Business Q774
COMBINATORIAL OPTIMIZATION: COMPLEXITY AND HEURISTICS

Winter 2019 Course Outline

Operations Management Area
DeGroote School of Business
McMaster University

COURSE OBJECTIVE

- Gain knowledge of most common combinatorial optimization problems
- Understand complexity theory and use it to classify the hardness of optimisation problems
- Study common polynomial algorithms for common combinatorial optimization problems
- Understand different classes of heuristics and approximation algorithms
- Develop heuristics and text them computationally.

INSTRUCTOR AND CONTACT INFORMATION

Dr. Elkafi Hassini

Instructor
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Office: DSB #414
Office Hours: By ppointment
Tel: (905) 525-9140 x27467

Time and location: W 9:30-12:30 DSB A102

Course Website: http://avenue.mcmaster.ca/

COURSE DESCRIPTION

The first part of the course will focus on solvable network flow problems such as assignment, transportation, transshipment, shortest path, max flow and minimum spanning tree problems. Well known algorithms (such as Dijkstra, Bellman-Ford and Augmenting path algorithm) will be discussed as well as general methodology such as lifting procedures polyhedral theory (strong valid inequalities). The second part will focus on complexity theory and heuristic methods and covers NP-Completeness, Approximation algorithms, local and random search, and metaheuristics (such as ant colony, genetic algorithms, simulated annealing and tabu search). GAMS and a general purpose programming language (e.g., C, Matlab or Python) will be used in a computational project.

LEARNING OUTCOMES

Upon completion of this course, students will be able to complete the following key tasks:

- Identify the complexity of common combinatorial optimization problems
- Analyse the complexity of algorithms and heuristics, including developing provable bounds
- Develop and test heuristics and approximation algorithms for combinatorial optimization problems

REFERENCES

There is no required textbook for this course. The following texts include elaborate expositions of most of the topics we will cover in this course:

- Ahuja, R.K., Magnanti, T.L. and Orlin, J.B., 1993. Network Flows Prentice Hall. Englewood Cliffs, NJ.
- Cook, W.J., Cunningham, W.H., Pullyblank, W.R. and Schrijver, A., 1998. Combinatorial Optimization. Wiley-Interscience Series in Discrete Mathematics and Optimization.
- Korte, B., Vygen, J., Korte, B. and Vygen, J., 2012. Combinatorial optimization (Vol. 2). Heidelberg: Springer.
- Papadimitriou, C.H. and Steiglitz, K., 1998. Combinatorial optimization: algorithms and complexity. Courier Corporation.

SOFTWARE APPLICATIONS

GAMS: you can download a free demo version from www.gams.com. The full version can be used with a licence. More details will be provided later in the course.
You may also need to use Python, MAPLE and/or Matlab depending on your prior experience.

EVALUATION

Components and Weights

Assignments	40%
Computational Project	30%
Final Exam	30%
Total	100%

NOTE: The use of a McMaster standard calculator is allowed during examinations in this course. See McMaster calculator policy at the following URL:

http://www.mcmaster.ca/policy/Students-AcademicStudies/examinationindex.html

Conversion

At the end of the course your overall percentage grade will be converted to your letter grade in accordance with the following conversion scheme.

LETTER GRADE	PERCENT
A+	90 - 100
A	85 - 89
A-	80 - 84
B+	75 - 79
B	70 - 74
B-	60 - 69
F	00 - 59

Final Exam (30%, individual work)

A two hour in-class comprehensive exam.

Assignments (40%, individual work)

There will be four assignments. A late submission of assignments will be penalised at a rate of 5% per day.

Computational Project (30%, individual work)

In your project you are expected to investigate a combinatorial optimisation problem and develop a solution procedure to solve it. You will code and test your algorithm or heuristic. A topic choice has to be finalised by the third week of the term and I encourage you to discuss your choice with me during that period.
If you do not have a combinatorial optimization problem that is related to your thesis research you may choose one of the following: multidimensional knapsack problem, bin-packing problem, multicommodity flows, network design problem or travelling salesman problem.
Your report has to include an introduction and motivation, literature review of problem application and solution procedures, a suggested solution procedure, computational tests and conclusions.
You will be required to present your work at the end of the term.

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at:

www.mcmaster.ca/academicintegrity

The following illustrates only three forms of academic dishonesty:

1. Plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. Improper collaboration in group work.
3. Copying or using unauthorized aids in tests and examinations

AUTHENTICITY/PLAGIARISM DETECTION

In this course we will be using a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. Students will be expected to submit their work electronically either directly to Turnitin.com or via Avenue to Learn (A2L) plagiarism detection (a service supported by Turnitin.com) so can be checked for academic dishonesty. Students who do not wish to submit their work through A2L and/or Turnitin.com must still submit an electronic and/or hardcopy to the instructor. No penalty will be assigned to a student who does not submit work to Turnitin.com or A2L. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). To see the Turnitin.com Policy, please go to;

www.mcmaster.ca/academicintegrity.

MISSED ACADEMIC WORK

Late assignments will not be accepted. No extensions are available except under extraordinary circumstances. Please discuss any extenuating situation with your instructor at the earliest possible opportunity.

POTENTIAL MODIFICATIONS TO THE COURSE

The instructor reserves the right to modify elements of the course during the term. There may be changes to the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of

the student to check their McMaster email and course websites weekly during the term and to note any changes.

The University reserves the right to change the dates and deadlines for any or all courses in extreme Circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

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http://library.mcmaster.ca/about/copying.pdf

STUDENT ACCESSIBILITY SERVICES

Students who require academic accommodation must contact Student Accessibility Services (SAS) to make arrangements with a Program Coordinator. Academic accommodations must be arranged for each term of study. Student Accessibility Services can be contacted by phone 905-525-9140 ext. 28652 or e-mail sas@mcmaster.ca.
For further information, consult McMaster University's Policy for Academic Accommodation of Students with Disabilities:

http://www.mcmaster.ca/policy/Students-AcademicStudies/AcademicAccommodation-StudentsWithDisabilities.pdf

ACKNOWLEDGMENT OF COURSE POLICIES

Your enrolment in this course will be considered to be an implicit acknowledgement of the course policies outlined above, or of any other that may be announced during lecture and/or on Avenue to Learn. It is your responsibility to read this course outline, to familiarize yourself with the course policies and to act accordingly.

Lack of awareness of the course policies cannot be invoked at any point during this course for failure to meet them. It is your responsibility to ask for clarification on any policies that you do not understand.

COURSE SCHEDULE

WEEK	TOPIC	KEY EVENTS
1	Introduction to combinatorial optimisation and complexity	
2	Optimal Trees and Paths in Networks	
3	Network Flow Problems	Project Topic Due
4		Assignment 1
5	No Classes	
6	Optimal Matching	
7	Polyhedral Theory	
8	Complexity Theory	Assignment 2
9	Heuristics and Approximation Algorithms	
10	Travelling Salesman Problem	Assignment 3
11	Knapsack Problem	
12	Bin-Packing Problem	
13	Network Design Problems	Project Presentation + Report Assignment 4