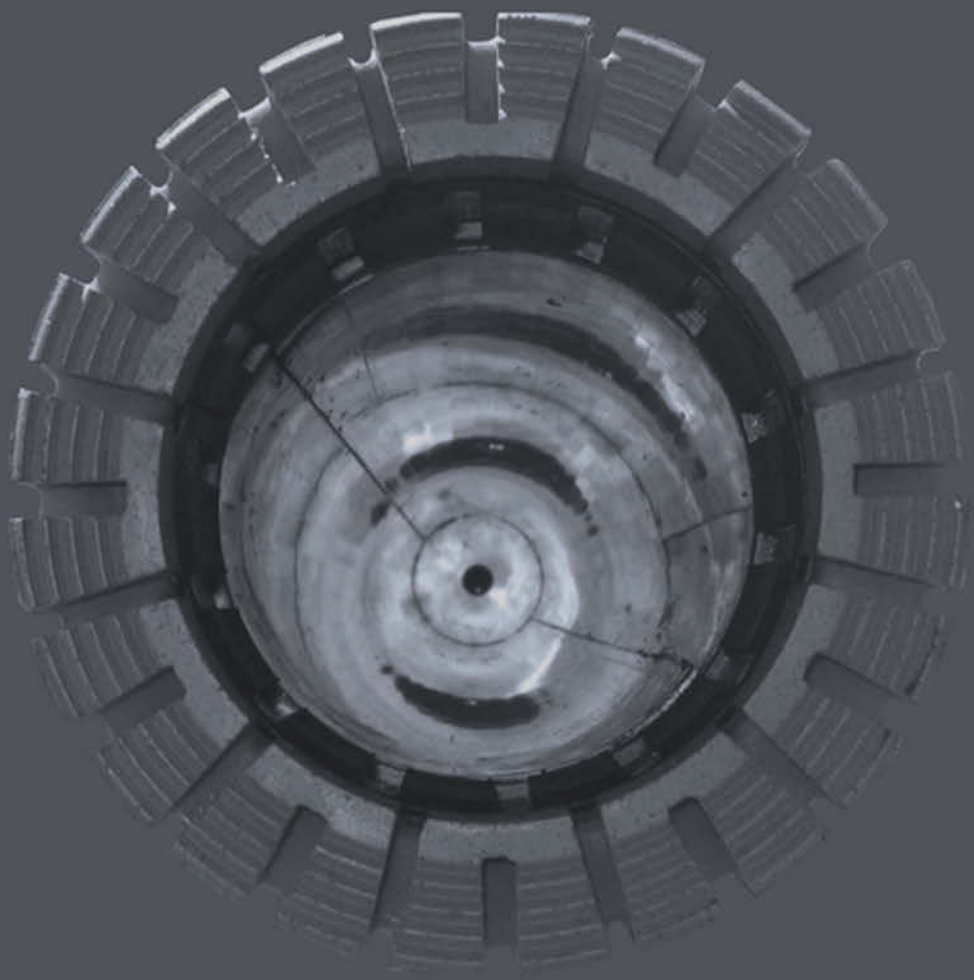
FUNDAMENTALS OF DRILLING ENGINEERING

Multiple Choice Questions and Workout Examples for Beginners and Engineers

M. Enamul Hossain



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To my grandfathers, the late Al-Haj Rahim Box Talukder (paternal) and the late Maheruzzaman Talukdar (maternal)

Contents

Preface

Petroleum energy continues to fuel the modern-day economy. In petroleum operations, drilling plays the most prominent role. Financially, drilling costs typically account for 50 to 80% of exploration finding costs, and 30 to 80% of field development costs. Drilling budget remains somewhat unaffected by the oil price. However, historically, whenever oil prices dwindle, the number of drilling rigs decreases. As we enter the Information Age, oil price declines correlate with decreasing drilling rig numbers but the oil production per new well continues to increase. This puts an extraordinary constraint on the efficiency of drilling technology and shows that today's drilling engineers must work with unparalleled efficiency. Anything that is done in petroleum drilling operations becomes a template for other drilling applications, such as exploration of other natural resources, environmental monitoring and remediation underground excavation and infrastructure development and general subsurface exploration. Yet, there is no textbook that has step-by-step procedures with explicit citation of worked out examples. The current book is impeccable in its timing, scope and content.

