CS 510: NUMERICAL ANALYSIS, Fall 2019, 3 Credits

Instructor: Bahman Kalantari (kalantar@cs.rutgers.edu)
Lecture: Thursday 12:00-2:50 PM, TIL-226, LIV (Livingston).
Office Hours: Wed 1:00-2:00 PM, Hill Center 444 (also by appointment).
Prerequisites: Multivariate Calculus, Linear Algebra, Ability to program in a high level language, e.g., Matlab, Python, C, C++
Grading: Midterm 20%; Final 30%; Programming (Group) Project 50%
Teaching Assistant: Chun Leung Lau; larryl@cs.rutgers.edu; **Office:** Hill Center 427; **Office hours:** Tuesday 12:00-1:00PM
Objectives: Introduction to derivation, analysis, algorithms, and their computer implementation and application in order to solve fundamental numerical problems.
Course Outline:

- Floating point numbers and roundoff error
- Solution of nonlinear algebraic equations
  - bisection method, regula falsi, fixed point iteration, secant method, Newton's method
  - convergence rates (linear, quadratic)
  - systems of nonlinear equations - Newton's method
- Introduction to dynamical systems, fixed point iterations
  - basics of complex numbers, the geometric modulus principle, the fundamental theorem of algebra
  - Newton's method, Halley's method, the Basic Family of iteration functions
  - Taylor's theorem and generalized Taylor's theorem
  - basins of attraction, Voronoi diagrams of roots of polynomials
  - bounds on modulus of zeros of polynomials
  - Fatou and Julia sets, the Mandelbrot set
  - fractals, polynomiography
- Solution of linear algebraic systems
  - Gaussian elimination/ LU decomposition
  - special cases: symmetric, banded, sparse matrices
  - error analysis, norms, condition number
  - iterative methods (Jacobi, Gauss-Seidel, SOR, a geometric method, convergence rates)
  - overdetermined systems, least squares solutions
- Other numerical linear algebra topics + applications
  - QR decomposition
  - Singular value decomposition (SVD)
  - Web search, PageRank via power method, PageRank via a convex hull algorithm
  - some application of eigenvalue problems in optimization
- Interpolation, approximation of functions
  - the interpolating polynomial (its construction and error term)
  - piecewise polynomial interpolation, splines
  - Tchebycheff interpolation, minimax approximation
  - least squares approximation, orthogonal polynomials
- Numerical differentiation and integration
  - quadrature formulas, error terms
  - adaptive quadrature, Gaussian quadrature
  - numerical differentiation, error terms
- Numerical solution of ordinary differential equations
  - basic methods (Taylor methods, Runge-Kutta methods, multistep methods)
  - stability, consistency, convergence
  - higher order equations, systems

Some Reference:

M. T. Heath, Scientific Computing, An Introductory Survey, 2nd edition, McGraw-Hill, 2002.
G. Dahlquist & A. Bjorck, Numerical Methods, Prientice-Hall, 1974; SIAM, 2008.
G. H. Golub & C. F. Van Loan, Matrix Computations, 3rd edition, Johns Hopkins University Press, 1996.
Kendall Atkinson, An Introduction to Numerical Analysis, John Wiley & Sons, Inc., Second Edition, 1989.
Bahman Kalantari, Polynomial Root-Finding and Polynomiography, World Scientific, 2008.
Matlab tutorial + links to other references + some articles