Identification	**Subject**	PETE540 – Advanced Petroleum Reservoir Engineering – 8 ECTS
	Department	Petroleum Engineering
	Program	Graduate
	Term	Spring, 2024
	Instructor	Ulviyya Asgarova
	E-mail:	ulviyya.asgarova@khazar.org
	Classroom/hours	11 Mehseti str. (Neftchilar campus), Tuesday 18:40 - 21:00
Prerequisites	Reservoir Engineering, Phase Behaviour, Fluid Characterization, Physics of oil and gas reservoirs	
Language	English	
Compulsory/Elective	Compulsory	
Required textbooks and course materials	• *Ahmed, T.H. (2010). Reservoir engineering handbook. Amsterdam; Boston: Gulf Professional Pub.* • *Dake, L.P. (2001). Fundamentals of Reservoir Engineering.* • *Cosse, Basics of reservoir engineering, 1993*	
Course outline	Course is aimed for master students. It addresses in depth review of Petroleum Reservoir Engineering discipline and identification of reservoir characteristic. Reservoir analysis is the one of the main concerns of the course. The course combines theoretical foundations with practical applications. We will begin with a general overview in each topic and then go into more detail on several concepts. Students will be evaluated through: • **Problems** – to evaluate the ability of the student to cope with the given material. • **Presentation and group discussions** – to evaluate the students' individual presentation skills and ability to work in groups.	
Course objectives	This course explains the fundamentals of reservoir engineering and their practical application in conducting a comprehensive field study. 1st mid-term includes fundamentals of reservoir fluid behaviour with an emphasis on the classification of reservoir and reservoir fluids. Here the fundamental mathematical expressions that are used to describe the reservoir fluid flow behaviour in porous media. Principles of oil and gas well performances calculations are also discussed. Parallel you will be deeply familiar with water influx processes in reservoir. In the 2nd mid-term, it is introduced the basic principle of oil recovery mechanisms and presented by the generalized form of the material balance equation. Later, waterflooding and Enhanced Oil Recovery methods will be discussed. After gaining knowledge about Gas and fractured reservoirs, modern approach such as reservoir simulation will be discussed and illustrated at the end of the course.	
Learning outcomes	**By the end of the semester, students should be able to gain or improve thefollowing skills:** • Identify and articulate reservoirs by pressure-temperature diagrams • Formulate and calculate different types of fluid flow in reservoir • Formulate and calculate flow in reservoir for any kind of geometry • Classify numerical and analytical aquifers • Analysing fluid flow through in porous media • Understand how to solve unsteady state PDE. • How to use dimensionless method to obtain flow parameters in reservoir. • Understand recovery mechanisms by using Material Balance Equation • Familiarize with Reservoir Simulation (Dynamic modelling) • Analysing two phase flow. • Application relative permeability curves in reservoir engineering problems	

<table>
<tr><td rowspan="4">Teaching methods</td><td colspan="2">Lecture</td><td>x</td></tr>
<tr><td colspan="2">Group discussion</td><td>x</td></tr>
<tr><td colspan="2">Practical exercise</td><td>x</td></tr>
<tr><td colspan="2">Case analysis</td><td>x</td></tr>
<tr><td rowspan="3">Evaluation</td><td>Methods</td><td>Date/deadlines</td><td>Percentage %)</td></tr>
<tr><td>Midterm Exam</td><td>TBA</td><td>30</td></tr>
<tr><td>Class Participation</td><td></td><td>5</td></tr>
<tr><td rowspan="4"></td><td>Presentation/Group Discussion</td><td>TBA</td><td>10</td></tr>
<tr><td>Quiz</td><td>TBA</td><td>15</td></tr>
<tr><td>Final Exam</td><td>TBA</td><td>40</td></tr>
<tr><td>Total</td><td></td><td>100</td></tr>
<tr><td>Policy</td><td colspan="3">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.

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 individual study and preparation of students outside the class very 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 student's understanding of thelecture. After the lecture student should study his notes, work relevant problems and cases from the end of the chapter.

