PTE 500: Computational Aspects of Reservoir Modeling

(3 Units)

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Class Location: OHE-136

Class Hours: Mondays 15:30-18:10

Office Hours: Wednesdays 14:00-16:00 (HED-313)

Teaching Assistant: Reza Khaninezhad (Office: PCE 301 – Email: m.khaninezhad@usc.edu)

Catalogue Description:

Introduction to mathematical and computational methods in modeling the subsurface flow and transport phenomena.

Extended Course Description

PTE-500 is an introductory to intermediate graduate level course that covers a wide range of applied mathematical and computational topics for modeling of the subsurface flow and transport processes. Specific topics include applied linear algebra, vector calculus, series and transforms, numerical solution of partial differential equations, optimization, and probability and statistics. The main application of the course is modeling and simulation of the subsurface flow and transport systems. The course is designed primarily for subsurface scientists and engineers who are interested in studying advanced topics in subsurface description, geophysical modeling, geostatistical reservoir characterization, multiphase flow and transport processes, well testing, inverse modeling, and hydrocarbon production optimization. The preferred programming language for completing the assignments of the course is MATLAB.

Course Vision and Objectives

The main objective of the course is to help students to build a mathematical and computational foundation that is required for learning advanced topics in subsurface description, modeling, and characterization. The course serves as prerequisite for a number of other more specialized courses in subsurface modeling as well as simulation of multiphase flow and transport phenomenon in geologic formations.

Nature of the Course

All students admitted to the PTE graduate programs must have satisfied advanced Math courses equivalent to the topics covered in PTE 500. Otherwise, this will be a required deficiency course.

Recommended Preparation

Familiarity with basic calculus, differential equation, and MATLAB programming will be useful.

Text Book

No textbook is required for this course; related notes and reading material will be distributed electronically and/or will be posted to the class (DEN) website.

Course Grading Policy

Letter grade

Homework = 20% Midterm Exam = 30% Final Exam = 50%

Lectures and Labs
Lectures are scheduled for three hours per week. A number of computational lab sessions will also be scheduled for hands-on introduction to MATLAB.

Homework
There will be a total of eight (8) homework assignments that contribute to 20% of the course grade. Homework assignments will be provided at the end of the lecture on the specified dates in the tentative schedule sheet (posted to class DEN website) and are due before lecture begins on the due date. Late homework submissions will not be accepted unless prior arrangement is made with the instructors. In addition to carrying 20% of the course grade, homework problems are a crucial part of the learning and will invariably have a major impact on understanding of the material and largely contribute to students' performance in the exams. In undertaking the problem sets, moderate collaboration in the form of joint problem solving with one or two classmates is permitted provided each student will write up their work and answers independently.

Exams and Quizzes
There will be one midterm exam and one comprehensive final exam. The exams will be closed-book and closed-note (a formula sheet will be provided with the exam booklet).

EXAM DATES:

Midterm Exam: **October 27** (is tentative)
Final Exam: **December 15** (per University's Final Exam Schedule)

Statement for Students with Disabilities
Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. Website and contact information for DSP: http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html, (213) 740-0776 (Phone), (213) 740-6948 (TDD only), (213) 740-8216 (FAX) ability@usc.edu.

Statement on Academic Integrity
USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. *Scampus*, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: http://www.usc.edu/dept/publications/SCAMPUS/gov/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/

Emergency Preparedness/Course Continuity in a Crisis
In case of a declared emergency if travel to campus is not feasible, USC executive leadership will announce an electronic way for instructors to teach students in their residence halls or homes using a combination of Blackboard, teleconferencing, and other technologies.

