Identification	**Subject**	PETE 570 – Numerical Reservoir Simulation – 6 ECTS credits
	Department	Petroleum Engineering
	Program	Graduate
	Term	Fall, 2023
	Instructor	Rashad Nazaraliyev
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	Phone:	
	Classroom/hours	
	Office hours	
Prerequisites	Petroleum Reservoir Engineering, Differential Equations	
Language	English	
Compulsory/Elective	Compulsory	
Required textbooks and course materials	• Reservoir Simulation, Heriot Watt manual, 2005 • Lie (2019) An introduction to reservoir simulation using MATLAB/GNU Octave: User Guide for the Matlab Reservoir Simulation Toolbox (MRST). Cambridge University Press. • Field, M. and Golubitsky, M. (2009) Symmetry in chaos: A search for pattern in mathematics, art, and nature. Philadelphia: Society for Industrial and Applied Mathematics.	
Course outline	The course is designed for graduate students. Understanding of advanced reservoir engineering concepts is strongly required along with mathematical concepts including solution of ordinary and partially differential equations (ODE and PDE). Coding skills is expected from students for project implementation. Project is advised to be implemented using MATLAB but not limited to it (e.g., Python, etc. are welcomed). The goal is to build a reservoir simulator using MATLAB. Short introduction to MATLAB will be provided to students.	
Course objectives	The objectives are to improve analytical thinking and develop numerical computational skills regarding reservoir simulation and build own reservoir simulator. Implementation includes analysis of advanced reservoir engineering concepts, investigation of ODEs and PDEs used in reservoir simulation, linear algebra, numerical solution techniques. The key objective is understanding of commercial software and duplication of simple models. Case studies will be investigated which includes various EOR techniques. The overall aim of this course is to: • develop an understanding of the role of simulation in reservoir engineering, • gain insight into the value of simulation, • acquire further appreciation of reservoir engineering and the theory of fluid flow. **Class assignments** will be provided during the tutorial. It will be MRST based assessments. **Project** will mainly include case studies. Research skills and the techniques that learnt during class assignments and practical exercises will be the tools to complete the projects**.**	
Learning outcomes	On completion of the course, the student should be able to: • Appreciate of the use, application and impact of reservoir simulation in reservoir engineering • Understand the fundamentals of single phase incompressible and compressible flow • Understand the fundamentals of two phase flow • Understand the principles of numerical flow simulation • Describe the workflow for reservoir modelling and simulation • Demonstrate the concepts and techniques of upscaling and history matching • Outline methods for simulation of more advanced processes	
Teaching methods	**Lecture**	x
	Group discussion	x

	Practical exercises		x
	Simulation		x
	Case analysis		x
Evaluation	**Methods**	**Date/deadlines**	**Percentage (%)**
	Midterm Exam		30
	Class Participation		5
	Assignments		5
	Project		20
	Final Exam		40
	Total		100

- Class participation and activity during the class will be evaluated. The student receives 5 bonus points at the end of the semester if they attend all classes and follow all course policies and procedures.
- Assignments will be distributed throughout the classes to assess the participant's activity in lectures, practical classes and in the learning process in general.
- Projects will be distributed throughout the classes. A project represents an individual/collective endeavor undertaken by students within the realm of scientific inquiry. The incorporation of projects into the curriculum serves the dual purpose of showcasing the subject's research endeavors to potential students and illuminating the ongoing scholarly activities within the field. Projects will be conducted close to the end of semester in November. The project presentation date, time and structure will be announced during the semester.
- Midterm will be carried out in the week announced by the university. Time allocated will be announced close to the midterm. A midterm examination is a test administered approximately midway through an academic grading term, be it a quarter or semester. Its primary objective is to provide students with a clearer assessment of their progress within the course, enabling them to gauge their performance and understanding up to that point.
- Final exam date and time will be defined by the University. A final examination is an evaluative assessment presented to students at the conclusion of an academic term or course of study. This assessment typically consists of a predefined set of questions or exercises designed to gauge students' proficiency and comprehension of the subject matter.

