Identification	Subject	PETE570, Numerical Reservoir Simulation, 6 ECTS
	Department	Petroleum Engineering
	Program	Graduate
	Term	Spring 2026
	Instructor	Umid Shikhmammadov
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	Phone:	
	Classroom/hours	Thursday
	Office hours	
Prerequisites	Advanced petroleum reservoir engineering	
Language	English	
Compulsory/Elective	Compulsory	
Required textbooks and course materials	*Core textbooks:* *Reservoir Simulation: Mathematical Techniques in Oil Recovery,* Zhangxin Chen, 2007 *Advances in Reservoir Simulation,* Eds. Haifeng Zhao, Xia Yang, etc., 2025 *Supplementary material:* Class Lecture Handouts and Additional Reading Materials	
Course outline	The course is designed for graduate students. Understanding of advanced reservoir engineering concept is strongly required along with mathematical concepts including solution of ordinary and partially differential equations (ODE and PDE). Some coding skills are expected from students for project implementation. Students will be evaluated through: **Project:** Python-based processing and analysis of numerical reservoir simulation input and output files, including automated data extraction, interpretation of simulation results, calculation of reservoir performance indicators, and graphical visualization of production and reservoir behavior trends for reporting and decision-making. **Quiz** is aimed to test students on particular topics. Group discussion among students and following presentation is demonstration phase of the project. The aim is to improve teamwork and presentation skills. In the **Presentation/Group Discussion** part, students should conduct research on the topics assigned to them and prepare a presentation covering the topics they researched **Class participation** will consider students' attendance in class as well as their level of activity during the classes they attend	
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. Although it is not a primary objective, use of commercial softwares is crucial. Case studies will be investigated.	
Learning outcomes	**By the end of the course the students should be able:**	

	▪ To apply reservoir engineering concepts for numerical simulation ▪ To manage input data ▪ To treat Parabolic and Hyperbolic equations ▪ To work with various types of discretization techniques in time and space ▪ To implement Cartesian grids construction ▪ To solve tridiagonal matrix equations ▪ To analyze Simultaneous and Implicit Pressure Explicit Saturation solution methods and their convergence properties ▪ To analyze Sequential Solution Method ▪ To solve pentadiagonal matrix equations including LU method ▪ To treat wells as source or sink terms ▪ To couple reservoir-wellbore hydraulics models ▪ To code own simulator ▪ To work with commercial software (eg. Eclipse) ▪ To link disciplines and data management used in reservoir simulation ▪ To analyze state-of-the-art advances of the current field ▪ To demonstrate ability for construction of other complicated models	

Teaching methods		
	Lecture	X
	Group discussion	X
	Experiential exercise	X
	Simulation	X
	Case analysis	X
	Course papers	X
	Others	

Evaluation			
	Methods	**Date/deadlines**	**Percentage (%)**
	Midterm Exam		30
	Class Participation		5
	Assignment and quiz		10
	Project		10
	Presentation/Group Discussion		5
	Final Exam		40
	Total		100

Policy	
	Midterm exam 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. Quiz will cover the materials covered in previous classes and will be consist of open-ended questions. Quiz will be distributed throughout the classes. Overall, 15 points will be given for one quiz. There will be only 1 quiz during semester. Anticipated week for the quiz is week 5. Date and time will be

announced a week before.

Project will be Python-based processing and analysis of numerical reservoir simulation input and output files, including automated data extraction, interpretation of simulation results, calculation of reservoir performance indicators, and graphical visualization of production and reservoir behavior trends for reporting and decision-making.

The student receives 5 bonus points for the class participation and activity at the end of the semester if they attend all classes and follow all course policies and procedures.

Presentation/Group Discussion will be conducted close to the end of semester in December. Date and time will be announced during the semester. A presentation/group discussion is a collaborative activity of students relating to research about drilling technology. The reasons for including a presentation/group discussion in the subject course is to evaluate the students' individual presentation skills and ability to work in groups.

A final examination is an exanimation administered at the end of an academic term, with a set of questions or exercises evaluating the skill or knowledge of students. 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.

- **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 and work relevant problems and cases from the end of the chapter and sample exam questions.

- **Withdrawal (pass/fail)**

Students are expected to achieve a mark of at least 65% 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 consideration.

	▪ **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.

