

# MPE140: *ENGINEERING METHODS IN PETROLEUM SCIENCES*

## Preface

This course of lectures was initially designed for graduate students as the course describing methods of problem solving most commonly used in various engineering applications. However, later on topics covered in these lecture notes were enhanced by several modern approaches and methods that are still considered as non-conventional but have a great potential for practical applications in the near future. Among those methods are:

- Theory of fuzzy sets and fuzzy logic
- Solution of multiple-objective problems
- Decision making under conditions of uncertainty, etc.

These notes are based on a course of lectures delivered by the author at the State Academy of Oil and Gas named after Gubkin (Moscow, Russia) in 1989 - 1991 (from 2002 – the Russian State University of Oil and Gas named after Gubkin), and later at Stavanger College (from 2005 – University of Stavanger, Norway). Approaches and methods described in this course are applicable to any type of problem. However, the emphasis is given to the petroleum engineering applications. Numerous examples from petroleum sciences such as reservoir geology, reservoir and production engineering, economics and decision making, helped to fulfill this task.

The context of the book is divided in two volumes. Volume I is a textbook while Volume II is a collection of exercises a reader is advised to solve. Both volumes have the same numeration of parts (Modules) and chapters which makes it easier to follow both volumes simultaneously.

Chapter 1 is an introduction to the deterministic and probabilistic approaches to data handling. It explains the major difference between two approaches, and describes basic concepts in probability. Several examples illustrate the application of these approaches to data handling.

Chapter 2 describes the least square method (LSM) – one of the most commonly used methods of the experimental data handling. One of important applications of LSM – classification task – is also described in this chapter.

Chapter 3 introduces the reader to the fuzzy sets and methods of handling fuzzy data. Examples included in the text, illustrate the applicability of fuzzy sets to the solution of various important engineering problems: classification of objects and their ranking, as well as optimization.

Chapter 4 acquaints the reader with dimensional analysis, similarity and self-similarity, and their practical application. A special emphasis is given to a very important and yet

often underestimated area of application: scaling up an experiment which, in its most features, should reflect a prototype phenomenon.

Different approaches to the reservoir performance modeling are described in chapter 5. Models of different scale of observation (i.e., micro-models, network models, models based on principles of continuum mechanics, etc.) are considered and a hierarchy of models is briefly described enabling to endorse connections between the models.

Chapters 6 and 7 are devoted to a graph-analytical method of solution to a particularly important classical reservoir engineering problem: a one-dimensional (1-D) two-phase flow of fluids in porous media. The importance of this problem to reservoir engineering is that it is based on physical assumptions identical to those which most of the numerical simulators are built upon. Yet a simple analytical solution obtainable in case of 1-D flow enables to efficiently conduct comparative analysis of quite complex in nature enhanced oil recovery processes like surfactant and polymer flooding, gas and steam injection, water alternate gas (WAG) injection, etc. However, introducing this technique to the reader, we restricted ourselves to a simplest case of a two-phase flow, namely, immiscible displacement of oil by water, e.g. waterflooding.

Chapter 8 serves as a short introduction to inverse problems and their solutions. The text is illustrated by a simple example of averaging (upscaling) the reservoir properties.

Chapters 9 and 10 introduce the reader to the basics of a systems approach and decision analysis. This is followed by chapters 11 – 13 dealing with decision under certainty, multiple-objective problems, and decision under uncertainty and risk.

The last chapter included in Volume II represents an exercise on selecting the best scenario of an oil field development. Students should solve this exercise using any combination of the methods described previously.

A reference list is given at the end of the book, where only some necessary references and key publications are included.

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