Course Information.

Instructor: Shahin Kamali (LAS-3052A)
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TA: Wenhao Zhu (zwhshy@my.yorku.ca)

Lectures: 14:30 - 15:50, Tuesdays and Thursdays (LSB 101)
Lectures will be broadcast live on Zoom and also recorded via Zoom
https://yorku.zoom.us/j/98698076646?pwd=LzKl4kbjYRwDtaLJTVF69gb2irMT6l.1
Due to the limited recording capabilities in the classroom, Zoom live sessions and recordings do not guarantee high video quality. Zoom lectures are not intended to replace in-person attendance, and you are expected to attend classes in person.

Office hours:
Thursdays 16:00 - 16:45 in person at LAS-3052A
Thursdays 16:45 - 17:30 on Zoom:
(https://yorku.zoom.us/j/96566210807) (or by appointment)

Email:
kamalis@yorku.ca (add "[EECS 4171]" in the subject line, and allow 24 hours for response)

Course Goals and Intended Learning Outcomes.

This is an advanced course in design and analysis of algorithms. The course exposes students to various topics in design, analysis, application, and restrictions of algorithms. We cover various topics in exact algorithms (e.g., flow, matching, string algorithms), approximation algorithms (graph problems, knapsack), randomized algorithms (e.g., primality testing, random walks) geometric algorithms (convex hull, art-gallery, geometric matching), streaming algorithms (majority problem, lower bounds), online algorithms (ski-rental, search, paging, and regret minimization), linear programming (algorithms and applications), and algorithmic fairness.

Students will learn various tools and analysis techniques to allow them design algorithms with provable guarantees in practical scenarios. While the course covers a wide range of algorithmic problems, one or two algorithms from each topic will be discussed in depth.

By the end of this course, students are expected to be able to design algorithms that use techniques such as LP duality or randomization and be able to analyze and improve these algorithms using analysis techniques that provide performance guarantee in terms of time complexity or quality of the solutions.

Course Overview.

Possible topics to be covered include (note that these material is subject to slight change):

1. Approximation Algorithms
   - Traveling salesperson (TSP problem): NP-completeness overview, Christofides algorithm, Euclidean TSP.
   - Coloring, vertex cover, and Unique Game Conjecture
2. Exact Algorithms
   - Flow algorithms: Ford-Fulkerson, Edmond-Karp & Push-relabel algorithms
   - Graph matching, bipartite matching, Blossom algorithm
   - String algorithms and pattern matching: KMP, Boyer-Moore, suffix trees
   - Data compression: bZip2 and LZ algorithms
3. Randomized Algorithms
   - Primality testing, Miller-Rabin algorithm
   - Verifying matrix multiplication: Freivald's algorithm
   - Identity testing, Schwartz-Zippel Theorem
   - Randomized complexity classes: ZPP, RP, co-RP, BPP
   - Random walks, Papadimitrou's 2SAT algorithm
4. Introduction to Steaming and Online Algorithms
   - Majority problem and algorithms: Boyer-Moore majority vote, Bloom filters
   - Matching and information-theory lower bounds
   - Ski-rental, cow-path, and paging
   - Online learning and regret minimization
5. Linear programming (LP)
   - LP duality, approximation algorithms
   - Minimax / Simplex
   - LP applications in design of online algorithms: online set cover
6. Fairness in Algorithm Design
   - Time Fairness: Secretary and Knapsack problems
   - Group fairness: matching and clustering
7. Geometric Algorithms
   - Convex hull algorithms

- Art-gallery problem
- Non-crossing matching

8. Further Topics

    - Polynomial Time Approximation Schemes (PTAS): bin packing
    - Fully Polynomial Time Approximation Schemes: Knapsack
    - Fixed Parameter Tractable Algorithms

Textbook.

No book is required to be purchased. References and lecture notes will be posted for various topics.

Grading [tentative]

All students will be required to complete five assignments, two quizzes, a midterm exam, and a final exam. **If class size allows, a course project will be added as a required part of the course** Tentatively, the final grades are to be calculated as follows.

assignments 25%
quiz 1 5%
quiz 2 5%
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. Two quizzes will be online. There will be a midterm exam held in class and a final exam held during the exam period. Exams and quizzes will be closed book.

Tentative allocation of final mark

letter grade	percent grade
A+	90-100
A	80-89
B+	75-79
B	70-74
C+	65-69
C	60-64
D+	55-59
D	50-54
E	(marginally below 50%)
F	(below 50%)

Important Dates

These dates are tentative and may slightly change.

September5: first class
September 26: assignment 1 due
October 1: quiz 1
October 9: assignment 2 due
October 12-18: reading week (no class)
October 24: assignment 3 due
October 31: midterm
November 16: assignment 4 due
November 20: quiz 2
November 30: assignment 5 due
December 3: last class
December 5-20: exam period

Updated September 5, 2024.