Grade	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	D
Score	>93	90-92	87-89	83-86	80-82	77-79	73-76	70-72	67-69	63-66	60-62	<59

Tentative Course Topics and Schedule

Week	Date	Lecture	Reading	Out	In
		Part I. Introduction, Objectives, and Overview			
		Topic 1: Introduction, Objectives, and Overview			
1	25-Aug	T1L1: Course Introduction, Objectives, and Expectations	T1L1		
		T1L2: Course Overview	T1L2		
		Part II. Linear Algebra			
		Topic 2: Vector Spaces and Matrix-Vector Operations			
1	25-Aug	T2L1: Vector Spaces, Vector-Matrix Operations	T2L1		
		T2L2: Linear Systems of Equations	T2L2		
		Topic 3: Solutions of Systems of Equations			
2	01-Sep	T3L1: Solution of Linear Systems of Equations	T3L1	**HW1**	
		T3L2: Under-determined and Over-determined Equations	T3L2		
		T3L3: Nonlinear Systems of Equations	T3L3		
		Topic 4: Matrix Factorizations, Eigen-Value and Singular-Value Decomposition			
3	8-Sep	T4L1: Matrix Factorizations	T4L1	**HW2**	**HW1**
		T4L2: Eigen-Value and Singular-Value Decomposition	T4L2		
		Part III. Series and Transforms (Laplace, Fourier, and Wavelet)			
		Topic 5: Transforms and Series			
4	15-Sep	T5L1: Introduction to Series and Transforms	T5L1	**HW3**	**HW2**
		T5L2: Laplace Transform in Reservoir Engineering	T5L2		
		Topic 6: Applications of Series/Transforms in Reservoir Engineering			
5	22-Sep	T6L1: Fourier and Wavelet Transform	T6L1		
		T6L2: Application: Low-Rank Approximations	T6L2		
		Part IV. Vector Calculus and Optimization			
		Topic 7: Scalar and Vector Functions: Gradient and Hessian			
6	29-Sep	T7L1: Vector Functions: Gradient, Jacobian, and Hessian	T7L1	**HW4**	**HW3**
		T7L2: Taylor Series for Linear and Quadratic Approximation	T7L2		
		Topic 8: Introduction to Optimization Principles			
7	6-Oct	T8L1: Elements of Optimization	T8L1	**HW5**	**HW4**
		T8L2: Convex Sets and Functions	T8L2		
		T8L3: Optimality Conditions	T8L3		
		Topic 9: Types of Optimization Problems			
8	13-Oct	T9L1: Local versus Global Optimization	T9L1	**HW6**	**HW5**
		T9L2: Constrained Optimization and Lagrange Multipliers	T9L2		
		T9L3: Numerical Optimization	T9L3		
		Part V. Ordinary and Partial Differential Equations			
		Topic 10: Ordinary Differential Equations			
9	20-Oct	T10L1: Analytical Solution of ODEs	T10L1		
		T10L2: Numerical So0lution of ODEs	T10L2		
		T10L3: Reservoir Engineering Applications	T10L3		
10	27-Oct	**MIDTERM EXAM (SPE-ATCE 2014)**			
		Topic 11: Partial Differential Equations			
11	3-Nov	T11L1: Types of PDEs (Elliptic, Parabolic, hyperbolic)	T11L1	**HW7**	**HW6**
		T11L2: Analytical Solution of PDEs	T11L3		
		T11L3: Numerical Solution of PDEs	T11L2		
		Part VI. Probability and Statistics			
		Topic 12: Probability Axioms and Baye's Rule			
12	10-Nov	T12L1: Probability Axioms	T12L1	**HW8**	**HW7**
		T12L2: Conditional Probability, Independence, Baye's Rule	T12L2		
		Topic 13: Univariate and Bivariate Statistics			
13	17-Nov	T13L1: Random Variables, PDF and CDF	T13L1		
		T13L2: Statistical Moments and Expectation	T13L2		
		T13L3: Common Probability Distributions	T13L3		
		T13L4: Sampling and Monte-Carlo Simulation	T13L4		
14	24-Nov	**THANKSGIVING RECESS**			
		Topic 14: Bivariate and Multivariate Statistics			
15	1-Dec	T14L1: Bivariate Statistics: Covariance and Correlation	T14L1		**HW8**
		T14L2: Multivariate Gaussian Distribution	T14L2		
16	15-Dec	**FINAL EXAM**			