TEMPLATE FOR COURSE SPECIFICATION

HIGHER EDUCATION PERFORMANCE REVIEW: PROGRAMME REVIEW

COURSE SPECIFICATION

This course includes derivations of basic equations and underlying principles used in developing reservoir simulators. It covers the development of a simple governing equation, partial differential equations for single-phase and multiphase flow in porous media. Finite difference approximations are used to solve the equations. Input data requirements and applications of simulation models for history matching and prediction of field performance are discussed. A spreadsheet, i.e. Microsoft Excel, is used for many of the examples and exercises.

1. Teaching Institution	Al-Ayen University
2. University Department/Centre	College of Petroleum Engineering
3. Course title/code	Numerical Methods and Reservoir Simulation
4. Modes of Attendance offered	Online, classrooms and labs
5. Semester/Year	Academic year 2022/2023
6. Number of hours tuition (total)	48 Theoretical hours+48 lab hours=96 Hs
7. Date of production/revision of this specification	15/1/2023
8. Aims of the Course	
• Learning how to derive the partial differential equations that governing the flow in porous media. • Learning how to solve numerically the partial differential equations that governing the flow in porous media.	

9· Learning Outcomes, Teaching ,Learning and Assessment Methods

A- Cognitive goals.

A1. Applying the finite difference approximations to solve partial differential equations.

A2. Applying different methods to solve systems of linear equations.

B- The skills goals special to the course.

B1. Learning use of spreadsheet, i.e. Microsoft Excel software to solve systems of linear equations.

B2. Applying reservoir simulation techniques to predict future behavior of petroleum reservoirs. B3.

Teaching and Learning Methods

- Lectures
- Discussions, dialogues and questions.
- Group tasks.

Assessment methods

- Quizzes
- Monthly exams
- Homework
- Evaluation of the performance in the laboratory.
- Final exam

C. Affective and value goals

C1. Academic honesty in duties and not use cheating.

C2. Get knowledge about the latest technologies.

Teaching and Learning Methods

- Lectures
- Discussions, dialogues and questions.
- Group tasks.
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Assessment methods

- Quizzes
- Monthly exams
- Homework
- Evaluation of the performance in the laboratory.
- Final exam

D. General and rehabilitative transferred skills(other skills relevant to employability and personal development)

D1. Encouraging teamwork and self-confidence to accomplish tasks better.

D2. Encouraging creativity, innovation, and modernization.

10. Course Structure

Week	Hours	ILOs	Unit/Module or Topic Title	Teaching Method	Assessment Method
1	2 lecture + 2 lab	Linear, Lagrange, Least square method (Linear equations, Polynomial equations)	Interpolation	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
2	2 lecture + 2 lab	Review of matrix properties, Determinants, inverse of matrix	Matrices	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
3	2 lecture + 2 lab	Key Steps in a Reservoir Simulation Study: Clear Objectives, Reservoir Characterization	Introduction to Reservoir Simulation	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
4	2 lecture + 2 lab	Model Selection, Model Construction, Model Validation, Predictions	Types of Simulators	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
5	2 lecture + 2 lab	Types of fluids, Flow Regimes, Flow geometry, Number of flowing fluids in the reservoir	Basic Equations of Fluid Flow in Porous Media (Part 1)	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
6	2 lecture + 2 lab	Unsteady-State Single-Phase Flow, Linear Unsteady-State Single-Phase Flow, Basic Differential Equations of Single-Phase Flow in Porous Media	Basic Equations of Fluid Flow in Porous Media (Part 2)	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.

7	2 lecture + 2 lab	Finite Differences, Forward Differences, Backward Differences, Central Differences, Identifying Error of Finite Difference Using Taylor Series, Application of Finite Differences to Partial Differential Equations (PDEs), Explicit Finite Difference Approximation of the Linear Pressure Equation, Implicit Finite Difference Approximation of the Linear Pressure Equation, Discretization	Principles of Finite Difference Approximation (Finite Difference Scheme & Discretization)	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
8	2 lecture + 2 lab	1D single phase flow of slightly compressible fluid in a homogeneous linear-reservoir, Explicit Method, Stability of Explicit Method	Principles of Finite Difference Approximation (Explicit Approximation)	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
9	2 lecture + 2 lab	1D single phase flow of slightly compressible fluid in a homogeneous linear-reservoir, Implicit Method, Matrix-Vector Formulation	Principles of Finite Difference Approximation (Implicit Approximation)	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
10	2 lecture + 2 lab	Definition of a System of Linear Equations, Matrices.	Methods of Solving Systems of Linear Equations (Part 1)	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
11	2 lecture + 2 lab	General Methods for Solving Linear Equations, Direct Methods for Solving Linear Equations, Gaussian Elimination Method, Thomas Algorithm.	Methods of Solving Systems of Linear Equations (Part 2)	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
12	2 lecture + 2 lab	Gauss-Jordan Elimination Method, Iterative Methods for Solving Linear Equations, The Jacobi Method, Strictly Diagonally Dominant Matrix.	Methods of Solving Systems of Linear Equations (Part 3)	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
13	2 lecture + 2 lab	Gauss-Seidel Method, Comparison of Iterative and Direct Methods for Solving Linear Equations	Methods of Solving Systems of Linear Equations (Part 4)	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the

