Toronto Metropolitan University

**Department of Electrical, Computer, & Biomedical Engineering**
Faculty of Engineering & Architectural Science

# Course Outline (W2025)

## COE428: Engineering Algorithms and Data Structures

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| **Instructor(s)** | Dr. Reza Samavi [Coordinator]<br>Office: ENG457<br>Phone: (416) 979-5000 x 554903<br>Email: samavi@torontomu.ca<br>Office Hours: TBA<br><br>Dr. Reza Sedaghat<br>Office: ENG431<br>Phone: (416) 979-5000 x 556083<br>Email: rsedagha@torontomu.ca<br>Office Hours: TBA<br><br>Dr. Arghavan Asad<br>Office: EPH432<br>Phone: TBA<br>Email: arghavan.asad@torontomu.ca<br>Office Hours: Thursdays 6:00pm-7:00pm |
| **Calendar Description** | The main topics covered in this course include basic data structures (arrays, pointers), abstract data structures (trees, lists, heaps), searching, sorting, hashing, recursive algorithms, parsing, space-time complexity, NP-complete problems, software engineering and project management, object-oriented data structures. Case studies and lab exercises will be implemented using a high level programming language. (Formerly ELE 428.) |
| **Prerequisites** | COE 318 |
| **Antirequisites** | None |
| **Corerequisites** | MTH 314 |
| **Compulsory Text(s):** | 1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein. Introduction to Algorithms, Fourth Edition, MIT Press, 2022, ISBN: 978-0-262-04630-5 |
| **Reference Text(s):** | 1. Knuth, Donald Ervin, The Art Of Computer Programming (3 volumes) Addison-Texts Wesley,1977. This is the classic book on computer programming, algorithms, and data structures. It is very mathematical and also has extensive problems and solutions.<br>2. Brian W. Kernighan and Rob Pike, The Practice of Programming, Addison-Wesley, 1999, ISBN:0-201-61586-X, 267 pages. This excellent book will help you hone your programming skills in any language (although the emphasis is on C).<br>3. Standish, Thomas A., Data Structures, Algorithms and Software Principles in C, Addison-Wesley 1995, ISBN: 0-201-59118-9<br>4. Brian W. Kernighan, Dennis Ritchie, The C Programming Language, Prentice-Hall, 2nd edition 1988. This is the classic book on C, written by the language developers.<br>5. Laboratory Manual: Available through the course web page:http://www.ee.ryerson.ca/~courses/coe428 |

**Learning Objectives (Indicators)**

At the end of this course, the successful student will be able to:

1. Develop knowledge of designing and analyzing algorithms that can be used to solve various computational problems in the domain of engineering. (**1a**)
2. Apply mathematical principles to determine the run-time complexity (best, worst and average cases) of various algorithms. Learn about various asymptotic notations used for bounding the algorithm running times and develop knowledge on how to solve recurrence equations. (**1b**)
3. Learn about various data structures (e.g. stacks, queues, linked lists, binary search trees, red black trees, priority queues, heaps, hash tables etc.) that can be applied to construct efficient algorithms for a variety of engineering problems. (**1c**)
4. Analyze the efficiency of various Graph algorithms that are used in solving network related problems. The analysis will help to rank/rate alternative algorithms for a given problem. (**4b**)
5. Compare different approaches for designing algorithms such as incremental approach versus divide-and-conquer approach. Learn how to select the best design alternative for a given input size of a problem. (**4c**)
6. Follow lab and exam instructions and develop required algorithms. (**7a**)

**NOTE:***Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board (CEAB).*

**Course Organization**

3.0 hours of lecture per week for 13 weeks
2.0 hours of lab per week for 12 weeks
0.0 hours of tutorial per week for 12 weeks

**Teaching Assistants**

TBA

**Course Evaluation**

| **Theory** | |
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| Mid-term Examination | 35 % |
| Final Examination | 40 % |
| **Laboratory** | |
| Labs | 25 % |
| TOTAL: | 100 % |

**Note:** In order for a student to pass a course, a minimum overall course mark of 50% must be obtained. In addition, for courses that have both **"Theory and Laboratory"** components, the student must pass the Laboratory and Theory portions separately by achieving a minimum of 50% in the combined Laboratory components and 50% in the combined Theory components. Please refer to the **"Course Evaluation"** section above for details on the Theory and Laboratory components (if applicable).

