CS 591 - Numerical Analysis I

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1 General Information

(a) Instructor: K. Subramani

(b) Meeting Times: Tu-Th, 8:00 am - 9:15 am
Location: 109 MRB.

(c) Contact Information: 749 ESB, ksmani@csee.wvu.edu

(d) Office Hours: MW, 09:00 am - 10:00 am

(e) Textbook - [SM03] is the primary course textbook.

(f) URL - http://www.csee.wvu.edu/~ksmani/courses/fa07/numal/numal.html

(g) Assessment:

  (a) Homework Assignments (2) - You will be handed a homework on September 6, due on September 13 and a second homework on October 18, due on October 25. Each homework is worth 15% (for a total of 30%), of your grade.

  (b) Quizzes (2) - The first quiz will be held on September 20, and the second quiz on November 8. Both quizzes are closed-book and each quiz is worth 15% (for a total of 30%) of your grade.

  (c) Midterm - The midterm will be held on October 9 (in-class, closed book) and is worth 20% of your grade.

  (d) Final - The final will be held on December 13 (in-class, closed-book, $3:00$ pm - $5:00$ pm) and is worth 20% of your grade.

(h) Grade Boundaries

  (a) **A**: 75 and up

  (b) **B**: $65-74$

  (c) **C**: $50-64$

  (d) **D**: $45-49$

  (e) **F**: $0-44$

(i) Grading policy - If you have any questions about the grading, you must contact the instructor within two days of your paper being returned.

(j) Makeup Policy - If for some reason, you are unable to attend a test or an exam, please meet me at the earliest and I will set an alternate date.

(k) **Course Objectives** - The objectives of this course are as follows:

(a) Exposing students to the basic concepts of numerical analysis at a graduate level.

(b) Introducing iterative techniques to solve equations.

(c) Discussing algorithmic techniques to determine eigenvalues and eigenvectors.

(d) Presenting techniques to approximate polynomials in various norms.

(l) **Expected Learning Outcomes** - Upon successful completion of this course, students will be able to:

(i) Appreciate the fundamental theorems of sequences and series.

(ii) Apply iterative techniques to solve systems of equations.

(iii) Apply advanced algorithms such as the Householder method towards determining eigenvalues and eigenvectors.

(iv) Approximate polynomials in various norms.

2 Syllabus Sketch and Weekly Schedule

2.1 Iterative solutions of equations

Sequences and Series, Calculus Theorems, The iterative approach, Newton's method, the secant method and the bisection method. These topics will be covered from Chapter 1 of [SM03] (2 Lectures).

2.2 Solving Systems of Linear Equations

Gaussian Elimination, LU Factorization, Pivoting, Work Analysis, Norms and conditions numbers, Hilbert matrix, Least Squares method. These topics will be covered from Chapter 2 of [SM03] (2 Lectures).

2.3 Special matrices

Symmetric positive definite matrices, Tridiagonal and band matrices, Monotone matrices. These topics will be covered from Chapter 3 of [SM03] (1 Lecture).

2.4 Eigenvalues and eigenvectors of a symmetric matrix

The characteristic polynomial, Jacobi's method, Gerschgorin's theorems, Householder's method, The QR procedure, The Rayleigh quotient. These topics will be covered from Chapter 5 of [SM03] (2 Lectures).

2.5 Polynomial Interpolation

Introduction, Lagrange interpolation, Convergence, Hermite Interpolation, Differentiation. These topics will be covered from Chapter 6 of [SM03] (2 Lectures).

2.6 Introductory Numerical Integration

Introduction, Newton-Cotes formulae, Error estimates, The Runge phenomenon, Composite formulae, The Euler-Maclaurin expansion, Extrapolation methods. These topics will be covered from Chapter 7 of [SM03] (2 Lectures).

2.7 Polynomial Approximation in the ∞-norm

Introduction, Normed Linear Spaces, Best approximation in the ∞-norm, Chebyshev polynomials, Interpolation. These topics will be covered from Chapter 8 of [SM03] (2 Lectures).

2.8 Polynomial Approximation in the 2-norm

Introduction, Inner product spaces, Best approximations in the 2-norm, Orthogonal polynomials, Comparisons. These topics will be covered from Chapter 9 of [SM03] (2 Lectures).

2.9 Advanced Numerical Integration

Introduction, Construction of Gauss quadrature rules, Direct construction, Error estimation for Gauss quadrature, Composite Gauss formulae, Radau and Lobatto quadrature. These topics will be covered from Chapter 10 of [SM03] (2 Lectures).

2.10 Piecewise polynomial approximation

Introduction, Linear interpolating splines, Basis functions for the linear spline, Cubic splines, Hermite cubic splines, Basis functions for cubic splines. These topics will be covered from Chapter 11 of [SM03] (2 Lectures).

2.11 Initial value problems for Ordinary Differential Equations

Introduction, One-step methods, Consistency and convergence, Runge-Kutta methods, Linear multistep methods, zero-stability, Consistency, Dahlquist's theorems, Systems of Equations, Stiff systems, Implicit Runge-Kutta methods. These topics will be covered from Chapter 12 of [SM03] (3 Lectures).

2.12 Boundary value problems for Ordinary Differential Equations

Introduction, Error analysis, Boundary conditions involving a derivative, The general self-adjoint problem, The Sturm-Liouville eigenvalue problem, The shooting method. These topics will be covered from Chapter 13 of [SM03] (2 Lectures).

I would like to reiterate that this is a sketch of the topics that we will be covering. For various reasons, I may choose to drop a mentioned topic or cover a new topic. In such cases, advance notice will be given. I have also reserved some lectures for discussions on Homework Assignments, Quizzes and Exams.

3 Social Justice Statement

West Virginia University is committed to social justice. I concur with that commitment and expect to foster a nurturing learning environment, based upon open communication, mutual respect and non-discrimination. Our University does not discriminate on the basis of race, sex, age, disability, veteran status, religion, sexual orientation, color or national origin. Any suggestions to further such a positive and open environment in this class will be appreciated and given serious consideration. If you are a person with a disability and anticipate needing any type accommodation, in order to participate in this class, please advise me of the same and make appropriate arrangements with Disability Services $(293 - 6700)$.

If you feel that you are being treated inappropriately or unfairly in any way, please feel free to bring your concerns to my attention; rest assured that doing so will not prejudice the grading process. In return, I expect you to behave professionally and ethically.

References

[SM03] Endre Süli and David Mayer. *An Introduction to Numerical Analysis*. Cambridge University Press, 1^{st} edition, 2003.