examples and exercises.
- CLO8: Understand the design, selection, and evaluation of drillstring and Bottom-hole assembly (BHA) through enough workout examples and exercises.
- CLO9: Understand the factors affecting rate of penetration (ROP) and become acquainted with ROP optimization techniques (i.e., drill-off test and drilling response test) through enough workout examples and exercises.
- CLO10: Ability to understand the casing design and selection criteria through enough workout examples and exercises.
- CLO11: Become familiar with the basic concepts of directional drilling, coiled tubing, horizontal departure and planning of a directional well path through enough workout examples and exercises.
- CL012: Ability to understand different drilling costs and economic and accordingly develop a drilling plan based on economic analysis i.e., authorization for expenditure (AEF) through enough workout examples and exercises.
- CLO13: Become familiar and in-depth understanding with the various drilling systems and well design techniques through enough workout examples and exercises.

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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	

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
- Enough MCQs for study and self-practiced MCQs with answers in pdf form in the MLS system
- Reading materials if any in pdf form

Textbook and resources (If any)

- 1) **Hossain, M.E.** (2016). Fundamentals of Drilling Engineering: MCQs and Workout Examples for Beginners and Engineers. ISBN: 978-1-119083-56-6, John Wiley & Sons, Inc. Hoboken, New Jersey, and Scrivener Publishing LLC, Salem, Massachusetts, USA, pp. 854.
- 2) **Hossain, M.E.** and Al-Majed, A.A. (2015). Fundamentals of Sustainable Drilling Engineering. ISBN 978-0-470878-17-0, John Wiley & Sons, Inc. Hoboken, New Jersey, and Scrivener Publishing LLC, Salem, Massachusetts, USA, pp. 786.

9.0 Academic Integrity

Students are encouraged to have a look at the NSRIC's statement of academic integrity at 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 an academic course (i.e., K12, and university level courses) based on individual and team performance as shown in Table 1. Therefore, the program courses contain nine assessments instead of assignments and quizzes for assessment. Student will receive a "Certificate of completion" after successful completion of the course.

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Table 1: NSRIC grading system

Type of Assessment	Grade %
Participation/Engagement/Performance	10%
Assignments	15%
Quizzes	10%
Research Project	20%
Midterm Exam I	15%
Midterm Exam II	15%
Final Exam	15%
Total	100%

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

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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

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-attende disrupts the flow of the class for both the instructor and the other students.

Additional information (During Online Course offering Period)

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

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12.0 Course Topics

- Introduction to drilling engineering and petroleum engineering units.
- Drilling rig systems, planning and managing, drilling operations.
- An overview of drilling engineering and mud pump and hoisting system design.
- Well control, kick, and monitoring system.
- Drilling fluids composition and rheology.
- Drilling fluid hydraulics.
- Formation pore and fractures pressure estimation.
- Cementing design.
- Basic concepts of casing and its properties, casing design and selection criteria including casing design criteria.
- Basic concepts of rotary drilling bit and classification, drilling bit tooth wearing, design, selections, and evaluation.
- Fundamental concepts of drillstring and bottom-hole assembly.
- Drillstring and bottom-hole assembly design/evaluation.
- Factors affecting rate of penetration (ROP) and ROP optimization techniques.
- Drill-off test and drilling response test.
- Prediction and detection of abnormal pressure zones.
- Basic concepts of directional drilling, importance, classification, and planning of a directional well path.
- Well planning and wellbore surveying techniques.
- Drilling costs estimation and authorization for expenditure (AFE)

Requirements/Instructions

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

Bundled Program Description

These bundled courses program is designed for the audiences who are interested to learn the about in-depth of drilling engineering related to oil and gas operations through enough practices on scientific theories and mathematical relations in the form of workout examples and exercises, and Q&A session mode. The course content is designed for audiences who are in diploma or undergraduate level and early career professionals in petroleum, oil and gas industry and interested in learning drilling engineering in details. This program includes all the basic aspects and in-depth design of drilling engineering including an introduction to drilling engineering, rig operations, drilling fluids, drilling hydraulics, well control and monitoring system, pore and fracture pressure estimation, drillstring and drill bit design, cementing jobs design, casing design, horizontal and directional drilling and drilling cost analysis.

