Lecturer: Christina Christara (ccc@cs.toronto.edu)

Lectures: Monday 3-5 PM, Room BA 2185 and online

Tutorial: Wednesday 3-4 PM, Room BA 2185 and online (some tutorials used for lectures)

Office Hours: mostly online, unless there is some very special need

available from the SIAM website, cheaper if you become student member, see details in course website below

alternative: Uri Ascher and Chen Greif, A first course in Numerical Methods, SIAM 2011 (e-book on library)


Aims of course
Formulate numerical methods for approximation, integration, eigenproblems and ODEs.
Evaluate numerical methods with respect to their convergence, stability, and efficiency.
Develop and practice computer skills in implementing numerical methods efficiently on the computer.
Use high level software for studying numerical methods.

Skills / Knowledge testing in the course
Apply basic principles, not recall lecture notes in detail
Problem recognition
Method recognition
Apply a given method correctly
Solve a numerical problem efficiently and reliably using mathematical software.
Judge the quality and efficiency of the numerical results.

Prerequisite Mathematics and Numerical Analysis
Ability to handle notation and to do algebraic manipulation
Induction
Calculus including differentiation and integration of polynomial, trigonometric, exponential, logarithmic and rational functions, continuity, limits, graphs of functions, Taylor series, Rolle’s theorem, mean-value theorem, de l’ Hospital’s rule, some exposure to multivariate differentiation, etc.
Elementary Linear Algebra including
Matrix and vector addition and multiplication, elementary row operations, linear (in)dependence, inverse matrix, etc.
Numerical Linear Algebra (such as CSC336 or CSC350) including
Linear solvers for banded matrices and Nonlinear equations solvers
Computational methods: Understanding of round-off error, computer arithmetic, etc.
Programming: knowledge of some programming language, such as MATLAB, python, FORTRAN or C.

Computer accounts
You will get (or have already) a computer account on the Teaching Labs (CDF) Unix system. Consoles/workstations are located in the Bahen building, but there use depends on covid developments... You must log-in frequently and read mail, news and other messages relating to the course through your account.

Marks distribution
Homework 1 Wed 23 Sept 2%
Homework 2 Wed 30 Sept 4%
Homework 3 Wed 7 Oct 4%
Assignment 1 Wed 14 Oct 12%
Test 1 Wed 28 Oct 13%
Assignment 2 Wed 18 Nov 13%
Test 2 Wed 25 Nov 13%
Assignment 3 Thu 10 Dec 13%
Final test TBA 2 hrs 26%

• Must get at least 33% in the final exam, and at least 20% in each of the other assessments; can’t skip any
• Must get at least 33% average in the computing parts of the assignments.
• Term tests and final exam: Calculators and course materials are the only aids permitted.
Problem sets / Computer assignments

problem sets: please write as clearly as possible.

Indicate your last (family) name by capitalisation or underlining in the front page of your paper.

computer assignments: don’t leave it to the last minute - think of the following

– the machine being down, when you need it.
– the workstation room being crowded.
– the printer being stuck, when you are just at the time to get your final listing.
– accidentally deleting an important file.

overcome this by using backup procedures (for the source and data files only).

The above are not good reasons for extension of the assignment due date.

Late assignment policy

Assignments are due the day posted, at lecture time. Assignments submitted late have a reduction of marks based on the maximum total marks the assignment could get, had it been submitted on time (and not on the total marks the assignment actually got). Each day costs 10%, to a maximum of 3 days. Assignments submitted later than 3 days after the due date do not receive any marks. Weekends and holidays count as regular days for the purpose of late assignment policy.

Topics to be covered

• Interpolation (Ch. 7)

  Polynomial interpolation - Weierstrass theorem
  Monomial basis, Lagrange basis, Newton’s divided differences
  Existence and uniqueness of interpolating polynomial
  Error of polynomial interpolation
  Evaluation of a polynomial - Horner’s rule
  Polynomial interpolation with derivative data - Hermite interp.
  Monomial basis, Lagrange basis, Newton’s divided differences
  Existence and uniqueness of Hermite interpolating polynomial
  Error of Hermite polynomial interpolation
  Problems with polynomial interpolation - Runge’s function
  Piecewise polynomial interpolation - splines
  Basis for piecewise polynomials

• Integration -- Quadrature (Ch. 8)

  Simple quadrature rules - rectangle, midpoint, trapezoidal, Simpson’s, corrected trapezoidal
  Gauss quadrature rules
  Compound quadrature rules
  Romberg integration
  Adaptive integration
  Infinite integrals, singularities

• Ordinary Differential Equations (Ch. 9)

  Initial Value Problems and Boundary Value Problems
  Stability of ODEs and of methods for ODEs
  Euler’s method
  Implicit methods, backward Euler’s and trapezoidal method
  Runge-Kutta methods
  Taylor’s series methods
  Linear Multistep Methods

• Least Squares Approximation (Ch. 3)

  Least squares problems - data fitting
  Inner products and norms of functions
  Normal equations, QR factorisation, Gram-Schmidt algorithm
  Orthogonal and orthonormal polynomials

• Computing eigenvalues and eigenvectors (Ch. 4)

  The power method; the QR iteration

References

Michael Heath
Scientific Computing: an introductory survey
SIAM 2018 (or McGraw-Hill Inc. 2002)

Uri Ascher and Chen Greif
A first course in Numerical Methods
SIAM 2011 (e-book on library)

Richard L. Burden and J. Douglas Faires
Numerical Analysis
Brooks/Cole

David Kincaid and Ward Cheney
Numerical Analysis
Brooks/Cole

James Epperson
An introduction to Numerical Methods and Analysis
Wiley 2003

Samuel D. Conte and Carl de Boor
Elementary Numerical Analysis
SIAM 2018 (also McGraw-Hill Inc.)

L. W. Johnson and R. D. Riess
Numerical Analysis
Addison Wesley

G. Dahlquist and A. Bjorck (trans. N. Anderson)
Numerical Methods
Prentice Hall

J. Stoer and R. Bulirsch
Introduction to Numerical Analysis
Springer Verlag
Additional information

Assignments, homeworks and exams must be your own individual work and using only course materials. While students at your level are well aware of what academic integrity means, please note that violating academic integrity includes more things than presenting others’ work as one’s own. For example, not taking reasonable measures to protect your work from being plagiarized by others is also a violation of academic integrity. This is becoming particularly important now that so many things are online.

Assignments, homeworks and exams will be submitted electronically.

Assignments will be typed in latex. A template is given in the course website.

Some homeworks will be typed in latex, some will be handwritten and scanned. Specific instructions will come with each homework.

Exams will be handwritten and scanned, or, alternatively, typed in latex.

Tests/exams will be synchronous. The default time for term tests is the teaching time of the day, but, depending on timezones and availability, there may be another time chosen. The final test will be scheduled by the University.

Lectures/tutorials will be offered onsite and online (through zoom). I expect to be able to post recordings too. Links will be posted in the course website or e-mailed.

Office hours will be available with pre-arrangement, either at default times posted, or at other mutually agreeable times. Office hours will be for individual students, not for a group of students.