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| **Identification** | | | **Subject** | PETE 551:Fluid Flow in Porous Media- 4 credits | | |
| **Department** | Petroleum Engineering | | |
| **Program** | Graduate | | |
| **Term** | Fall, 2016 | | |
| **Instructor** | Jabrayil Eyvazov | | |
| **E-mail:** | jabrayil.eyvazov88@gmail.com | | |
| **Phone:** | (+994 77) 531-12-31 | | |
| **Classroom/hours** | 11 Mehseti str.(Neftchilar campus), Thursday18:30-21:20 | | |
|  | | | **Office hours** |  | | |
| **Prerequisites** | | | Consent of instructor | | | |
| **Language** | | | English | | | |
| **Compulsory/Elective** | | | Required | | | |
| **Required textbooks and course materials** | | | ***Coretextbook:***  Dr. R.W. Zimmerman –Flow in Porous Media ,2003  L.P. Dake- Fundamentals of Reservoir Engineering ,1978  Ahmed Tarek- Reservoir Engineering Handbook, 2001 | | | |
| **Course outline** | | | The dynamics of large fluid compartments – the ocean or the atmosphere,  even rivers and lakes – is often dominated by the nonlinear inertia term [v·∇]v which causes turbulence. Boundary conditions for these compartments are simple because the direct influence of the boundaries extends only through a small fraction of the flow domain. In contrast, the dynamics of fluids in porous media is generally dominated by the porous matrix which pervades the entire volume and leads to an efficient dissipation of the fluid’s kinetic energy.  ***Quizzes***  First quiz will be in 5th week and will be based on course materials which had been taught by between 1-5 weeks.  Second quiz will be in 13th week and will be based on course materials which had been taught by between 7-13 weeks.  ***Presentation***  Presentation will be conducted on the one of the topics of the course, which will be chosen by students.( They have to present real cases according to their research ) | | | |
| **Course objectives** | | | ***Generic Objective of the Course:***  Basic concepts of origin, accumulation and recovery of hydrocarbon fluids. Fluid properties, PVT behaviour and classification of hydrocarbon reservoirs. Material balance equations for gas cap, solution gas, depletion and water drive reservoirs, and gas reservoirs. Reservoir rock properties and core analysis procedures, porosity-permeability relationships. Darcy's law for linear and radial flow, steady-state and pseudo steady-state flow. Wellbore damage, skin-factor and well productivity. Horizontal wells. Wettability, capillary pressure and vertical distribution of reservoir fluids. | | | |
| **Learning outcomes** | | | **By the end of the course the students should be able to learn :**   * Reservoir Fluid Properties * Fundamentals of rock properties * Relative permeability * Drainage process * Imbibition process * Fundamentals of Reservoir Fluid Flow * Water and Gas Coning * Water Influx * Water and Gas injection | | | |
| **Teaching methods** | | | **Lecture** | | | x |
| **Group discussion** | | | x |
| **Experiential exercise** | | | x |
| **Simulation** | | | x |
| **Case analysis** | | | x |
| **Course paper** | | |  |
| **Others** | | |  |
| **Evaluation** | | | **Methods** | | **Date/deadlines** | **Percentage (%)** |
| **Midterm Exam** | |  | 30 |
| **Case studies** | |  |  |
| **Class Participation** | |  | 5 |
| **Assignment and two quizzes** | |  | 15 |
| **Project** | |  |  |
| **Presentation/Group Discussion** | |  | 10 |
| **Final Exam** | |  | 40 |
| **Others** | |  |  |
| **Total** | |  | 100 |
| **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 and work relevant problems .   * **Withdrawal (pass/fail)**   This course strictly follows grading policy of the School of Economics and Management. Thus, a student is normally 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.  **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 | 15.09.16 | **Fundamentals of reservoir and reservoir fluids**   * Classification of reservoirs and reservoir fluids * Pressure-temperature diagram * Oil reservoirs * Gas reservoirs * Undefined petroleum fractions | | | |  |
| 2 | 22.09.16 | **RESERVOIR-FLUID PROPERTIES**   * Properties of natural gases * Behavior of ideal gases * Behavior of real gases * Effect of non-hydrocarbon components of the Z-factor * Non-hydrocarbon adjustment methods * The Wichert-Aziz correction method * Correction for high-molecular weightgases * Direct calculation of compressibilityfactors * Compressibility of natural gases * Gas formation volume factor * Gas viscosity * Methods of calculating the viscosity of natural gases | | | |  |
| 3 | 29.09.16 | **RESERVOIR-FLUID PROPERTIES**   * Properties of crude oil systems * Crude oil gravity * Specific gravity of the solution gas * Gas solubility * Bubble-point pressure * Oil formation volume factor * Isothermal compressibility coefficient of crude oil * Oil formation volume factor for undersaturated oils * Crude oil density * Crude oil viscosity * Methods of calculating viscosity of the * dead oil * Methods of calculating the saturated oil * viscosity * Methods of calculating the viscosity of * the undersaturated oil * Surface/interfacial tension * Properties of reservoir water * Water formation volume factor * Water viscosity * Gas solubility in water * Water isothermal compressibility | | | |  |