• Withdrawal (pass/fail)
This course strictly follows grading policy of the School of Science and Engineering. Student is normally expected to achieve a mark of at least 65% to pass. In case of failure, he/she will be required to retake the course the followingterm or year.</td></tr>
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	• **Cheating/plagiarism** Cheating or other plagiarism during the Quizzes, Mid-term and Final Examinations will lead to paper cancellation and invalidation of student's results. • **Professional behaviour guidelines** Students shall behave in professional way to create favourable academic environment during the class hours for themselves and their colleagues. Unauthorized discussions and unethical behaviour are strictly prohibited. • **Expected behaviour.** 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 the attendance sheet is passed on, you will be marked absent. If you are late by 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	20.02.2024	Introduction to reservoir engineering: Understand the location, formation, fluid content of a hydrocarbon reservoir; understand the definitions of reserves; be aware of the role of reservoir engineering in exploration and development.	Chapter 1
2	27.02.2024	Reservoir pressure and temperature: Formation fluid density and pressure gradient in the reservoir; location of water/oil/gas contacts; use of contacts and pressure gradients to delineate reservoir units; measurement of fluid gradients.	Chapter 2
3	05.03.2024	Reservoir fluids composition: Understanding composition of hydrocarbon fluids; classification systems based on density; simple models of fluid behaviour	Chapter 3
4	12.03.2024	Phase behavior of hydrocarbon systems: Define: system, components, phases, equilibrium, intensive and extensive properties; understand relationship between pressure and temperature and phase for single and multi-component systems; define the expected phase changes in a reservoir fluid as it is produced to surface. Behavior of gases: Define equation of state wrt a reservoir gas; modify pv=nrt to account for compressibility factor z (pv=znrt); use of pseudo critical values to account for gas mixtures; calculation of gas volumes and gas formation factor; use of equations of state in volume calculations.	Chapter 4, 5
5	**19.03.2024**	**Novruz Holiday**	
6	**26.03.2024**	**Novruz Holiday**	
7	02.04.2024	Properties of reservoir liquids: Definition of black oil and compositional models of reservoir fluid; use of flash and differential liberation to obtain black oil parameters; definition of Bo, Rs, Bg; define gas formation volume factor for a gas condensate; calculation of reservoir fluid viscosity. Fundamental properties of reservoir rocks: Definition of porosity and permeability; use of Darcy's Law to calculate permeability of single phase; definition of interfacial tension; use of capillary pressure to determine saturation changes in reservoir; definition of effective and relative permeability; use of drainage/imbibition curves to characterize reservoir relative permeability; understanding pore doublet model in relation to recovery factors in reservoir fluid systems	Chapter 6, 7, 8
8	**09.04.2024**	**Mid-term Exam**	
9	16.04.2024	Fluid flow in porous media - Understand the diffusivity equation in relation to slightly compressible systems; show the main flow regimes that can occur in a reservoir; calculate the steady state, unsteady state and pseudo steady state pressures in a reservoir; apply unsteady state relations to calculate pressure within a reservoir; understand the application of unsteady state techniques to well testing Drive mechanisms - Understand the relative compressibility in a reservoir system; indicate the dominate drive mechanisms for water, gas cap and solution gas drive systems; understand the effects of the drive mechanisms on production through time	Chapter 9
10	23.04.2024	Vapor-liquid equilibria - Define equilibrium ratio. Derive equations for vapor-liquid equilibrium calculations for real systems and explain the application of the equations; Derive and explain the use of equations to determine the dew point pressure and bubble point pressure of a fluid mixture; Describe in general terms the impact of separator conditions the gas-oil ratio and oil formation volume factor. PVT analysis - Describe the scope of PVT analysis; describe the main apparatus used in the experiments; Determine the bubble point pressure from a set of P vs. V relative volume test data;	Chapter 10
11	30.04.2024	Calculate oil formation volume factors above the bubble point; Determine the total formation volume factors above and below the bubble point; Determine the oil formation volume factors and gas-oil ratios for pressures below the bubble point pressure.	Chapter 11
12	07.05.2024	Material balance - Present a material balance (MB) equation for a dry gas reservoir with and without water drive; Demonstrate the linear form of the MB equation for a gas reservoir with water drive and comment on its application; Be able to derive the material balance equation including gas cap expansion, water influx and core	Chapter 12

		and water compressibility; Given the equation be able to identify the component parts of the MB equation, eg. gas cap expansion etc.; Comment briefly on the assumptions, significance, use, data and limitations of the MB equation.	
13	14.05.2024	Natural water influx - Calculate the total water influx resulting from a known aquifer volume in terms of total aquifer compressibility and pressure drop over the aquifer; Sketch and describe the Schiltuis steady state model and the Van Everdingen and Hurst Unsteady State Model for Water; Sketch the progressive pressure profile for a constant boundary pressure; Explain how a constant boundary pressure profile solution can be used for declining pressure aquifer/reservoir pressure; Calculate given prerequisite equations the water influx as a function of time for a declining pressure profile. Immiscible flow - Describe briefly the various benefits of water injection; Present a simple equation for the fractional flow of water in terms of water and oil flow rate; Comment briefly on the impact of ;angle of dip, capillary pressure, and velocity on the fractional flow; Plot a set of relative permeabilities and identify end-point relative permeabilities; Define mobility ratio and present an equation for it and calculate its value given relative permeability data; Generate a fractional flow curve given relative permeability and viscosity data for injected and displaced fluids; Derive the Buckley-Leverett Frontal Advance Equation; Show the shape of the fractional flow curve and its associated derivative curve and the progressive saturation displacement profile.	Chapter 13, 14, 15
14	**21.05.2024**	**Presentation/Group Discussion**	
15	**28.05.2024**	**Independence Day**	
16	**TBA**	**Final Exam**	

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