MATH 609: Numerical Analysis
Texas A&M, Fall 2013
Section: 600, CRN: 14062
Lecture: M,W,F, 10:20 am-11:10 am, Zachry Engineering Center 119D
Lab: Thursday, 3:55 pm - 4:45 pm, Blocker Building 123

Instructor: Dr. Adam Larios **Email:** alarios@math.tamu.edu
Office: Blocker Building, 641 C **Math Dept. Phone:** (979) 845-3261
Office Hours: M,W,F, 9:00 am - 10:00 am, or by appointment

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Office: Blocker Building, 509

Course Description: Interpolation, numerical evaluation of definite integrals and solution of ordinary differential equations; stability and convergence of methods and error estimates.

Prerequisite: Knowledge of computer programming (C or FORTRAN).

Restrictions: Must be enrolled in the Graduate level, and may not be enrolled in the English Language Institute College

Textbooks: *Numerical Analysis: Mathematics of Scientific Computing,* 3^{rd} *Edition.* D. Kincaid and W. Cheney. Brooks & Cole Publ., 2001. ISBN-10: 0534389058, ISBN-13: 978-0534389055.

Lectures 1-5 from Numerical Linear Algebra. L. Trfethen and D. Bau.
Available for free at: http://people.maths.ox.ac.uk/trefethen/text.html

Other books about numerics that may be useful:
- Golub & VanLoan: Matrix Computations
- Stoer & Bulirsch: Introduction to Numerical Analysis.

Contacting me: The best way to get in contact with me is by email, alarios@math.tamu.edu. Please put [MATH 609] somewhere in the title and make sure to include your whole name with your email. Polite, courteous emails are appreciated; see my website for tips on email etiquette. My office is in Blocker Building, 641 C, and my office hours are M,W,F 9:00 am - 10:00 am. Drop-ins are welcome during these times. If you want to meet me at a different time, please email me, and we will try to schedule a time to meet.

Motivation: This is a one-semester course on numerical analysis which gives an introduction to various topics in numerical methods and provides a firm basis for future study.

This class introduces some of the fundamental concepts of numerical analysis: consistency, stability, approximation, orthogonality and contractions. They are studied as essential analytical tools applied to problems like interpolation, quadrature, and iterative solution methods. In the second part of the class, we will study numerical methods for ordinary differential equations.

Numerical methods lie at the heart of an extremely large number of practical and theoretical problems in science, mathematics, and engineering. Our growing understanding of these methods has yielded a massive amount of progress for human kind.

Furthermore, the unsolved problems are enormously varied, rich, and challenging. New algorithms and techniques are being invented every day, and many recent break-

throughs have changed the world. Numerical methods are found at the cutting edge of nearly every discipline in science and mathematics, with recent progress exploiting cutting-edge mathematical tools, and the fastest supercomputers in the world.

Scientists, mathematicians, and engineers who have grown comfortable with computations and learned to wield the full power of numerical methods have been able to explore depths that once seemed unfathomable, and have soared to highest that once seemed impossible.

We will focus on rigorously development of numerical methods. The methods involved are incredibly useful in science, and will require us to develop sophisticated and interesting mathematics to handle them.

Homework: Homework is designed to help students understand the material and to prepare them for the exams. One homework score will be dropped, corresponding to your lowest homework score. Homework assignments will be posted on the website roughly every one to two weeks, with due dates included. Homework may be turned in late by one class day past the due date with a penalty of 5 percentage points. Homework will not be accepted later than one class day, except possibly with an excused absence.

Collaboration: Collaboration is encouraged in this course. However, copying someone else's work and submitting it as your own is unacceptable. This act of academic dishonesty will be prosecuted in accordance with university policy.

Lab Work: The labs provide help in programming and problem solving. You will learn some of the skills techniques you need to know for your programming assignments. Programming assignments will be announced in class, and will be posted on the course website.

Electronic devices: There will be no calculators (or other electronic devices) allowed on exams and quizzes, unless otherwise stated. Laptops, cell phones, and other electronic devices, are not allowed to be used during class or exams, unless otherwise stated. Cell phones must be set on vibrate or off. If you need to take a call, send a text message, etc., please quietly leave the classroom to do so, so that you do not distract other students. You are welcome to return to class quietly when you are finished. If you wish to take notes using an electronic device, you must first demonstrate to me that you can type or write fast enough to do so properly, and that you can do it without distracting others, before the privilege to use such devices may be granted. If you are found to be abusing this privilege, you risk forfeiting it.

Grading: The final course grade will be computed as follows.

Homework:	20%
Programming Assignments:	20%
Midterm Exams:	20% + 20% = 40%
Final Exam:	20%

Your *minimum* grade will be A, B, C, D, or F, for averages equal to or above 90%, 80%, 65%, 50%, or 0%, respectively.

Attendance: Daily attendance for class lectures is expected and is extremely important. While attendance is not recorded, missing even one class will put you behind. Note that there is a strong correlation between class absences and poor grades. You are responsible for all material and announcements in class regardless of whether or not you attended. **You are also responsible for making arrangements with another classmate**

to find out what you missed. You should not ask me to go over material that you missed (due to tardiness or absences) during office hours or over email.