| 4 | 06.10.16 | **FUNDAMENTALS OF ROCK PROPERTIES**   * Porosity * Absolute porosity * Effective porosity * Saturation * Average saturation * Wettability * Surface and interfacial tension * Capillary pressure * Capillary pressure of reservoir rocks * Capillary hysteresis * Initial saturation distribution in a reservoir * Leverett J-function * Converting laboratory capillary pressure data | | | |  |
| 5 | 13.10.16 | **FUNDAMENTALS OF ROCK PROPERTIES**   * Permeability * The Klinkenberg effect * Averaging absolute permeabilities * Weighted-average permeability * Harmonic-average permeability * Geometric-average permeability * Absolute permeability correlations * Rock compressibility * Net pay thickness * Resevoir heterogeneity * Vertical Heterogeneity * Areal heterogeneity | | | |  |
| 6 | 20.10.16 | **RELATIVE PERMEABILITY CONCEPTS**   * Two-phase relative permeability * Drainage process * Imbibition process * Two-phase relatie permeability correlations * 1 Wyllie and Gardner correlation * 2 Torcaso and Wyllie correlation * 3 Pirson’s correlation * 4 Corey’s method * 5 Relative permeability from capillary pressure data * 6 Relative permeability from analytical equations * Relative permeability ratio * Dynamic pseudo-relative permeabilities * Normalization and averaging relative permeability data * Three-phase relative permeability * Three-phase relative permeability correlations * Wyllie’s correlations * Stone’s model I * Stone’s model II * The Hustad-Holt correlation | | | |  |
| 7 | 27.10.16 | **FUNDAMENTALS OF RESERVOIR FLUID FLOW**   * Types of fluid * Flow regimes * Resevoir geometry * Number of flowing fluids in the resevoir * Fluid flow equations * Darcy’s Law * Steady-state flow * Linear flow of incompressible fluids * Linear flow of slightly compressible fluids * Linear flow of compressible fluids (gases) * Radial flow of incompressible fluids * Radial flow of slightly compressible fluids * Radial flow of compressible gases * Horizontal multiple-phase flow * Unsteady-state flow * Basic transient flow equation * Radial flow of slightly compressible fluids | | | |  |
| 8 | 03.11.16 | **FUNDAMENTALS OF RESERVOIR FLUID FLOW**   * Constant-terminal-pressure solution * Constant-terminal-rate solution * The E-function solution * The dimensionless pressure drop (Pd)solution * Radial flow of compressible fluids * The m(p)-solution method(exact-solution) * The pressure-squared approximationmethod (p2-method) * The pressure-approximation method * Pseudosteady-state flow * Radial flow of slightly compressible fluids * Radial flow of compressible fluids(gases) * Pressure-squared approximation method * Pressure-approximation method * Skin factor * Turbulent flow factor * Principle of superposition * Effects of multiple wells * Effects of variable flow rates * Effects of the reservoir boundary * Accounting for pressure-change effects | | | |  |
| 9 | 10.11.16 | **Midterm Exam** | | | |  |
| 10 | 17.11.16 | **WATER INFLUX**   * Classification of aquifers * Degree of pressure maintenance * Outer boundary conditions * Flow regimes * Flow geometries * Recognition of natural water influx * Water influx models * The pot aquifer model * Schilthuis’ steady-state model * Hurst’s modified steady-state model * The Van Everdingen-Hurst * unsteady-state model * The edge-water drive * Bottom-water drive * The Carter-Tracey water influx model * Fetkovich’s method | | | |  |
| 11 | 24.11.16 | **Oil Recovery Mechanisms**   * Primary recovery mechanisms * Rock and liquid expansion * The depletion drive mechanism * Gas cap drive * The water-drive mechanism * The gravity-drainage-drive mechanism * The combination-drive mechanism | | | |  |
| 12 | 01.12.16 | **GAS AND WATER CONING**   * Coning * Coning in vertical wells * Vertical well critical rate correlations * The Meyer-Garder * correlation * The Chierici-Ciucci approach * The Hoyland-Papatzacos-Skjaeve methods * Chaperson’s method * Schols’ method * Breakthrough time in vertical wells * The Sobocinski-Cornelius method * The Bournazel-Jeanson method * After breakthrough performance * Coning in horizontal wells * Horizontal well critical rate correlations * Chaperson’s method * Efros’ method * Karcher’s method * Joshi’s method * Horizontal well breakthrough time * The Ozkan-Raghavan method * Papatzacos’ method | | | |  |
| 13 | 08.12.16 | **Presentation(Project)** | | | |  |
| 14 | 15.12.16 | **PRINCIPLES OF WATERFLOODING**   * Factors to consider in waterflooding * Reservoir geometry * Fluid properties * Reservoir depth * Lithology and rock properties * Fluid saturations * Reservoir uniformity and pay continuity * Primary reservoir driving mechanisms * Optimum time to waterflood * Effect of trapped gas on waterflood * Recovery * First theory * Second theory | | | |  |
| 15 | 22.12.16 | **PRINCIPLES OF WATERFLOODING**   * Selection of flooding patterns * Irregular injection patterns * Irregular injection patterns * Peripheral injection patterns * Regular injection patterns * Crestal and basal injection patterns * Overall recovery efficiency * Displacement efficiency * Areal sweep efficiency * Vertical sweep efficiency * Calculation of vertical sweep efficiency * Methods of predicting recovery * performance for layered reservoirs * Simplified Dykstra-Parsons method * Modified Dykstra-Parsons method * Craig-Geffen-Morse method | | | |  |
|  |  | **Final Exam** | | | |  |
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This syllabus is a guide for the course and any modifications to it will be announced in advance.