There is an ancient Chinese proverb: "I read and I forget; I see and I remember; I do and I understand." One of the most important reasons that our current education system is becoming so outdated is that our textbooks fail to capture the imagination beyond what could be learned from the Internet. It is not an exaggeration to say that the Information Age will soon see conventional textbooks become redundant as a result of freely available information. It is refreshing to see that this book has taken the approach of "doing" in order to elucidate complex scientific and engineering phenomena. Numerous worked out examples are given from all aspects of drilling engineering as well as cost analysis and well completion. Examples from horizontal and vertical drilling cases are given liberally. This dexterity makes the book suitable for both North America/Europe and the Middle East, where horizontal and vertical wells are prevalent, respectively. Questions are set in such a way that there is room for creative design and learning with maximum efficacy. Examples are such that the book is useful for both students and practicing engineers.

This book is useful for every student, academic and practicing engineer interested in knowing drilling operations and learning design techniques hands-on. Even though the book pertains to petroleum drilling, it is equally useful for drilling in other disciplines. The book will be remembered as a pioneering work both in content and form and as a template for future textbooks that should be written in a format different from old-style textbooks.

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Summary

Drilling engineering is one of the oldest technologies on earth. The technological advancement in this area is well recognized by scientists, engineers, researchers and petroleum industries. The technological advancement and good understanding in drilling engineering is the key to success in this information era. Unfortunately, the petroleum industry is one of the most hazardous and expensive branches of the industrial hub. The risk and uncertainty are due to the knowledge gap in drilling technology and the science behind it. In addition, 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, multiple choice questions (MCQs) in the area of drilling engineering. To date there are several textbooks that explain and cover drilling operations with fundamentals of drilling engineering. Unfortunately, there is no book so far where enough workout examples, exercises, and MCQs exist as an independent book. As the first and only complete guide for petroleum engineering students, trainee engineers on basic drilling engineering and a milestone book for basic illustrations and understanding, this book is the best choice for the drilling engineering community. It will be a unique production in this discipline.

The book also covers the fundamental issues for beginners who are interested in learning drilling engineering through enough workout examples in each chapter, exercise, exercises for self-practice, enough MCQs to have a deep understanding on each topic and some self-practice MCQs. The book explains the concepts of the basic subject matter clearly and presents the existing knowledge ranges from the history of drilling technology to well completion. The book 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. In addition, each chapter contains enough workout examples and exercises for a comprehensive understanding of the subject. This will make the reader interested in reading the book. The book explains the scientific concepts in the form of MCQs, mathematical formulations in a readable fashion very clearly. It includes all the basic aspects 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, basics of drillstring design, cementing jobs design, drillbit and casing design, horizontal and directional drilling, drilling cost analysis and finally, well completions. However, we believe that each chapter deserves to be a short book and we tried to focus on the most important

concepts and main topics of the subject matter. The book is a foundation and resource guide, and an excellent resource for petroleum engineering students and drilling engineers who want to learn how to design and calculate different drilling engineering calculations in the classroom and field.

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1

Introduction

1.1 Introduction

This book is designed to help in solving the exercises and workout examples that are related to drilling engineering. This chapter introduces the fundamental aspects of the drilling engineering problems in general. Sets of multiple choice questions (MCQs) are included which are related to basic definitions about drilling engineering, importance and the procedure for drilling operations. The MCQs also cover the applications and history of drilling, the systematic approach and the aspects of sustainable drilling operations. The MCQs are based on the writer's textbook, *Fundamentals of Sustainable Drilling Engineering* – ISBN: 978-0-470-87817-0.

1.2 Introduction to Drilling Engineering

Some scholars consider petroleum hydrocarbons to be the lifeblood of modern civilization. The complete cycle of petroleum operations includes seismic survey, exploration, field development, hydrocarbon production, refining, storage, transportation/distribution, marketing, and final utilization to the end user. The drilling technology has been developed through the efforts of many individuals, professionals, companies and organizations. This technology is a necessary step for petroleum exploration and production. Drilling is one of the oldest technologies in the world. *Drilling engineering is a branch of knowledge where the design, analysis and implementation procedure are completed to drill a well as sustainable as possible*. It is the technology used to utilize crude oil and

natural gas reserves. The responsibilities of a drilling engineer are to facilitate the efficient penetration of the earth by wellbore and cementing operations from the surface to an optimum target depth that prevents any situation that may jeopardize the environment.

