Course Information

Instructor: Steph Durocher
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Lectures: 9:30–10:30 am, Mon., Wed., & Fri. in EITC E2-304
Office hour: 9:00–10:00 am Tuesday

Course Description. Algorithm design with emphasis on formal techniques in analysis and proof of correctness. Computational geometry, pattern matching, scheduling, numeric algorithms, probabilistic algorithms, approximation algorithms and other topics.

Course Goals and Intended Learning Outcomes. COMP 4420 is intended as an advanced course in theoretical computer science. A primary objective of COMP 4420 is to allow students to discover advanced data structures and their associated algorithms from a theoretical perspective. Students will learn new techniques for solving specific problems more efficiently and for analyzing space and time requirements. Several of the data structures discussed are recent developments that are not yet found in textbooks. The emphasis is on theoretical analysis of the data structures and algorithms. If you like recurrence relations, double logarithms, and worst-case linear-time selection, you wonder whether it is possible to make balanced search trees more efficient, and you feel $O(\log n / \log \log n)$ time is a significant improvement over $O(\log n)$ time, then this course is for you.

Syllabus. Topics to be covered in the course will include the following, subject to change at the discretion of the instructor and based on the learning needs of the students.

- *Dictionaries:* van Emde Boas trees, y-fast tries, skip lists, cuckoo hashing, splay trees, fusion trees, atomic heaps
- *Array Range Query:* range trees, wavelet trees, Cartesian trees, range minimum, range selection, range mode, lowest common ancestor, interval trees
- *Resizeable Arrays*
- *String and Sequences:* suffix trees and suffix arrays, string matching (Knuth-Morris-Pratt algorithm)
- *Selection:* linear-time selection, finding the second largest element, selection in dictionaries, binary rank and select
- *Additional Possible Topics:* geometric data structures, disjoint sets, Fibonacci heaps, persistent data structures, randomized algorithms, succinct data structures, parameterized complexity, online algorithms

Prerequisites. An upper-year undergraduate course in algorithms (COMP 3170) is required, as are courses in discrete mathematics (COMP 2130), algorithm analysis (COMP 2080), and data structures (COMP 2140). The university calendar also lists STAT 1000 or STAT 1001 as a prerequisite. Students are expected to have a strong background in theoretical computer science (e.g., A or A+ in COMP 3170) and to be familiar with intermediate

topics in design and analysis of algorithms, data structures, and discrete mathematics, including sorting, searching, big Oh notation, trees, graph theory, and set theory.

Textbook. The following book is recommended (but not required) and is available at the University of Manitoba bookstore:

- Introduction to Algorithms, third edition, by Cormen, Leiserson, Rivest, and Stein, MIT Press, 2009.

The following books are useful references available on reserve at the Sciences and Technology Library:

- Algorithms and Data Structures, by Mehlhorn and Sanders, Springer, 2008.
- The Algorithm Design Manual, second edition, by Skiena, Springer, 2008.
- Advanded Data Structures, by Brass, Cambridge, 2008.

A limited number of copies of Cormen et al. are available for electronic viewing through the University of Manitoba Library website. Most Springer publications are available online at SpringerLink through the University of Manitoba Library.

Assignments. Assignments will consist of problem sets, seeking constructive solutions to algorithmic problems related to lecture material and assigned reading. Solutions should include sufficiently detailed descriptions, presented clearly and unambiguously. Four assignments will be distributed in class during the term. You will have one week to complete each assignment individually. Solutions must be submitted by the start of class on the due date. Include your name, student number, and email address at the top of the first page on all submitted material, as well as the names of people with whom you have discussed your assignment solution. Cite any sources to which you refer, as you should do when presenting any scientific document. You must submit your solution electronically using UMLearn. Only pdf files will be accepted. To permit the prompt distribution of solutions and return of marked assignments, **late assignments will not be accepted**.

Examinations. There will be two quizzes and a midterm exam held in class, and a final exam held during the exam period. Quizzes and exams will be closed book.

Course Project. The purpose of the course project is for students to select and explore an advanced topic in theoretical computer science, to study a current research problem in that topic, to make a new contribution on that topic, and to present the results, in both a written report and a class presentation. The nature of the project can vary; examples include:

- writing a survey paper that examines and discusses one or more current data structures or algorithmic techniques,
- writing code to implement and compare the performance of algorithms for solving a given problem, or
- exploring possible solutions to an open problem on a given topic.

As part of the project, students must submit a preliminary project proposal, a final written report, and give a class presentation.

Students may choose to complete the project individually or in groups of two.

Grading. Grades will be calculated according to the following table:

assignments	20%
project	15%
quizzes	10%
midterm exam	20%
final exam	35%

Important Dates.

