CSCI 4113/6101 — Design and Analysis of Algorithms II Course Syllabus

Instructor Information

Instructor:	Dr. Norbert Zeh	**Office:**	MC 4246
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Class Meeting Time:	TR 13:05–14:25	**Room No:**	LSC C206
Course Homepage:	https://dal.brightspace.com/		

Important Dates

- First day of class: September 6
- Holidays (no classes): September 30, October 10, November 11
- Study break (no classes): November 7–11
- Final Exam: Individual oral exams to be scheduled December 9–16
- Final Withdrawal Date without academic penalty: October 3
- Final Withdrawal Date with financial penalty: November 1
- Deadlines: 10 assignments due at 23:59 on Sep 22 & 29; Oct 6, 13, 20 & 27; Nov 3, 17 & 24; Dec 1

Course Description

This course is divided into two parts. Part I focuses on advanced techniques for solving optimization problems that are widely applicable. Topics include linear programming, network flows, matchings in graphs, and graph cuts. These techniques will be used as building blocks for the algorithms discussed in Part II of the course. Part II focuses on approaches to solve NP-hard problems and is divided into three blocks. The first block focuses on approximation algorithms, that is, algorithms with polynomial running time that provide a guaranteed bound on the deviation of the computed solution from the correct answer. If we want an exact solution to an NP-hard problem, we have no choice but to accept an exponential running time. The second block of Part II focuses on techniques to make exponential algorithms as efficient as possible. The third block focuses on fixed-parameter algorithms, which limit the exponential explosion of the running time to a hopefully small hardness parameter of the input and take polynomial time in the size of the input. In all three blocks, we will discuss various techniques for designing the types of algorithms covered in the block.

Learning Outcomes

- Model various optimization problems as (integer) linear programs.
- Understand how the simplex algorithm solves linear programs efficiently.
- Model various optimization problems as network flow problems.
- Understand a wide range of techniques for solving network flow problems.
- Model various optimization problems as matching problems.
- Understand techniques for solving matching problems.
- Analyze the approximation ratio of greedy approximation algorithms.
- Design approximation algorithms based on LP rounding and layering.
- Design exact exponential algorithms based on dynamic programming, branching search, and inclusion exclusion.
- Analyze branching algorithms using measure and conquer.
- Construct a problem kernel for a fixed-parameter tractable problem.
- Design fixed-parameter algorithms based on dynamic programming, branching search, and inclusion-exclusion.

Class Format and Course Communication

- Content will be delivered in the form of lectures that include active discussion.
- Lectures will be recorded and made available via Brightspace.
- Detailed lecture notes will also be available on Brightspace.
- Course announcements will be posted to Brightspace and/or the course mail list as appropriate. The mailing list comprises the instructor's and students' Dal emails. It is the student's responsibility to check their Dal e-mail on a daily basis. To access your Dal e-mail see: https://www.dal.ca/dept/its/o365/services/email.html

Evaluation Criteria

- Assignments (A)
  - 10 assignments of equal weight. The 8 best assignments count.
  - Late assignments will not be accepted.
  - Assignments must be uploaded to Brightspace before the deadline.
- Final Exam (F)
  - Individual oral exams will be scheduled December 9–16.
  - The exam will cover all material in the course.
- The final grade is calculated as max(F, 60% * A + 40% * F)

Notes

- You may be worried about having an oral final exam. Don't be. Students tend to score higher grades in oral exams than they would in written exams, for good reason. If you have questions about this, talk to me and I'm happy to explain. The only psychological hurdle is that you will be sitting face-to-face with me during the exam. To put your mind at ease, remember that I want you to succeed, not fail.
- As of 2015, a minimum grade of C must be achieved in all required CS courses.
- The grade conversion scale in Section 17.1 of the Academic Regulations, Undergraduate Calendar will be used.
- A student must pass (50%) both the assignment component and the final exam to pass the course.

Required Texts and Resources

- The main text for the course is provided in the form of lecture notes shared on Brightspace.
- The following books are valuable additional resources that explore various topics covered in the course in greater depth:
  - Cormen, Leiserson, Rivest, Stein. *Introduction to Algorithms.* MIT Press, 2009. (Earlier editions are fine; covers linear programming and some network flow algorithms in greater detail than the next book. Call# QA 76.6 C662 2009 (3rd ed.), 2001 (2nd ed.), 1990 (1st ed.))
  - Ahuja, Magnanti, Orlin. *Network Flows.* Prentice Hall, 1993. (Still the bible on all things related to flows. Call# T 57.85 A37 1993)
  - Vazirani. *Approximation Algorithms.* Springer-Verlag, 2001. (Covers a wide range of approximation algorithms. Call# QA 76.9 A43 V39 2003 (StFX library, can be ordered).)
  - Niedermeier. *Invitation to Fixed-Parameter Algorithms.* Oxford University Press, 2006. (Covers a wide range of techniques for designing fixed-parameter algorithms. Available as electronic resource from the library.)
  - Fomin, Kratsch. *Exact Exponential Algorithms.* Springer-Verlag, 2010. (Covers a wide range of techniques for desiging exact exponential algorithms. Available for download from http://www.ii.uib.no/~fomin/BookEA/BookEA.pdf.)
  - Cygan, Fomin, Kowalik, Lokshtanov, Marx, Pilipczuk, Pilipczuk, Saurabh. *Parameterized Algorithms.* Springer-Verlag, 2015. (Another book on parameterized algorithms, writ-

ten by the current kings of the area; downloadable from http://parameterized-algorithms.mimuw.edu.pl/parameterized-algorithms.pdf.)