Tentative Schedule			
Week	**Date/Day (tentative)**	**Topics**	**Textbook/ Assignments**
1	19.02.26	Introduction, an overview of the course objectives, structure, and key topics to be covered in the field of numerical reservoir simulation.	Lecture Handouts, ***Reservoir Simulation: Mathematical Techniques in Oil Recovery,*** *Zhangxin Chen* , Ch-1
2	26.02.26	Knowledge sharing of practical applications, A dedicated session for discussing real-world applications of reservoir simulation, encouraging students or participants to share practical experiences and industry-based insights.	Lecture Handouts, ***Advances in Reservoir Simulation,*** Eds. Haifeng Zhao, Xia Yang, etc., 2025, Ch-1
3	05.03.26	Basic Concepts in Reservoir Engineering Reservoir Simulation Model set-up, A detailed introduction to the fundamental principles of reservoir engineering, including fluid properties, rock characteristics, and reservoir drive mechanisms.	Lecture Handouts, ***Reservoir Simulation: Mathematical Techniques In Oil Recovery,*** *Zhangxin Chen* , Ch-1
4	12.03.26	Gridding in Reservoir Simulation, A study of grid design techniques used in simulation, such as structured and unstructured grids, grid refinement, and the impact of gridding on simulation accuracy and performance.	Lecture Handouts, ***Reservoir Simulation: Mathematical Techniques In Oil Recovery,*** *Zhangxin Chen* , Ch-3
5	18.03.26	Wells in Reservoir Simulation, An in-depth discussion on how wells are modeled within a simulation framework, covering well types, completions, productivity indices, and well control options.	Lecture Handouts, ***Advances in Reservoir Simulation,*** Eds. Haifeng Zhao, Xia Yang, etc., 2025, Ch-2
6	19.03.26	Single Phase Pressure equations, A mathematical formulation and numerical implementation of pressure equations in single-phase flow systems within porous media.	Lecture Handouts, ***Reservoir Simulation: Mathematical Techniques In Oil***

			Recovery, Zhangxin Chen , Ch-3
7	02.04.26	Single Phase Pressure equations, Further exploration and solution of single-phase flow equations, including boundary conditions, discretization methods, and solver strategies.	Lecture Handouts, ***Reservoir Simulation: Mathematical Techniques In Oil Recovery,*** *Zhangxin Chen* , Ch-3
8		**Midterm Exam**	
9	09.04.26	Two Phase Flow equations, Introduction to the governing equations for two-phase (oil-water or gas-oil) flow in porous media, emphasizing the coupling between pressure and saturation.	Lecture Handouts, ***Reservoir Simulation: Mathematical Techniques In Oil Recovery,*** *Zhangxin Chen* , Ch-5
10	16.04.26	Two Phase Flow equations, A continuation of the study of two-phase systems, focusing on solution techniques, numerical stability, and practical implementation issues.	Lecture Handouts, ***Reservoir Simulation: Mathematical Techniques In Oil Recovery,*** *Zhangxin Chen* , Ch-5
11	23.04.26	Numerical Methods in Reservoir Simulation, A comprehensive review of numerical techniques such as finite difference, finite volume, and Newton-Raphson methods used in solving the reservoir flow equations.	Lecture Handouts, ***Reservoir Simulation: Mathematical Techniques In Oil Recovery,*** *Zhangxin Chen* , Ch-6
12	30.04.26	Data Management, Discussion on managing large datasets in reservoir simulation projects, including input data handling, output visualization, and simulation result interpretation.	Lecture Handouts, ***Advances in Reservoir Simulation,*** Eds. Haifeng Zhao, Xia Yang, etc., 2025, Ch-3
13	07.05.26	Case Studies	Lecture Handouts, ***Advances in Reservoir Simulation,*** Eds. Haifeng Zhao, Xia Yang, etc., 2025, Ch-2
14	14.05.26	Compositional Simulators, Introduction to compositional modeling, including the use of equations of state to model multicomponent systems and simulate complex processes like gas injection or miscible flooding.	Lecture Handouts, ***Reservoir Simulation: Mathematical Techniques In Oil Recovery,*** *Zhangxin Chen* , Ch-8
15	21.05.26	Thermal Simulators, Exploration of thermal simulation techniques used in modeling heat transfer within	Lecture Handouts, ***Reservoir Simulation:***

		reservoirs, especially for enhanced oil recovery processes such as steam injection and in-situ combustion.	*Mathematical Techniques In Oil Recovery,* Zhangxin Chen , Ch-8
16		**Final Exam**	

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