PEGN 513A: Reservoir Simulation I

Fall 2009

http://www.mines.edu/~hkazemi

Tuesdays: 9:00 am - 11:50 am

Instructor

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Office hours: Tuesdays and Thursdays, 1:30 pm to 2:45 pm

Course objectives

This is the first formal course in reservoir simulation. The objective is to teach students the rudiments of reservoir simulation, show them how it is built and how it is currently used in the industry as the most prominent reservoir management computational tool.

Description

The course provides the rudiments of reservoir simulation, which include flow equations, solution methods, and data requirement. Specifically, the course covers: equations of conservation of mass, conservation of momentum, and energy balance; numerical solution of flow in petroleum reservoirs by finite difference (FD) and control volume FD; permeability tensor and directional permeability; non-Darcy flow; convective flow and numerical dispersion; grid orientation problems; introduction to finite element and mixed finite-element methods; introduction to hybrid analytical/numerical solutions; introduction to multi-phase flow models; relative permeability, capillary pressure and wettability issues; linear equation solvers; streamline simulation; and multi-scale simulation concept.

Course Syllabus

- Conservation of Mass—Continuity Equation (1 week)
- Conservation of Momentum—Equation of Motion, Darcy and Non-Darcy Flow (2
- weeks)
- Energy Balance Equation (1 week)
- Pressure (diffusivity) Equation and FD Solution (4 weeks)
    - Finite Difference
    - Control Volume FD
    - Permeability Tensor and Directional Permeability
    - Linear Solvers
    - Finite Element and Mixed Finite Element
- Water-Oil Flow Model (3 weeks)
    - Buckley-Leverett Solution
    - Numerical Solution
    - Streamline Model Solution
- Well Models (2 weeks)
    - Steady-state Well Index
    - Transient Well Index
- Numerical Dispersion, Grid Orientation and Permeability Tensor (2 weeks)
- Geomechanics (1 week)
    - Linear Elasticity
    - The Impact of Pore Pressure on Minimum Normal Stress
    - The Impact of Pore Pressure on Dilation Shear Stress
- Hybrid Methods and Multi-Scale Modeling Approach (1 week)

Requirements

- PENG 424 or equivalent.
- Strong reservoir engineering background.
- Basic computer programming knowledge.

Exams

- Two tests and a final.

Homework Policy

Homework problems will be assigned throughout the semester. They are designed to facilitate student's understanding of the course material and its application to real world situations. The T.A. will post homework problems on the web page (www.mines.edu/~hkazemi) and Blackboard after each lecture. The student is to submit his/her homework on time to the T.A. A penalty of at least two marks (out of ten marks) for each day late will apply to any assignment or term project submitted after 4 pm on the day it is due. The homework must be typed with necessary intermediate steps included. Correct answers not supported by work will not receive credit. Additional points will be taken off when the homework is not typed, or the computer code is not submitted. All homework must be submitted before the T.A. has posted the solution on the web page or Blackboard. Any time later is a "0".

Collaboration Policy

Discussions of the assignments are encouraged; however, students must write their own code. Generally linear solver subroutines will be provided, but other than that, all other work submitted should be entirely of student's own creation. If not, this is considered academic dishonesty and will be treated as such. This treatment includes many of the potential punishments outlined in the Department academic dishonesty policies and as chosen by the faculty involved. The incident will be reported to the Dean of Student Life. A second occurrence will result in immediate reporting to the Dean of Student Life and potential expulsion from CSM and a notation in your transcript regarding academic dishonesty.

Grades

The student has one week from the time an assignment is returned to determine any possible grading errors. If after one week, an error is found, even an addition or subtraction error, there will be no change of grade. Since the class is on Blackboard, he/she will have the opportunity to check his/her grades online. If there is an error in posting, show the actual graded document to the TA. The grade will be corrected.

TAs

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Grading

Homework: 30%

Three tests: 30%

Project: 30%

Class contribution: 10%

References

Adibrata, Bob Wikan H., Hurley, and Neil F.: "Flow-Unit Modeling Using Neural Networks, Logs, and Core in a Vuggy Dolomite Reservoir, Dagger Draw Field, New Mexico," SPWLA 44th Annual Logging Symposium, June 22-25, 2003.

Atan, S., Al-Matrook, M., Kazemi, H., Ozkan, E., and Gardner, M.: "Dual-Mesh Simulation of Reservoir Heterogeneity in Single- and Dual- Porosity Problems," SPE 93294, Reservoir Simulation Symposium, Jan. 2005 Houston, TX.

Aziz, K. and Settari, A.: Petroleum Reservoir Simulation, Applied Science Publishers Ltd (1979).

Caers, Jef: Petroleum Geostatistics, SPE (2005) .

Dickey, P. A.: Petroleum Development Geology, PennWell Books (1986).

Ertekin, T., Abou-Kassem J. H. and King, G.R.: Basic Applied Reservoir Simulation SPE Textbook Series Vol. 7 (2001).

Foster, W.R., McMillen, J.M., Odeh, A.S.: "The Equations of Motion of Fluids in Porous Media: I. Propagation Velocity of Pressure Pulses," SPEJ (December 1967) 333-341: Trans. AIME, Vol. 240.

Foster, W.R., McMillen, J.M., Wallick, G. C.: "The Equations of Motion of Fluids in Porous Media: II. Shape of Pressure Pulses," SPE 2322 (December 1968).

Kazemi, H., Atan, S., Al-Matrook, M., Drier, J., and Ozkan, E.: "Multilevel Fracture Network Modeling of Naturally Fractured Reservoirs," SPE 93053, Reservoir

Simulation Symposium, Jan. 2005 Houston, TX.

Laudon, Robert C.: Principle of Petroleum Geology, Prentice Hall (1996).

Mattax, C.C. and Dalton R.L.: Reservoir Simulation, SPE Monograph Volume 13 (1990).

Pereira, C. A., Kazemi, H., and Ozkan, E.: "Combined Effect of Non-Darcy Flow and Formation Damage on Gas Well Performance of Dual-Porosity and Dual- Permeability Reservoirs," SPE 90623, ATCE, Sept. 28, 2004, Houston, TX.

Waite, M., Johansen, S. and Betancourt, D.: "Modeling of Scale-Dependent Permeability Using Single-Well Micro-Models: Application to Hamaca Field, Venezuela," SPE 86967, SPE Heavy Oil Symposium, March 16-18, 2004, Bakersfield, California, U.S.A.