Prerequisites

CSCI 3110

Tentative List of Topics

- Linear programming
  - Modelling shortest paths and MST as linear programs
  - The simplex algorithm
- Maximum flows
  - Augmenting path algorithms
  - Preflow-push algorithms
- Minimum-cost flows
  - Negative cycle cancelling algorithms
  - Successive shortest paths algorithms
  - Scaling techniques
- Matchings
  - Maximum cardinality/weight matching
  - Minimum-weight perfect matching

- Approximation algorithms
  - Greedy algorithms
  - LP rounding
  - Primal-dual schema
  - Layering
- Exact exponential algorithms
  - Branching search
  - Dynamic programming
  - Inclusion-exclusion
  - Measure and conquer
- Fixed-parameter algorithms
  - Kernelization
  - Branching search
  - Dynamic programming
  - Inclusion-exclusion
  - Iterative compression

Responsible Computing Policy

Usage of all computing resources in the Faculty of Computer Science must be within the Dalhousie Acceptable Use Policies (http://its.dal.ca/policies/) and the Faculty of Computer Science Responsible Computing Policy. For more information please see https://www.cs.dal.ca/downloads/fcs_policy_local.pdf

Culture of Respect[1]

Every person has a right to respect and safety. We believe inclusiveness is fundamental to education and learning. Misogyny and other disrespectful behaviour in our classrooms, on our campus, on social media, and in our community is unacceptable. As a community, we must stand for equality and hold ourselves to a higher standard.

What we all need to do:
1. **Be Ready to Act:** This starts with promising yourself to speak up to help prevent it from happening again. Whatever it takes, summon your courage to address the issue. Try to approach the issue with open-ended questions like "Why did you say that?" or "How did you develop that belief?"
2. **Identify the Behaviour:** Use reflective listening and avoid labeling, name-calling, or assigning blame to the person. Focus the conversation on the behaviour, not on the person. For example, "The comment you just made sounded racist, is that what you intended?" is a better approach than "You're a racist if you make comments like that."

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[1] Source: Speak Up! © 2005 Southern Poverty Law Center. First Printing. This publication was produced by Teaching Tolerance, a project of the Southern Poverty Law Center. Full "Speak Up" document found at: http://www.dal.ca/dept/dalrespect.html. Revised by Susan Holmes from a document provided April 2015 by Lyndsay Anderson, Manager, Student Dispute Resolution, Dalhousie University, 902.494.4140, lyndsay.anderson@dal.ca www.dal.ca/think.

3. **Appeal to Principles:** This can work well if the person is known to you, like a friend, sibling, or co-worker. For example, "I have always thought of you as a fair-minded person, so it shocks me when I hear you say something like that."
4. **Set Limits:** You cannot control another person's actions, but you can control what happens in your space. Do not be afraid to ask someone "Please do not tell racist jokes in my presence any-more" or state "This classroom is not a place where I allow homophobia to occur." After you have set that expectation, make sure you consistently maintain it.
5. **Find or be an Ally:** Seek out like-minded people that support your views, and help support others in their challenges. Leading by example can be a powerful way to inspire others to do the same.
6. **Be Vigilant:** Change can happen slowly, but do not let this deter you. Stay prepared, keep speaking up, and do not let yourself be silenced.

University Statements

This course is governed by the academic rules and regulations set forth in the University Calendar and the Senate.
https://academiccalendar.dal.ca/Catalog/ViewCatalog.aspx?pageid=viewcatalog&catalogid=69&chapterid=3457&loaduseredits=False

Academic Integrity

At Dalhousie University, we are guided in all of our work by the values of academic integrity: honesty, trust, fairness, responsibility and respect (The Center for Academic Integrity, Duke University, 1999). As a student, you are required to demonstrate these values in all of the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity. http://www.dal.ca/dept/university_secretariat/academic-integrity.html

Accessibility

The Advising and Access Services Centre is Dalhousie's centre of expertise for student accessibility and ac- commodation. The advising team works with students who request accommodation as a result of: a disability, religious obligation, or any barrier related to any other characteristic protected under Human Rights legislation (NS, NB, PEI, NFLD). http://www.dal.ca/campus_life/student_services/academic-support/accessibility.html

Student Code of Conduct

Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students dont follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal mannerperhaps through a restorative justice process. If an informal resolution cant be reached, or would be inappropriate, procedures exist for formal dis- pute resolution.
https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/student-life-policies/code-of-student-conduct.html

Diversity and Inclusion – Culture of Respect

Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness (Strategic Priority 5.2). http://www.dal.ca/cultureofrespect.html

Recognition of Mikmaq Territory

Dalhousie University would like to acknowledge that the University is on Traditional Mikmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel and support. Visit the office in the McCain Building (room 3037) or contact the programs at elders@dal.ca or 902-494-6803 (leave a message).

Learning and Support Resources

- General Academic Support — Advising
  http://www.dal.ca/campus_life/student_services/academic-support/advising.html
- Fair Dealing Guidelines
  https://libraries.dal.ca/services/copyright-office/guidelines/fair-dealing-guidelines.html
- Dalhousie University Library http://libraries.dal.ca/