Make-up exams: Make-up exams will only be given with written evidence of an official University excused absence. Section 7.3 of the University Student Rules states that for an absence: "to be excused the student must notify his or her instructor in writing (acknowledged email message is acceptable) prior to the date of absence if such notification is feasible. In cases where advance notification is not feasible (e.g., accident or emergency) the student must provide notification by the end of the second working day after the absence. This notification should include an explanation of why notice could not be sent prior to the class."

Incompletes: A grade of "incomplete" may be considered if all but a small portion of the class has been successfully completed , but the student in question is prevented from completing the course by a severe, unexpected, and documented event. Students who are simply behind in their work should consider dropping the course.

Special Services: The American with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protections for persons with disabilities. Among other things, this legislation provides that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact Disability Services, Cain Hall, Room B118, (979) 845-1637. For additional information, visit: `http://disability.tamu.edu`

Copyright policy: Printed materials disseminated in class or on the web are protected by copyright laws. One Xerox copy (or download from the web) is allowed for personal use. Multiple copies or sale of any of these materials is strictly prohibited.

Honor Code: Academic dishonesty is taken extremely seriously, and will be dealt with according to university policy. Always abide by the Aggie Code of Honor: "An Aggie does not lie, cheat or steal, or tolerate those who do." For additional information, please visit: `http://www.tamu.edu/aggiehonor`

Useful Websites:
Course Website: `http://www.math.tamu.edu/~alarios/courses/TAMU/2013_fall_M609/content.html`
My Website: `http://www.math.tamu.edu/~alarios`
Department of Mathematics: `http://www.math.tamu.edu`
Campus emergency: `http://studentaffairs.tamu.edu/emergency`
Student Rules: `http://student-rules.tamu.edu`
Aggie Honor: `http://aggiehonor.tamu.edu/`
Disability Services: `http://disability.tamu.edu`

Disclaimer: While this syllabus was prepared carefully and according to information available at the beginning of the semester, changes may be necessary in the interest of good teaching. Changes to any of the information above will be announced in class and posted on the class web site. This includes in particular possible updates or corrections to the syllabus, and changes of exam dates.

Rough schedule: The following tentative schedule is a rough guide to the material covered in the course, but is subject to change.

#	Day	Date	Material
1	M	8/26	Basic facts regarding the system $A\mathbf{x} = \mathbf{b}$.
2	W	8/28	Easy to solve systems. LU-decomposition.
3	F	8/30	LL^T-Cholesky, operation count.
4	M	9/2	Analysis of Gaussian elimination.
5	W	9/4	Matrix norms. The idea of iterations.
6	F	9/6	Basic iterative methods.
7	M	9/9	The main theorem of iterative methods.
8	W	9/11	Convergence of iteration for diagonally dominant matrices.
9	F	9/13	Convergence of SOR for SPD matrices.
10	M	9/16	The idea of extrapolation.
11	W	9/18	Chebyshev acceleration: introduction.
12	F	9/20	Chebyshev acceleration: advantages and implementation.
13	M	9/23	Variational method. SD Method.
14	W	9/25	Convergence of SD.
—	F	9/27	**Exam #1**, in class.
15	M	9/30	Conjugate Gradient Method, GMRES, MINRES.
16	W	10/2	Convergence of CG. Newton's Method.
17	F	10/4	Polynomial interpolation; Lagrange interpolation.
18	M	10/7	Newton divided difference formula.
19	W	10/9	Hermit & Birkhoff interpolation.
20	F	10/11	Cubic spline interpolation.
21	M	10/14	Error in cubic spline interpolation.
22	W	10/16	Trigonometric interpolation.
23	F	10/18	FFT (Fast-Fourier Transform).
24	M	10/21	Quadratures, Newton-Cotes.
25	W	10/23	Gaussian quadratures.
—	F	10/25	**Exam #2**, in class.
26	M	10/28	Peano Kernel Theorem.
27	W	10/30	Euler and Runge-Kutta for IVPs for ODEs.
28	F	11/1	R-K methods, local truncation error, error estimates.
29	M	11/4	Error control and adaptive step refinement.
30	W	11/6	Adams-Bashforth and Adams-Moulton methods.
31	F	11/8	General Theory of residual methods.
32	M	11/11	Dahlquist equivalence theory.
33	W	11/13	Stability, consistency, and convergence.
34	F	11/15	A-stability of ODE methods. [**Q-drop deadline**]
35	M	11/18	Wrap-up: Numerical Methods for IVPs for ODEs.
36	W	11/20	Nonlinear methods for two-points BVPs.
37	F	11/22	Stability of L^2 and H^1 discrete norms.
38	M	11/25	Stability in max-norm convergence of FD methods.
39	W	11/27	Stiff equations.
—	F	11/29	[**Thanksgiving Holiday**] **No class**
40	M	12/2	Review. (Last day of lecture for our class.)
—	Tues	12/10	**Final Exam 8:00 am**

Exams: You are required to bring and possibly present your Aggie Card or a government issued ID card when taking exams, as well as standard writing materials.

- Exam 1: 9/27, Material from lectures 1-14.
- Exam 2: 10/25, Material from lectures 15-25 (may include earlier material).
- Final: 12/10, 8:00am, Material from lectures 26-40 (may include earlier material).