1.3 Importance of Drilling Engineering

It is well known that the petroleum industry drives the energy sector, which in turn drives modern civilization. Every day human beings are benefiting from the petroleum industry. Modern civilization is based on energy and hydrocarbon resources. The growth of human civilization and the necessities of livelihood over time inspired human beings to bore a hole for different reasons (such as drinking water, agriculture, hydrocarbon extraction for lighting, power generation, to assemble different mechanical parts, etc.). There is no surface hydrocarbon resource; rather, all resources are underground in this planet. To keep serving the whole civilization, drilling engineering has a significant role in this issue. Moreover, the world energy sector is dependent on drilling engineering. Without drilling a hole, how are we going to extract the hydrocarbon from underground and bring it to the surface of the earth? To the best of our knowledge, right now, there is no alternative technology available to extract hydrocarbon without drilling a hole. If the petroleum industry falls, the whole civilization will probably collapse. Therefore, for the survival of our existence, we need to know and keep updating our knowledge especially about the technology, drilling engineering. Based on this motivation, the human necessity of drilling a hole by excavation on earth has motivated researchers to develop different sophisticated technologies for drilling engineering. Drilling engineering has a vital role in our daily life, economy, society, and even in national and international politics.

1.4 Application of Drilling Engineering

In the development of human civilization over time, human beings have needed to make a hole in different objects for different purposes. This ranges from just a child playing a game with a toy to the drilling of a hole for the purpose of any scientific and technological usage. Humans have been using this technology for underground water withdrawal since ancient times. Drilling technology is a widely used expertise in the applied sciences and engineering such as manufacturing industries, pharmaceutical industries, aerospace, military defense, research laboratories, and any small-scale laboratory to a heavy industry like petroleum. Modern cities and urban areas use drilling technology to get underground water for drinking and household use. The underground water extraction by boring a hole is also used for agricultural irrigation purposes. Therefore, there is no specific field of application of this technology. It has been used in a wide range of fields based on its necessity. This book focuses on drilling a hole with the hope of hydrocarbon discovery; therefore, here the drilling engineering application means a shaftlike tool (i.e., drilling rig) with two or more cutting edges (i.e., drill bit) for making holes toward the underground hydrocarbon formation through the earth layers, especially by rotation. Hence the major application of drilling engineering is to discover and produce redundant hydrocarbon from a potential oil field.

1.5 Multiple Choice Questions

1. Technology necessary for extracting oil and gas reserves is
   a) Drilling
   b) Coiled tubing
   c) Hydraulic fracturing
   d) None of the above
2. Technology which is used to utilize crude oil and natural gas reserves is
   a) Reservoir engineering
   b) Stimulation technology
   c) Drilling technology
   d) All of the above
3. All the hydrocarbon resources present on the globe are found
   a) At surface
   b) Underground
   c) At rivers
   d) None of the above
4. The only method available to extract hydrocarbon reserves to date is
   a) Process engineering
   b) Production engineering
   c) Drilling technology
   d) All of the above
5. In early days, drilling was done to extract
   a) Underground water
   b) Coal
   c) Oil and gas reserves
   d) None of the above
6. Large deposits of untapped crude oil was mostly hidden below the surface until the middle of which century?
   a) 1700
   b) 1900
   c) 1800
   d) None of the above
7. In early days, oil seeps were used for
   a) Medicinal purpose
   b) Caulk boats
   c) In buildings
   d) Lubricating machinery
   e) All of the above
8. The first oil was drilled
   a) In Iraq and in 450 BC
   b) In China and in 347 BC
   c) In Macedonia and in 325 BC
   d) In Canada and in 1857