**Examinations**

Midterm exam in Week 7, two hours, problems, closed book (covers Weeks 1-6).
Final exam, during exam period, 2-3 hours, closed-book (covers Weeks 1-13).

**Other Evaluation Information**

In order to achieve a passing grade in this course, the student must achieve an average of at least 50% in both theoretical and laboratory components.

**Teaching Methods**

1. Lectures will be delivered during the scheduled class hours.
2. Notes/slides from the class lectures will be posted on D2L.

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| | 3. Laptops/computer systems are mandatory requirement for the course lectures and labs. |
| **Other Information** | All the labs have to be performed individually by each student. Each lab has its own weight as specified in the lab manuals. In case any two students have the same code, it will automatically be considered as plagiarized, therefore it is strongly advisable to write your own code and do the submission. Any late submission of the lab deliverable will be deducted 10% per day up to 8 days, whereby the lab will not be accepted. |

## Course Content

| Week | Hours | Chapters / Section | Topic, description |
|---|---|---|---|
| 1 | 3 | Ch. 1 | Introduction: Course overview. Introduction to algorithms. Role of algorithms in solving various computational problems. |
| 2 | 3 | Ch. 2 | Analyzing and designing algorithms Incremental approach divide-and-conquer approach insertion sort algorithm merge sort algorithm introduction to recursion comparison of the two sorting algorithms. |
| 3 | 3 | Ch. 3 Appendix A (A.1) | Complexity analysis Growth rate of functions asymptotic notations. |
| 4 | 3 | Ch.4: 4.3, 4.4, 4.5 | Recurrence equations The substitution method the recursion tree. |
| 5 | 3 | Ch. 6, Ch. 10: 10.1, 10.2, 10.3 Appendix B: B.5 | Elementary Data Structures Stacks Queues Priority Queues linked lists max heaps min heaps basic operations on these data structures maintaining the Maxheap property building a max heap heapsort algorithm. |
| 6 | 3 | Ch. 11: 11.1, 11.2, 11.3 (11.3.1, 11.3.2) 11.4 | Hash Tables Direct address table Hash table basic operations on these data structures and the complexity analysis of those operations hash functions collision resolution using chaining. |
| 7-9 | 9 | Ch. 12: 12.1, 12.2, 12.3 Ch. | Trees Binary Search Trees insertion deletion Red Black Trees rotation insertion |

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| | | 13 | deletion Balanced Search Trees |
| 10 | 3 | Ch. 20: 20.1, 20.2, 20.3 Appendix B (B.4) | Graphs<br>Undirected graph directed graph weighted graphs representations of graphs adjacency-list representation adjacency-matrix representation breadth-first search (BFS) depth-first search (DFS) |
| 11-12 | 6 | Ch. 21, Ch. 21 and 22 and 23.1 | Elementary Graph Algorithms<br>Minimum spanning trees Kruskal's algorithm shortest paths Dijkstra's algorithm Bellman-Ford algorithm. |
| 13 | 3 | Ch. 24 and 34 (pp 1042-1048) | Flow Networks, Introduction to NP-Completeness, Course Review |

## Laboratory(L)/Tutorials(T)/Activity(A) Schedule

| Week | L/T/A | Description |
|---|---|---|
| 2 | Lab 1 | Introduction<br>Reviews C programming<br>( 2 hours ) |
| 3 | Lab 2 | Recursion<br>Understanding of recursion using Tower of Hanoi problem.<br>( 2 hours ) |
| 4 | Lab1-2 review | Lab 1 and 2 review |
| 5-6 | Lab 3 | Sorting<br>Implement and analyze insertion sort and merge sort algorithms.<br>( 4 hours ) |
| 7-8 | Lab 4 | State machines<br>Implement the flow of control from state to state.<br>( 4 hours ) |
| 9-10 | Lab 5 | Use of Stacks and XML-based HEAP<br>XML Balancing stacks direct-mapped tables and hash table, Develop an algorithm to determine whether the start and end-tags balance by using a Stack data structure that |

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| | | keeps track of previously read start-tags. Design a heap data structure and print it as an XML expression.<br>( 4 hours ) |
| 11 | Lab5 review | Lab 5 review |

## University Policies & Important Information

Students are reminded that they are required to adhere to all relevant university policies found in their online course shell in D2L and/or on the Senate website

Refer to the Departmental FAQ page for furhter information on common questions.