January 18	first class	March 29	quiz
February 8	assignment 1 due	March 31	last day for withdrawal
February 15	quiz	April 5	assignment 4 due
February 20–24	midterm break - no class	April 14	Good Friday - no class
March 1	assignment 2 due	April 21	last class
March 6	midterm exam	April 21	project report due
March 15	project proposal due	April 22–29	exam period
March 22	assignment 3 due		

Referencing Style. Assignments and projects should use one of the standard citation formats for Compute Science, such as ACM, IEEE, or AMS. For example:

Boucher, C., Erdős, P., and Obama, B. *Title of Article*. Journal of Algorithms 10(2), 104–122 (2017).

Academic Integrity. The Faculty of Science takes academic integrity very seriously. Any evidence of academic dishonesty on assignments, labs and/or tests will be forwarded to the appropriate authorities for potential disciplinary actions.
The University Student Discipline By-Law may be accessed at: `http://umanitoba.ca/admin/governance/governing_documents/students/student_discipline.html`.
Information from the Faculty of Science regarding Cheating and Plagiarism can be found at `http://umanitoba.ca/faculties/science/undergrad/resources/webdisciplinedocuments.html`.
Students are encouraged to discuss course concepts and the general interpretation of homework problems with other students in the class. No written record should be taken from such discussion. Each student must work on the final solution of assignment problems independently. On a cover page, each student must list the names of people with whom he or she has discussed the assignment solution. Following conventions for citing reference materials in scientific writing is mandatory. Submitting the work of another person as your own constitutes academic misconduct. Any course work that does not follow these guidelines will be considered plagiarism and will be reported to the Faculty of Science. Students are to abide by the university's policies regarding academic dishonesty which can be found on this web site: `http://umanitoba.ca/student/resource/student_advocacy/academicintegrity/students/`

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Recording Class Lectures. Stephane Durocher and the University of Manitoba hold copyright over the course materials, presentations and lectures which form part of this course. No audio, video, or photographic recording of lectures or presentations is allowed in any format, openly or surreptitiously, in whole or in part without permission of Stephane Durocher. Course materials (both paper and digital) are for the participants private study and research.

Course Technology. It is the general University of Manitoba policy that all technology resources are to be used in a responsible, efficient, ethical and legal manner. The student can use all technology in classroom setting only for educational purposes approved by instructor and/or the University of Manitoba Student Accessibility Services. Student should not participate in personal direct electronic messaging / posting activities (e-mail, texting, video or voice chat, wikis, blogs, social networking (e.g. Facebook) online and offline gaming during scheduled class time. If student is on call (emergency) the student should switch his/her cell phone on vibrate mode and leave the classroom before using it. (Copyright S. Kondrashov. Used with permission)

Class Communication. The University requires all students to activate an official University email account. For full details of the Electronic Communication with Students please visit: `http://umanitoba.ca/admin/governance/media/Electronic_Communication_with_Students_Policy_-_2014_06_05.pdf`
Please note that all communication between myself and you as a student must comply with the electronic communication with student policy (`http://umanitoba.ca/admin/governance/governing_documents/community/electronic_communication_with_students_policy.html`). You are required to obtain and use your U of M email account for all communication between yourself and the university.

Student Accessibility Services. If you are a student with a disability, please contact SAS for academic accommodation supports and services such as note-taking, interpreting, assistive technology and exam accommodations. Students who have, or think they may have, a disability (e.g. mental illness, learning, medical, hearing, injury-related, visual) are invited to contact SAS to arrange a confidential consultation. Student Accessibility Services
`http://umanitoba.ca/student/saa/accessibility/`
520 University Centre
204 474 7423
`mailto:Student_accessibility@umanitoba.ca`

Academic Recourses. Various academic resources are available to students including the Science and Technology Library and various departmental help centers.

Health & Mental Health Resources. Students with Health and/or Mental Health issues may seek advice and/or help from Student Counselling Center, Student Accessibility

Services, and University Health Services.

Respectful Behaviour Resources. Students are expected to act in a respectful manner. Policies regarding respectful work and learning environment and sexual assault can be found at `http://umanitoba.ca/admin/governance/governing_documents/community/230.html`.

Final Examinations, Grades and Grade Appeals Resources. Final examination and grades policies can be found at `http://umanitoba.ca/admin/governance/governing_documents/academic/1299.html`.
Students wishing to appeal their term work grade can do so through the Registrars office. A fee is charged for each appeal.
To view your final examination, please check with the department offering the course for policies.
To appeal your final grade, you can initiate the process at the Registrars office. A fee will be charged for each appeal. See the Registrars office for more information.

Limited Access and VW Resources. Students who fail or VW from a course will be subject to limited access to that course in future terms. That is, students will not be able to register for a course (for which they have VWed or failed) during the limited access registration period. For more information, please see the policy document for repeated courses at `http://www.umanitoba.ca/admin/governance/media/Repeated_Course_Policy_-_2016_09_01.pdf`.