9. The petroleum industry in the Middle East was established by the
   a) Ninth century
   b) Eighth century
   c) Seventh century
   d) None of the above
10. In early days, the Chinese were using _____ as modern drill pipe to extract oil.
   a) Bamboo
   b) Cable tool rig
   c) Rotary system
   d) None of the above
11. Mohammad ibn Zakariya Razi produced _____ from petroleum using the distillation process in the ninth century.
   a) Diesel
   b) Kerosene
   c) Gas
   d) All of the above
12. Distillation process became available in Western Europe through Islamic Spain by
   a) Eleventh century
   b) Twelfth century
   c) Tenth century
   d) None of the above
13. In the West, _____ was the first place of commercial production.
   a) United States
   b) Canada
   c) Brazil
   d) France
14. The first breakthrough in the oil industry's drilling history was the year _____.
   a) 1839
   b) 1849
   c) 1859
   d) 1921
15. The first oil well drilled in the United States was _____ ft deep.
   a) 59 feet
   b) 69 feet
   c) 79 feet
   d) 89 feet
16. The principal party in the oil industry is called
   a) Service company
   b) Operator company
   c) Contractor
   d) Consultant

17. The first task an operator has to do is the engagement of a
    a) Consultant
    b) Geologist
    c) Landman
    d) Surveyor

18. A _____ is hired by the operator to acquire drilling rights.
    a) Landman
    b) Surveyor
    c) Geologists
    d) None of the above

19. A contractor who owns the drilling rig and employs the crew to drill the well is called
    a) Drilling contractor
    b) Service company
    c) Operator
    d) None of the above

20. Operator hires _____ to conduct other rig jobs.
    a) Specialist consultants
    b) Geologists
    c) Landman
    d) Surveyor

21. Petroleum and mineral resources are usually owned by the _____ of the host country.
    a) Gangsters
    b) Government
    c) Private Sector
    d) Bureaucrats

22. _____ licenses allow licensees to drill for, develop and produce hydrocarbons from whatever depth is necessary.
    a) Exploration
    b) Production
    c) Drilling
    d) Seismic

23. A well that helps to determine the presence of hydrocarbons is called _____ well.
    a) Wildcat
    b) Development
    c) Exploration
    d) None of the above

24. A well that is drilled to establish the extent (size) of reservoir is called _____ well.
    a) Wildcat
    b) Development
    c) Appraisal
    d) None of the above

25. A well that is drilled in a proved production field or area to extract natural gas or crude oil is called _____ well.
    a) Wildcat
    b) Development
    c) Appraisal
    d) None of the above

26. A well that is sealed and closed is called an
    a) Wildcat
    b) Development
    c) Appraisal
    d) Abandonment

27. _____ licenses do not allow a company to drill any deeper than certain depth.
    a) Exploration
    b) Production
    c) Drilling
    d) Seismic

28. On average, only one in eight exploration wells are successful in _____.
    a) Red Sea
    b) North Sea
    c) Atlantic Ocean
    d) Pacific Ocean

29. The role of drilling engineer during drilling operations is
    a) Planning
    b) Design
    c) Supervision
    d) All of the above

30. Which one is not a type of drilling well?
    a) Exploration well
    b) Appraisal well
    c) Development well
    d) Wild dog Well

31. It is believed that the revolution of modern civilization benefited much from the revolution of:
    a) Drilling technology
    b) Seismic technology
    c) Oil industry
    d) EOR technology

32. Considering the lifecycle of the well, drilling operations are required at
    a) The middle stage of the lifecycle
    b) The initial stage of the lifecycle
    c) The last stage of the lifecycle
    d) All of them

33. The main objective of drilling engineering is to
    a) Have sustainable drilling operations
    b) Explore deep reservoirs
    c) Increase productivity
    d) Avoid breaking the formations

34. A sustainable drilling operation can be achieved by
    a) Efficient designing
    b) Analyzing the drilling data
    c) Implementing the right procedures
    d) All of the above

35. The responsibilities of a drilling engineer are to
    a) Decide the location of the well to be drilled
    b) Prepare the well pad
    c) Determine the depth of the well
    d) None of the above

36. Which of the following does the drilling engineer has some flexibility to decide on?
    a) Well location
    b) Well trajectory
    c) Well depth
    d) Well cost

37. Which of the following does the drilling engineer not have flexibility to decide on?
    a) Well location
    b) Casing depths
    c) Holes diameter
    d) Rig maintenance

