AMATH 242/CS 371:
Introduction to Computational Mathematics
Spring 2022

University of Waterloo
Cheriton School of Computer Science
Section 1: 1:00-2:20 pm, Mon & Wed, MC 4041
Section 2: 2:30-3:50 pm, Mon & Wed, MC 4041

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Office hours: Tues 11:30 am - 12:30 pm
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Teaching Assistants

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Course Description

Computational math deals with the design of algorithms to perform mathematical calculations on a computer. Topics covered include the numerical evaluation of integrals, interpolation using splines, sparse linear systems, signal processing, and image compression. Assignments will involve both theoretical work and programming tasks.

Websites & Resources

We will be using LEARN as the main course webpage. Notes, videos, announcements, and this outline will be posted there. In addition, Piazza will be used for questions & discussion. Crowdmark will be used to submit assignments.

Textbook

Required:

- CS 371 Course Notes by Hans De Sterck (PDF available on LEARN)

Optional:

- Numerical Analysis, Seventh Edition, Burden and Faires, Brooks/Cole
- Introduction to Scientific Computing, C. Van Loan, Prentice-Hall.

Programming Languages

Students should use Python 3 (suggested libraries include SciPy and NumPy).

Marking scheme

Assignments	28% (5 total, worth 4%, 6%, 6%, 6%, 6% each)
Midterm Exam	24%
Final Exam	48%

You must pass the final exam (i.e., achieve a grade of at least 50%) to pass the course, otherwise your final grade will equal the grade on your final exam.

Assignment Marking

The assignments will consist of programming problems and analytic work. Note: Many of the marks for programming problems will be given for algorithm descriptions (i.e., pseudo-code) and explanation of the results/output. Simply handing in "raw code" and bare output will get very few marks.

Tests

The midterm and final exam will be held in-person. Students will be allowed a single-sided 'cheat' sheet for tests. If a student has a legitimate conflict with the scheduled midterm on June 16, please contact me no later than June 2, so that alternative arrangements can be made.

Late Work

In the interest of allowing students to submit their best work, assignment deadlines can be extended upon request under some circumstances. If you find yourself unable to complete an assignment on time, please contact me before the deadline expires and explain why. The maximum length of an extension is three days. Note that late assignments will receive a mark of zero if the student has not received an extension.

COVID Contingency Plans

In the event that we cannot continue in-person activity, the course will carry on virtually. Recorded lectures will be posted regularly. The LEARN classroom will be used for virtual sessions during the normal course hours – these sessions will a mix of lecture material, practice problems, and Q&A time. The midterm and final exam will become take-home tests.

Schedule

The following lecture plan is tentative and may be subject to change.

Week	Dates	Topic	Readings	Assessments
1	May 2,4	Floating Point Systems	Chapter 1	
2	May 9, 11	Root finding	Chapter 2	
3	May 16, 18	Linear Systems	Chapter 3	Assignment 1 (May 20)
4	May 25	Linear Systems	Chapter 3	
5	May 30, June 1	Linear Systems Fourier Approximation	Chapter 3, 4	Assignment 2 (June 3)
6	June 6, 8	Fourier Approximation	Chapter 4	
7	June 13, 15	Fourier Approximation	Chapter 4	Midterm (June 16)
8	June 20, 22	Fourier Approximation Polynomial Interpolation	Chapter 4, 5	
9	June 27, 29	Polynomial Interpolation	Chapter 5	Assignment 3 (July 1)
10	July 4, 6	Polynomial Interpolation	Chapter 5	
11	July 11, 13	Polynomial Interpolation Numerical Integration	Chapter 5, 6	Assignment 4 (July 15)
12	July 18, 20	Numerical Integration	Chapter 6	
13	July 25	Numerical Integration	Chapter 6	Assignment 5 (July 26)

Topics

1. Floating point systems
    - Floating point numbers and operations
    - IEEE standards
    - Approximation error
    - Condition of a mathematical problem
    - Unstable computations
2. Root Finding
    - Bisection method
    - Newton's method
    - Secant method
    - Rate of convergence
3. Numerical Linear Algebra
    - Page Rank Algorithm (Markov matrices, power iteration)
    - Solving linear systems (LU factorization, forward & backward substitution)
    - Condition number of a matrix
    - Iterative methods for solving linear systems (Jacobi method, Gauss-Seidel method)
4. Fourier Approximation
    - Fourier Series
    - Discrete Fourier transform
    - Fast Fourier transform
    - Power Spectrum
    - Applications for image processing
5. Polynomial Interpolation
    - Lagrange interpolation
    - Hermite Interpolation
    - Piecewise approximation
    - Spline interpolation
6. Numerical Integration
    - Quadrature rules (midpoint, trapezoid, simpson)
    - Composite rules
    - Gaussian integration

Academic Integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility.

[Check www.uwaterloo.ca/academicintegrity/ for more information.]

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4,
http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm.
When in doubt please be certain to contact the department's administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity to avoid committing academic offenses and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offense, or who needs help in learning how to avoid offenses (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course professor, academic advisor, or the undergraduate associate dean. For information on categories of offenses and types of penalties, students should refer to Policy 71, Student Discipline,
http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm.
For typical penalties check Guidelines for the Assessment of Penalties,
http://www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm.

Appeals: A decision made or penalty imposed under Policy 70, Student Petitions and Grievances (other than a petition) or Policy 71, Student Discipline may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72, Student Appeals,
http://www.adm.uwaterloo.ca/infosec/Policies/policy72.htm.

Note for students with disabilities: The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.