## Important Resources Available at Toronto Metropolitan University

- The Library provides research workshops and individual assistance. If the University is open, there is a Research Help desk on the second floor of the library, or students can use the Library's virtual research help service to speak with a librarian.
- Student Life and Learning Support offers group-based and individual help with writing, math, study skills, and transition support, as well as resources and checklists to support students as online learners.
- You can submit an Academic Consideration Request when an extenuating circumstance has occurred that has significantly impacted your ability to fulfill an academic requirement. You may always visit the Senate website and select the blue radio button on the top right hand side entitled: **Academic Consideration Request (ACR)** to submit this request.

  *For Extenuating Circumstances, Policy 167: Academic Consideration allows for a once per semester ACR request without supporting documentation if the absence is less than 3 days in duration and is not for a final exam/final assessment. Absences more than 3 days in duration and those that involve a final exam/final assessment, require documentation. Students must notify their instructor once a request for academic consideration is submitted. See Senate Policy 167: Academic Consideration.*
- If taking a remote course, familiarize yourself with the tools you will need to use for remote learning. The Remote Learning Guide for students includes guides to completing quizzes or exams in D2L Brightspace, with or without Respondus LockDown Browser and Monitor, using D2L Brightspace, joining online meetings or lectures, and collaborating with the Google Suite.
- Information on Copyright for Faculty and students.

## Accessibility

- Similar to an accessibility statement, use this section to describe your commitment to making this course accessible to students with disabilities. Improving the accessibility of your course helps minimize the need for accommodation.
- Outline any technologies used in this course and any known accessibility features or barriers (if applicable).
- Describe how a student should contact you if they discover an accessibility barrier with any course materials or technologies.

### Academic Accommodation Support

Academic Accommodation Support (AAS) is the university's disability services office. AAS works directly with incoming and returning students looking for help with their academic accommodations. AAS works with any student who requires academic accommodation regardless of program or course load.

- Learn more about Academic Accommodation Support.

- Learn how to register with AAS.

Academic Accommodations (for students with disabilities) and Academic Consideration (for students faced with extenuating circumstances that can include short-term health issues) are governed by two different university policies. Learn more about Academic Accommodations versus Academic Consideration and how to access each.

## Wellbeing Support

At Toronto Metropolitan University, we recognize that things can come up throughout the term that may interfere with a student's ability to succeed in their coursework. These circumstances are outside of one's control and can have a serious impact on physical and mental well-being. Seeking help can be a challenge, especially in those times of crisis.

If you are experiencing a mental health crisis, please call 911 and go to the nearest hospital emergency room. You can also access these outside resources at anytime:

- **Distress Line:**24/7 line for if you are in crisis, feeling suicidal or in need of emotional support (phone: 416-408-4357)
- **Good2Talk:**24/7-hour line for postsecondary students (phone: 1-866-925-5454)
- **Keep.meSAFE:** 24/7 access to confidential support through counsellors via My SSP app or 1-844-451-9700

If non-crisis support is needed, you can access these campus resources:

- **Centre for Student Development and Counselling:** 416-979-5195 or email csdc@torontomu.ca
- **Consent Comes First - Office of Sexual Violence Support and Education:** 416-919-5000 ext 3596 or email osvse@torontomu.ca
- **Medical Centre:** call (416) 979-5070 to book an appointment

We encourage all Toronto Metropolitan University community members to access available resources to ensure support is reachable. You can find more resources available through the Toronto Metropolitan University Mental Health and Wellbeing website.