38. For which of the following operations does the drilling engineer need assistance and recommendations?
    a) Drilling fluids design
    b) Cementing design
    c) Drill bits design
    d) All of the above

39. Which of the following is not one of the technologies needed to prove the existence of petroleum accumulations?
    a) Seismic technology
    b) Reservoir simulation
    c) Formation evaluation
    d) Drilling technology

40. Petroleum accumulations can only be proved after
    a) Performing seismic operations
    b) Performing reservoir simulation
    c) Drilling a well
    d) Well stimulation

41. Commercial hydrocarbon accumulations can only be proved after performing
    a) Well testing
    b) Well logging
    c) Drilling a well
    d) None of the above

42. Human civilizations used drilling technology for
    a) Drilling water wells
    b) Mega constructions
    c) Drilling oil wells
    d) All of the above

43. The first oil discovery was in _____, whereas the first nation to drill deep wells was _____
    a) China and Babylon
    b) Kirkuk and Macedonia
    c) Iraq and China
    d) Kirkuk and Canada

44. Breakthrough of oil production all over the world was in
    a) The eighteenth century
    b) The nineteenth century
    c) The twentieth century
    d) The twenty-first century

45. The earliest known oil well was drilled in
    a) Canada
    b) United States
    c) Macedonia
    d) China

46. The first country to drill a commercial oil well was
    a) China
    b) Canada
    c) United States
    d) Iraq

47. A small exploratory oil well drilled in land not known to be an oil field to get the geological information is known as
    a) Wildcat well
    b) Appraisal well
    c) Pilot well
    d) Abandonment well
48. A well drilled in a land that has dry wells drilled earlier is a/an
    a) Appraisal well
    b) Wildcat well
    c) Development well
    d) Observation well
49. A well drilled in a land which has one discovery well drilled is a/an
    a) Exploration well
    b) Development well
    c) Wildcat well
    d) Appraisal well
50. A well drilled in a land known to have proven commercial oil is a/an
    a) Wildcat well
    b) Appraisal well
    c) Injection well
    d) None of the above

Answers: 1a, 2c, 3b, 4c, 5a, 6c, 7e, 8a, 9b, 10a, 11b, 12b, 13b, 14b, 15b, 16b, 17a, 18a, 19a, 20a, 21b, 22b, 23c, 24c, 25b, 26d, 27a, 28b, 29b, 30b, 31c, 32b, 33a, 34d, 35d, 36b, 37a, 38d, 39b, 40c, 41a, 42d, 43c, 44c, 45d, 46b, 47a, 48b, 49d, 50c.

1.6 Summary

This chapter developed the MCQs on some of the core issues related to drilling engineering. Even before starting drilling operations, many activities need to be completed to fulfill the different parties' requirements, which are well covered here. Moreover, this chapter added some more MCQs for the student's self-practice and the answers are given in Appendix B. The MCQs covered almost all the materials covered in this chapter.

1.7 MCQs (Self-Practices)

The solutions are in Appendix B.

1. A well which is drilled with no traces of oil accumulations is known as
    a) Abandonment well
    b) Appraisal well
    c) Dry well
    d) Wildcat well

2. All of the following well types can be converted into a producing well except
   a) Injection well
   b) Exploration well
   c) Observation well
   d) Dry well
3. A producing well should be _____ in a sustainable fashion if it is not producing commercially any more
   a) Abandoned
   b) Shut in
   c) Stimulated
   d) None of the above
4. The first well that is drilled in a discovered field for gathering more information is called
   a) Exploration well
   b) Wildcat well
   c) Appraisal well
   d) All of the above
5. After drilling a wildcat well, which decision should be made right after completing the testing operation?
   a) Put the well on production
   b) Kill the well
   c) Abandon the well
   d) All of the above
6. The exploration well is drilled due to the following reason(s)—which one is the correct answer?
   a) Extent of the reservoir
   b) Oil existence
   c) Oil productivity estimations
   d) Production of oil
7. The appraisal well is drilled to find out
   a) Oil existence
   b) Rock and hydrocarbon properties
   c) Reservoir extent
   d) Reserve
8. The development well is drilled to
   a) Fix the designed rate
   b) Know the reservoir size
   c) Know the oil properties
   d) Extract hydrocarbons