This program contains three modules (Module I – III) and each module contains 12 to 16 lectures. Students are strongly advised to complete the course title “Basics of Drilling Engineering I and Drilling Engineering II” by Prof. M. Enamul Hossain at NSRIC Platform to understand this course content.

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13.0 Course Contents and Schedule

No.	Module	Topics	Remarks
Module I			
01	Introduction	Chapter 1-Introduction on basic drilling Engineering	
02	Drilling rig	Chapter 2a-Rig Components Mathematical Formulas	
03	Drilling rig	Chapter 2b-Rig Components Workout Examples and Exercises	
04	Drilling rig	Chapter 2c-Rig Components Exercises Solutions	
05	Drilling rig	Chapter 2d-Rig Components Self-Practices	Assessment 1
06	Drilling fluids	Chapter 3a-Drilling fluids Mathematical Formulas	
07	Drilling fluids	Chapter 3b-Drilling fluids Workout Examples and Exercises	
08	Drilling fluids	Chapter 3c-Drilling fluids Exercises Solutions	
09	Drilling fluids	Chapter 3d-Drilling fluids Self-Practices	Assessment 2
10	Drilling hydraulics	Chapter 4a-Drilling hydraulics Mathematical Formulas	
11	Drilling hydraulics	Chapter 4b-Drilling hydraulics Workout Examples and Exercises	
12	Drilling hydraulics	Chapter 4c-Drilling hydraulics Exercises Solutions	
13	Drilling hydraulics	Chapter 4d-Drilling hydraulics Self-Practices	Assessment 3
Module II			
14	Well Monitoring	Chapter 5a-Well Monitoring Sys Mathematical Formulas	
15	Well Monitoring	Chapter 5b-Well Monitoring Workout Examples and Exercises	
16	Well Monitoring	Chapter 5c-Well Monitoring Sys Exercises Solutions	
17	Well Monitoring	Chapter 5d-Well Monitoring Sys Self-Practices	Assessment 4
18	Formation Pressure	Chapter 6a-Formation Pressure Mathematical Formulas	
19	Formation Pressure	Chapter 6b-Formation Pressure Workout Examples and Exercises	
20	Formation Pressure	Chapter 6c-Formation Pressure Exercises Solutions	
21	Formation Pressure	Chapter 6d-Formation Pressure Self-Practices	Assessment 5
22	BHA Design	Chapter 7a-BHA Design Mathematical Formulas	
23	BHA Design	Chapter 7b-BHA Design Workout Examples and Exercises	
24	BHA Design	Chapter 7c-BHA Design Exercises Solutions	
25	BHA Design	Chapter 7d-BHA Design Self-Practices	Assessment 6
Module III			
26	Casing Design	Chapter 8a-Casing Design Mathematical Formulas	
27	Casing Design	Chapter 8b-Casing Design Workout Examples and Exercises	
28	Casing Design	Chapter 8c-Casing Design Exercises Solutions	
29	Casing Design	Chapter 8d-Casing Design Self-Practices	Assessment 7
30	Cementing	Chapter 9a-Cementing Mathematical Formulas	
31	Cementing	Chapter 9b-Cementing Workout Examples and Exercises	
32	Cementing	Chapter 9c-Cementing Exercises Solutions	
33	Cementing	Chapter 9d-Cementing Self-Practices	Assessment 8
34	Directional drilling	Chapter 10a-Directional drilling Mathematical Formulas	
35	Directional drilling	Chapter 10b-Directional drilling Workout Examples and Exercises	
36	Directional drilling	Chapter 10c-Directional drilling Exercises Solutions	
37	Directional drilling	Chapter 10d-Directional drilling Self-Practices	Assessment 9
38	Drilling Costs	Chapter 11a-Drilling Costs Mathematical Formulas	
39	Drilling Costs	Chapter 11b-Drilling Costs Workout Examples and Exercises	
40	Drilling Costs	Chapter 11c-Drilling Costs Exercises Solutions	
41	Drilling Costs	Chapter 11d-Drilling Costs Self-Practices	Assessment 10

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Office of the CEO & President - Headquarters

+1-226-271-7206

ceo@nsric.ca

Toronto, ON, Canada

www.nsrc.ca



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

Subtitle

The fundamental concepts for beginners and practicing engineers interested in learning drilling engineering through enough practical workout examples and solved exercises to have a deep understanding on each topic along with some self-practiced exercises for solutions.



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