Course Information.

Instructor: Shahin Kamali (LAS-3052B)
Lectures: 17:30 - 19:00, Mondays, Wednesdays at Keele CC 108
Office hours: Tuesday 14:00 - 15:00 at LAS-3052B, Tuesday 15:00 - 16:00 on Zoom (`https://yorku.zoom.us/j/3531400655`) (or by appointment)
Email: kamalis@yorku.ca (please add "[EECS 4101]" or "[EECS 5101]" in the subject line, and allow 24 hours for response)
TA: Alireza Pourali (alirezaprl11@gmail.com)
Webpage: `https://www.eecs.yorku.ca/~kamalis/Teaching/Winter23/EECS4101-5101.html`
Piazza: You can use Piazza for class discussion. The system is highly catered to getting you help fast and efficiently from classmates and the instructor. Rather than emailing questions, I encourage you to post your questions on Piazza (this can be done anonymously).
Find our class page at: `https://piazza.com/yorku.ca/winter2023/advanceddatastructures`

Grading. All students will be required to complete five assignments, two quizzes, a midterm exam, and a final exam.

assignments 25%
quizzes 10%
midterm exam 20%
final exam 45%

Assignments. Assignments will be distributed in class during the term. Solutions must be submitted on Crowdmark (`https://www.crowdmark.com/`). To permit the prompt distribution of solutions and return of marked assignments, **late assignments will not be accepted**. Please include your name and student number on all submitted material.
Examinations. Quizzes and the midterm exam will be held in class and the final exam will be held during the exam period. Exams and quizzes will be closed book.

Allocation of final mark:

letter grade	percent grade	grade point
A+	90-100	4.5
A	80-89	4.0
B+	75-79	3.5
B	70-74	3.0
C+	65-59	2.5
C	60-64	2.0
D+	55-59	1.0
D	50-54	1.0
E	(marginally below 50%)	0.0
F	(below 50%)	0.0

Course Goals and Intended Learning Outcomes. In this course, you will be invited to develop your ability to think clearly and carefully about data structures and the algorithms that operate on them, and to improve your skills in expressing those thoughts about data structures in a precise way. Data structures are a crucial component of most computer applications. Understanding them is a key ingredient for writing correct and efficient computer programs. By the end of this course, you will be able to do the followings things.

- **Describe important classes of data structures (for dictionaries, priority queues, disjoint sets, etc.) and explain how they work.**
  Before trying to design your own data structures, it is important to be aware of a good collection of classical ones. They are useful in their own right, but the ideas that underlie them are also useful for new data structures.

- **Augment data structures to expand their functionality.**
  If one of the standard data structures doesn't work for the task at hand, it is useful to be able to tweak an existing one to fit your purpose.

- **Analyze the efficiency of data structures, including the use of amortized analysis and online competitive analysis.**
  In many cases, there are multiple data structures that could be used to solve a problem. In some cases, it is important to be able to analyze the different options and choose the one that will solve the problem most efficiently. Amortized and competitive analysis are two special types of analysis that are useful in some settings.

- **Demonstrate knowledge of important themes in data structure design such as amortized analysis, self-adjustment, and potential function method.**
  Certain ideas can be applied in the construction of many different data structures, and we want to understand those concepts too. Amortized analysis concerns the *average* running time of operations on data structure, where the average is taken

over a long sequence of operations. Self-adjustment is used instead of carefully rebalancing data structures to improve the shape of the data structure in response to the sequence of operations performed on it. Potential function method is often used to provide upper bounds for the amortized running time of data structure operations (particularly, self-adjusting data structures)

- **Select or design appropriate data structures to help solve problems for algorithmic applications.**
  The ultimate goal is to ensure that you can find (or build) the right data structure for whatever task you want to solve. You should also be able to justify your design choices and explain why the algorithms that operate on the data structures are correct.

Course Overview. We will cover concepts related to the design and analysis of data structures and classic structures for implementing various abstract data types. If time allows, we will review applications of data structures in designing efficient algorithms. Tentative topics are listed below.

- **Introduction:**
  - Amortization, Self-Adjustment, Competitiveness.
- **Dictionaries:**
  - Move-to-Front Heuristic on Linear Lists.
  - Binary Search Trees review, Random BSTs, Red Black Trees.
  - B-trees, 2-3-4 Trees.
  - Red-Black Trees.
  - Splay Trees, Dynamic Optimality Conjecture.
  - Hash tables.
  - Augmenting Data Structures.
- **Priority Queues:**
  - Binomial Heaps and Fibonacci Heaps.
- **Disjoint Sets:**
  - Union-Find Data Structures.
- **Randomized Data Structures**
  - Skip Lists and Treaps.
- **String Data Structures**
  - Tries, Patricia Trees, and Suffix Trees.

Textbook. The following book is our main resource:

- 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.
- Pat Morin, Open data structures.
- Advanced Data Structures, by Brass, Cambridge, 2008.

Important Dates .

January 9 first class
January 31 assignment 1 due
February 12, assignment 2 due
February 15, quiz 1
February 18-24 reading week
March 2 assignment 3 due
March 6 midterm
March 17 assignment 4 due
March 22 quiz 2
April 8 assignment 5 due
April 10 classes end
April 12-27 Winter examination

Academic Integrity & Course Policies. Please refer to the posted material on eClass.