CSCD37H - Analysis of Numerical Algorithms for Computational Mathematics – Winter 2013

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Lectures: Mon 2:00 - 3:00 and Wed 3:00 - 4:00 in IC 326.

There is a weekly tutorial for this course that is currently scheduled for Monday 4:00 - 5:00 in IC 120.

Office hours: Lecturer: Mondays and Wednesdays 11:00 - 12:00 in IC 454.
Textbook: Michael Heath, "*Scientific Computing: an Introductory Survey, 2nd edition*", McGraw-Hill Inc. 2002.

Other texts for reference: check the webpage of the course for other related books.

Course goals (from the academic calendar): Mathematical models of real systems that cannot be solved analytically can be approximated by numerical algorithms. This course examines the efficiency, accuracy and reliability of numerical algorithms for several classes of models, including models involving least squares, nonlinear equations, optimization, quadrature and systems of ordinary differential equations.

Prerequisites: CSCC37H & MATB24H & MATB41H.

Course Outline:

Note that references in parenthesis, [·], are to section numbers of the text where the topic is addressed.

1. **General Information and Mathematical Background [2 weeks]**
   - Administration Details:
     Grading Scheme, Course Website, Tutorials, Office hours Prerequisites etc.
   - What is Numerical Analysis ?
     The generic difficulty, Mathematical Modelling and Numerical issues, Conditioning and Stability of a problem, The need to approximate, Using existing methods as implemented in available Software libraries
   - An interesting example showing that Numerical Algorithms can be very important (and developing them can be rewarding).
   - Mathematical Preliminaries and Notation:
     Floating Point arithmetic, Relevant notation and results/theorems from Linear Algebra and Calculus.
2. **QR Decomposition and Applications [4 weeks]**
   - Review of Gaussian Elimination [2.4]

- Matrix Norms and Condition Number [2.3]
- QR Decomposition
- Solving Linear Systems with QR [3.5]
- Linear Least Squares (LLSQ) Problems [3.1, 3.5]
- Eigenvalue Problems [4.1 – 4.5]

3. **Nonlinear Systems and Optimization [2 weeks]**

   - Review of Methods for Scalar (1 dimensional) Problems [5.1 – 5.5]
   - Extension of Newton's method to Systems of Nonlinear Equations [5.6]
   - Optimization Problems [6.1]

4. **Numerical methods for Ordinary Differential Equations [4 weeks]**

   - Motivation and Mathematical Preliminaries [5.1]
   - Taylor Series Methods [5.2, 5.3]
   - Runge-Kutta Methods [5.4]
   - Higher-order Runge-Kutta Methods [5.4, 5.5]
   - Error Estimates [5.5]
   - Stepsize Control [5.5]

5. **Gauss Quadrature and Multidimensional integration [optional]**

   - Errors in Interpolatory Rules [4.3]
   - Orthogonal Polynomials and Gauss Quadrature [4.7]
   - Two Dimensional Quadrature [4.8]

Home page for the course:

`http://www.cs.toronto.edu/~enright/teaching/D37`

Marking Scheme:

4 Assignments at 10% each	40%
1 Term Test at 20%	20%
Final Exam at 40%	40%
	100%

To pass the course, you must receive at least 35/100 on the final exam. See the webpage of the course for the policies on plagiarism and lateness.

Some additional material will be introduced in the tutorials. You are expected to know this material.

Schedule: **First lecture** - Jan 7

Assignment	**Hand-out Date**	**Due Date**	**Worth**
1	Jan 14	Jan 28	10%
2	Jan 28	Feb 25	10%
3	Feb 25	Mar 11	10%
4	Mar 11	April 1	10%

Midterm test - TBA

Reading week - Feb 18 – 22

Last lecture - April 6