Computational Science & Engineering I
MIT 18.085 (U) / 18.0851 (G) - Fall 2015
Course Description

Dr. Pedro J. Sáenz

September 28, 2015

1 Overview

Who? When? Where?

Class:	Tue(T)-Thu(R) 1:00-2:30 pm		
Location:	1-190 (Classes); TBA (Exams)		
Instructor:	Pedro J. Sáenz	TA:	Asad Lodhia
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Office:	E18-473	Office:	E18-401R
Office hours:	R 2:30-3:30 pm & F 8-9 am	Office hours:	T 5-6 pm & F 3-4 pm
TA:	Teng Fei	TA:	Sylvain Carpentier
E-mail:	tfei@mit.edu	E-mail:	syl_car@mit.edu
Office:	E18-301G	Office:	E17-301AB
Office hours:	W 7-8 pm & R 7-8 pm	Office hours:	M 7-8 pm & W 4-5 pm

Course description:

Review of linear algebra, applications to networks, structures, and estimation, finite difference and finite element solution of differential equations, Laplace's equation and potential flow, boundary-value problems, Fourier series, discrete Fourier transform, convolution. Use of MATLAB in a wide range of scientific and engineering applications.

Prerequisites:

Calculus and some linear algebra. Having some experience with numerical computation is helpful but not necessary.

Text book:

Computational Science and Engineering, by Gilbert Strang (ISBN number 9780961408817) (Amazon)
Book website: http://math.mit.edu/∼gs/cse/

Course website:

The official course website is at: http://math.mit.edu/classes/18.085/2015FA/index.html. All problem sets, associated documentation, and news will be posted on it. **Check it regularly**.

OCW site: http://ocw.mit.edu/courses/mathematics/18-085-computational-science-and-engineering-i-fall-2008/

Evaluation:

Grades: 40% problem sets, 60% three in-class quizzes (20% each).

Exams: There will be three in-class exams (1h30). No make-up exams. No final exam at the end of the semester.

Problem Sets: Due at start of class on Thursday, unless otherwise noted. The homework problem sets will consist of both theoretical and numerical questions. No late copy will be allowed, but the lowest score will be dropped. Please use MATLAB notation to describe algorithms. Use of MATLAB for tedious calculations is encouraged, however you need to know how to do the basic algorithms taught in the course by hand (at least for small matrices) for the quizzes.

Collaboration policy:

Problem sets should represent the student's own work but cooperation with another's is welcome. Any such cooperation should however be noted in writing on the problem set.

Add/drop policy:

ADD DATE (last day to add a subject): **Friday, October 9**.
DROP DATE (last day to drop a subject): **Wednesday, November 18**.

Students may join the class up to ADD DATE using an on-line Add/Drop form:

https://studentformsandpetitions.mit.edu/

Students may drop a subject up to DROP DATE. Ceasing to attend a course does not constitute dropping it. The student must officially drop the course with the Registrar by DROP DATE, or receive an 'F' at the end of the term.

2 Syllabus

1. Applied Linear Algebra
   - 1.1. Four Special Matrices
   - 1.2. Differences, Derivatives, and Boundary Conditions
   - 1.3. Elimination Leads to $\mathrm{K} = \mathrm{LDL}^{\mathrm{T}}$
   - 1.4. Inverses and Delta Functions
   - 1.5. Eigenvalues and Eigenvectors
   - 1.6. Positive Definite Matrices
   - 1.7. Numerical Linear Algebra: LU, QR, SVD
2. A Framework for Applied Mathematics
   - 2.1. Equilibrium and the Stiffness Matrix
   - 2.2. Oscillation by Newton's Law
   - 2.3. Least Squares for Rectangular Matrices
   - 2.4. Graph Models and Kirchhoff's Laws
   - 2.5. Networks and Transfer Functions
   - 2.6. Nonlinear Problems
   - 2.7. Structures in Equilibrium
3. Boundary Value Problems
   - 3.1. Differential Equations of Equilibrium
   - 3.2. Cubic Splines and Fourth Order Equations
   - 3.3. Gradient and Divergence
   - 3.4. Laplace's Equation
   - 3.5. Finite Differences and Fast Poisson Solvers
   - 3.6. The Finite Element Method
   - 3.7. Elasticity and Solid Mechanics
4. Fourier Series and Integrals
   - 4.1. Fourier Series for Periodic Functions
   - 4.2. Chebyshev, Legendre, and Bessel
   - 4.3. The Discrete Fourier Transform and the FFT
   - 4.4. Convolution and Signal Processing
   - 4.5. Fourier Integrals
   - 4.6. Deconvolution and Integral Equations
   - 4.7. Wavelets and Signal Processing

3 Tentative schedule

Note: This schedule is subject to change. Check the course website regularly for changes and updates.

	Date	**Topic**	**Homework**
L1	R, Sept 10	Course introduction Four special matrices Two ways of multiplying matrices	PSET 1 posted
L2	T, Sept 15	Differential & difference equations Review of linear algebra Solving linear systems	
L3	R, Sept 17	Delta function	PSET 1 due Solutions PSET 1 posted PSET 2 posted
L4	T, Sept 22	Eigenvalues & eigenvectors (I)	
L5	R, Sept 24	Eigenvalues & eigenvectors (II) Positive definite matrices	
L6	T, Sept 29	Spring & masses Oscillation (I)	
L7	R, Oct 1	Oscillation (II) Least squares	PSET 2 due Solutions PSET 2 posted PSET 3 posted
L8	T, Oct 6	Graphs & networks Kirchoff's current law (I)	
EXAM 1	**R, Oct 8**		
	T, Oct 13	No class!	
L9	R, Oct 15	Kirchoff's current law (II) Trusses (I)	PSET 3 due Solutions PSET3 posted PSET 4 posted
L10	T, Oct 20	Trusses (II)	
L11	R, Oct 22	Finite elements in 1D (I)	
L12	T, Oct 27	Finite elements in 1D (II) Quadratic & cubic elements	
L13	R, Oct 29	Element matrices 4^{th}-order bending equations Boundary conditions Splines	PSET 4 due Solutions PSET 4 posted PSET 5 posted
L14	T, Nov 3	Gradients & divergence Laplace's equation (I)	
EXAM 2	**R, Nov 5**		
L15	T, Nov 10	Laplace's equation (II)	
L16	R, Nov 12	Laplace's equation (III) Fast Poisson solver (I)	
L17	T, Nov 17	Fast Poisson solver (II)	
L18	R, Nov 19	Finite Elements in 2D Fourier series (I)	PSET 5 due Solutions PSET 5 posted
L19	T, Nov 24	Fourier series (II)	
	R, Nov 26	Thanksgiving day!	
L20	T, Dec 1	Discrete Fourier series	
EXAM 3	**R, Dec 3**		
L21	T, Dec 8	Fast Fourier Transform Convolution (I)	
L22	R, Dec 10	Convolution (II)	