					laboratory, and final exam.
14	2 lecture + 2 lab	Homogeneous Linear-Reservoir with Sources/Sinks.	Simple 1D Linear Flow with Sources/Sinks (part 1)	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
15	2 lecture + 2 lab	Heterogeneous Linear-Reservoir with Sources/Sinks, Transmissibility, Computation of Transmissibility, Harmonic Average Permeability	Simple 1D Linear Flow with Sources/Sinks (part 2)	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
16	2 lecture + 2 lab	Introduction to Point-Centered (or Point-Distributed) and Block-Centered Grids, Introduction to Dirichlet Boundary Conditions and Neumann Boundary Conditions	Introduction to Types of Boundary Conditions and Grid Systems	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
17	2 lecture + 2 lab	Dirichlet Boundary Conditions in the system of Block-Centered Grid, Neumann Boundary Conditions in the System of Block-Centered Grid	Incorporation of Boundary Conditions in the System of Block-Centered Grid	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
18	2 lecture + 2 lab	Dirichlet Boundary Conditions in the System of Point-Centered Grid, Neumann Boundary Conditions in the System of Point-Centered Grid	Incorporation of Boundary Conditions in the System of Point-Centered Grid	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
19	2 lecture + 2 lab	2D Cartesian System/Point-Centered, 2D Cartesian System/Block-Centered, 3Dimensional-Cartesian, 3D (Cylindrical), 2D Single-Phase Flow Problem.	Application of Finite Difference Approximation in 2D and 3D Systems (Part 1)	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
20	2 lecture + 2 lab	2D Flow Problem/Block-Centered Grid, Block	Application of Finite Difference Approximation in 2D	Theoretical lecture &	Quizzes, monthly exams, homework, evaluation of the

		ordering schemes used in reservoir simulation, Natural ordering, Diagonal (D2) ordering, Alternating diagonal (D4) ordering, Cyclic ordering, Zebra ordering, Cyclic-2 ordering.	and 3D Systems (Part 2)	computer lab applications	performance in the laboratory, and final exam.
21	2 lecture + 2 lab	2D Flow Problem/Point-Centered Grid, 3D Flow Problem/Block-Centered Grid, block index for natural ordering.	Application of Finite Difference Approximation in 2D and 3D Systems (Part 3)	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
22	2 lecture + 2 lab	Computation of flowing pressure in the well model, Peaceman 's Model, numerical solution of radial form of the flow equation.	Well Modelling	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
23	2 lecture + 2 lab	Two-Phase Flow in a 1D Linear- Reservoir, the Two-Phase Pressure and Saturation Equations, Application of Finite Differences to Two-Phase Flow, Implicit in Pressure and Explicit in Saturation (IMPES).	Introduction to the numerical simulation of multi-phase flow through porous media (Part 1)	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.
24	2 lecture + 2 lab	Multiphase- Flow Simulation, the Black Oil Simulator, Diffusivity Equations of flow: Oil, Water and Gas Phases for the black oil model, the Compositional Simulator, the diffusivity equation of flow for the compositional model.	Introduction to the numerical simulation of multi-phase flow through porous media (Part 2)	Theoretical lecture & computer lab applications	Quizzes, monthly exams, homework, evaluation of the performance in the laboratory, and final exam.

11. Infrastructure	
1. Books Required reading:	
2. Main references (sources) A- Recommended books and references (scientific journals, reports…).	1.Petroleum Reservoir Simulation A Basic Approach by Abou-Kassem J. H., Farouq Ali S. M. and Islam M. R. 2.Basic Applied Reservoir Simulation by Ertekin T., Abou-Kassem J.H. and King G. R. 3.Petroleum Reservoir Simulation by Aziz K. and Settari A.
B-Electronic references, Internet sites…	

12. The development of the curriculum plan
Adding more technical skills by introducing more problems.