PTE 500 Fall 2016
Computational Reservoir Modeling

Instructor: Jincai Chang, Ph. D., jincaich@usc.edu, 213-740-7459
Class Hours: Tuesdays, 3:30 – 6:10 pm, OHE 100D
Office Hours: Tuesdays 10:00 am – 12:00 noon, HED 314
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Office Hours: TBA

Course Description and Objectives:
Oil and gas production involves reservoir characterization, reserve estimation, subsurface and surface flows. Consequently, modeling oil and gas production requires extensive mathematical methods and skills. This course introduces a wide range of mathematical and computational topics which are essential to other petroleum engineering courses offered here at USC. Topics include linear algebra and application, vector calculus, series and transforms, numerical solution methods of ordinary and partial different equations, optimization, probability and statistics, analytical solution of PDE with Laplace transform, and numerical inversion of Laplace transformation.

This course is primarily intended for petroleum engineers to study advanced topics in subsurface description, geophysical modelling, geostatistical reservoir characterization, multiple phase flow and transportation process, well testing, inverse modeling, and optimization of oil and gas productions.

Computer programming is required to complete the homework assignments. Matlab is preferred for programming, but other programming languages such as C++ or VB are also acceptable.

Course Outline:
1. Aug 23: Introduction, objectives, course outline explanation, overview. Vector definition, vector spaces, vector-matrix operations
2. Aug 30: Solution method of linear equations. Under- and over-determined linear equations and possible solution methods
3. Sep 6: Matrix factorization, eigenvalue and single value decomposition. Matrix properties
4. Sep 13: Series and transforms, Laplace transform and its application in reservoir engineering. Numerical inversion of Laplace transform
5. Sep 20: Special functions and their applications in petroleum engineering
6. Sep 27: Vector functions --- gradient, Jacobian and Hessian definition and calculation. Taylor series for linear, quadratic and higher order approximations
7. Oct 4: Optimization, convex sets and functions, optimality conditions
8. Oct 11: Local and global optimizations, constrained optimization and Lagrange multipliers, numerical optimization method
9. Oct 18: **Midterm exam** 3:30 – 6:10 pm
10. Oct 25: ODE and solution methods: analytical and numerical methods, accuracy comparison, applications in petroleum engineering
11. Nov 1: PDEs and solution methods: analytical, Laplace transform and numerical
12. Nov 8: Probability and statistics, probability of single and multiple events, Bayes's theorem
13. Nov 15: Random variables, Probability Density Function and Cumulative Distribution Function, statistical moments and expectations, common probability distributions, sampling theory, Monte-Carlo simulation
14. Nov 22: Thanksgiving Week, no class
15. Nov 29: Bivariate statistics: covariance and correlation, multivariance Gaussian distribution
16. Dec 6: (Study Days) Review and Summary
17. Dec 13: **Final exam** 2-4 pm

Final Grade Calculation:
Homework 20%, Midterm Exam 35%, Final Exam 40%, Attendance & Class Participation 5%

100-95.1%	95.0 - 90.1%	90-85.1%	85-80.1%	80-75.1%	75-70.1%	70-65.1%	65 - 60.1%	60-0%
A	A-	B+	B	B-	C+	C	C-	F

Homework will be assigned at the end of each lecture, and the assignment is due at the beginning of the next lecture. Completing homework on time is an important part of the learning process. Students can have group studies and discussions outside of class. However, each student must complete his or her homework and project assignments independently. All homework and project will be graded and the results will be tabulated and used in determining the final grade.

Other requirements for this course:

1. It is important to attend all lectures. Please check the class schedule and arrange your work and travel plans accordingly.
2. The midterm and final exam dates cannot be changed. Missing one exam will likely result in a failing grade.
3. DEN students can type their homework with a word processor, or scan handwritten pages with an optical scanner. Convert the typed or scanned homework to a PDF file and submit the PDF file electronically to the DEN office before the deadline. Photos of homework are *not* acceptable because they are often hard to read.
4. On-campus students are encouraged to submit their typed or handwritten homework in PDF format. A dropbox will be created for each homework on the Desire2Learn website. Students must upload the homework before the due time. Do ***not*** send pdf files through emails. Students who have difficulty converting homework to PDF files may submit homework on paper (8.5 by 11 inches), single-sided only.
5. Computer codes must be submitted in electronic form if requested.
6. All homework assignments must be submitted on time. If an assignment is turned in late, 10% credit will be deducted for each day late. If a student has an emergency and cannot turn in homework on time, please contact the instructor in advance for late homework submission. Keep in mind that chronic late homework submissions can result in a failing grade.
7. Matlab and Microsoft Excel will be used extensively for homework assignments. Matlab can be installed on a PC. Please Google-search "USC Matlab" for installation instructions.
8. Extensive computer programming is required to complete the project and some of the homework assignments. Matlab is recommended but other programming languages such as C, C++ and VB are also acceptable.

Books and References:

Spegel, M. R. Advanced Mathematics for Engineers and Scientists, Schaum's Outline Series, Mc Graw Hill, 1971

SPE and other technical papers will be assigned as the course progresses.