Policy

- **Preparation for class**

The structure of this course makes your individual study and preparation outside the class extremely important. The lecture material will focus on the major points introduced in the text. Reading the assigned chapters and having some familiarity with them before class will greatly assist your understanding of the lecture. After the lecture, you should study your notes, assigned chapters and get ready for class assignments. Throughout the semester students will also have practical exercises and quizzes.

- **Withdrawal (pass/fail)**

This course strictly follows grading policy of Graduate School of Science, Art and Technology. Thus, a student is normally expected to achieve a mark of at least 60% to pass. In case of failure, he/she will be required to repeat the course the following term or year.

- **Cheating/plagiarism**

Cheating or other plagiarism during the Quizzes, Mid-term and Final Examinations will lead to paper cancellation. In this case, the student will automatically get zero (0) without any considerations.

- **Professional behavior guidelines**

The students shall behave in the way to create favorable academic and professional environment during the class hours. Unauthorized discussions and unethical behavior are strictly prohibited.

- **Expected behavior**

Includes attending all class activities; meeting deadlines; observing common courtesies to fellow students, teachers, and staff; being honest; making a diligent effort to learn; and does not engage in any disruptive irresponsible manner. Legitimate collaboration is encouraged but academic collusion or dishonesty will not be tolerated.

- **Class attendance**

Attendance is required! Please be in class on time. Attendance will be taken at the beginning of each class period. In case you are not present when attendance sheet is passed on, you will be marked absent. If you are late for more than 10 minutes you will not be allowed into the classroom not to cause distraction. You will receive a Dean's warning if you miss more than 3 classes and shall be dismissed from the course if you miss more than 5 classes. You shall receive 5 bonus points at the end of the semester if you attend all classes and follow all course policies and procedures.

- **Class discussion**

Feel free to voice your opinions and ask questions anytime during a class period. Practice your right and freedom to learn. Remember you are here to learn and we are here to teach and that teaching and learning are forever intertwined. You can help me teach you as much as I can help you learn. Be an active participant in the learning process!

Tentative Schedule

Week	Date/Day (tentative)	Topics	Textbook/Assignments

1		Introduction to Reservoir Simulation, Uses of reservoir simulation, Numerical and analytical solutions, Case studies in reservoir simulation, Introduction to MRST	HWU, Ch. 1
2		Review of basic reservoir engineering and material balance, Revision of Darcy's Law, STOIIP calculation, Fractional flow theory, Buckley-Leverett Exercise	HWU, Ch. 2
3		Different types of grids, Averaging properties between grid blocks, Buckely-Leverett Exercise, Wells in reservoir simulation, Wells in MRST	HWU, Ch. 3
4		Derivation of single-phase equations, Pressure diffusion, Simplification of pressure equation, Flow simulation in cross-section, Derivation of 2-phase flow equations	HWU, Ch. 4
5		Discretization of the single-phase pressure equation, Discretization of simple 2-phase flow equations	HWU, Ch. 5
6		Solution of Linear Equations, Solution of non-linear equations, Explicit pressure calculation, Solution of linear equations	HWU, Ch. 5
7		Introduction to modelling, Calculation of semivariogram, Natural Water Influx, Permeability averaging exercise, Upscaling of Two-Phase Flow, Numerical upscaling	HWU, Ch. 6
8		**Mid-term Exam**	
9		Capillary Pressure, Relative permeability, Hysteresis and Wettability, Effect of Wettability	HWU, Ch. 7
10		Introduction to History Matching, Workflow for History Matching	HWU, Ch. 8
11		Introduction to EOR, Chemical and Thermal EOR	HWU, Ch. 9
12		Fractured Reservoirs, History Matching	HWU, Ch. 9
13		Revision	
14		Revision	
16	TBA	**Final Exam**	

This syllabus is a guide for the course and any modifications to it will be announced in advance.