THE UNIVERSITY OF WINNIPEG

APPLIED COMPUTER SCIENCE

Course Number:	GACS-7105-001
Course Name:	Operations Research in Computer Science
Course Webpage:	https://nexus.uwinnipeg.ca/d2l/home/63690

Instructor Information

Professor: Yaser Al Mtawa **Office:** 3D06B
E-mail: y.almtawa@uwinnipeg.ca **Office Hours**: Thursday, 4:00 pm – 5:00 pm
Class Meeting Time: T/Th 2:30 PM - 3:45 PM (Duckworth Centre, 3D03 Lecture)

Important Dates

First Class:		September 3, 2024
Proposal Submission:		September 20, 2024
Reading Week (No Classes):		October 14-18, 2024
Final Withdrawal Date w/o academic penalty:		Wednesday, November 13, 2024*
Last Class:		November 28, 2024
Submission of term papers:		Dec. 12, 2024
University closures:	Truth and Reconciliation Day	Monday, September 30, 2024
	Thanksgiving	Monday, October 14, 2024
	Remembrance Day	Monday, November 11, 2024

*(A minimum of 20% of the work on which the final grade is based will be evaluated and available to the student before the voluntary withdrawal date)

Course Objectives/Learning Outcomes

This course provides a broad focus on algorithmic and practical implementation of Operations Research (OR) techniques, using theory, applications, and computations to teach students the basics of both deterministic and probabilistic decision-making. It introduces linear programming and emphasizes its underlying mathematical structures, algorithms, and solutions of practical programs. Topics covered include: formulations and relaxations, the geometry of linear optimization, convexity analysis, duality theory, the simplex method, sensitivity analysis, constrained and unconstrained optimization methods, robust optimization, network flows,

semidefinite optimization, nonlinear optimization, heuristic programming, game and decision theory, Markov chains and queuing systems. At the end of the course, students will be able to solve real world problems using optimization software tools. Students will also take on insightful reading activities on interesting applications of integer programming in computer science. The course involves a group project in which students apply the acquired knowledge in OR in the field of computer science. The course is a great asset for students willing to pursue graduate research in computer science.

Evaluation Criteria

Assignments: 40%

- There are 4 assignments worth 10% each.
- Due at 11:59:59 pm on due day.
- No late assignment will be accepted, or under special circumstances accepted with 10% off for each late day.
- Assignments are only submitted as PDF files via Nexus.
- Multiple submissions are not permitted. Students may submit a partially completed assignment and will receive credit for those attempted problems.
- Assignments will be written in groups of two.

Term project: 60%

- The research project in this course will involve the application of Operations Research to Computer Science problems. We will discuss examples and provide more details during classes.
- Your project should present a new idea and include a rigorous comparative analysis of the existing literature. You can refer to conferences and journals in computer science and engineering to find potential research topics.
- The project may lead to the publication of a scientific paper with instructor approval.
- Depending on class size, students may work in groups, with individual contributions evaluated.
- Proposals must be submitted as PDF files via Nexus no later than 11:59:59 pm on the due date. Proposals are limited to two pages, including an introduction, related work in the literature, research objectives, and methodology. Typed proposals only.
- Research projects are evaluated based on originality, technical soundness, realization of objectives, and quality of presentation. Group projects will have additional evaluation criteria.
- The final research paper must be a scientific publication of six to nine pages in two columns and 10-point font. Papers must be typed and formatted using a word processor or a Latex editor.
- The final research paper must be submitted as a PDF file via Nexus no later than 11:59:59 pm on the due date.
- Students are required to present their projects in class at the end of the term.

Final Letter Grade Assignment

Historically, numerical percentages have been converted to letter grades using the following scale. However, instructors can deviate from these values based on pedagogical nuances of a particular class, and final grades are subject to approval by the Department Review Committee.

A+	90+ - 100%	B+	75 - 79%	C	60 - 64%
A	85 - 90%	B	70 - 74%	D	50 - 59%
A-	80 - 84%	C+	65 - 69%	F	below 50%

Prerequisite and Restriction Information*

(This information can be found in the UW General calendar)

- Consent of Department Graduate Studies Committee Chair (or research supervisor)
- Students need to have some knowledge of linear algebra and calculus to take the course.

Class Cancellation, Students Correspondence, and Withdrawing from Course

- When it is necessary to cancel a class due to exceptional circumstances, the course instructor will make every effort to inform students via UWinnipeg email and Nexus.
- Students are reminded that they have a responsibility to regularly check their UWinnipeg e-mail addresses to ensure timely receipt of correspondence from the University and/or the course instructor.
    - It is recommended that electronic communication used for the course utilize a UofW email account or the Nexus platform to minimize the risk of filtering. Use 'GACS-7105' as subject in email communication.
- Please let course instructor know if you plan on withdrawing from the course. Note that withdrawing before the VW date does not necessarily result in a fee refund.

Regulations, Policies, and Academic Integrity

Students are encouraged to familiarize themselves with the Academic Regulations and Policies found in the University Academic Calendar at:
https://uwinnipeg.ca/academics/calendar/docs/regulationsandpolicies.pdf
Particular attention should be given to subsections 8 (Student Discipline), 9 (Senate Appeals) and 10 (Grade Appeals).

Avoiding Academic Misconduct: Academic dishonesty is a very serious offense and will be dealt in accordance with the University's policies.

Detailed information can be found at the following:

- Academic Misconduct Policy and Procedures:
  https://www.uwinnipeg.ca/policies/docs/policies/academic-misconduct-

policy.pdf and https://www.uwinnipeg.ca/policies/docs/procedures/academic-misconduct-procedures.pdf

- About Academic Integrity and Misconduct, Resources and FAQs: https://library.uwinnipeg.ca/use-the-library/help-with-research/academic-integrity.html

Uploading essays and other assignments to essay vendor or trader sites (filesharing sites that are known providers of essays for use by others who submit them to instructors as their own work) involves "aiding and abetting" plagiarism. Students who do this can be charged with Academic Misconduct.

Academic Integrity and AI Text-generating Tools: Students must follow principles of academic integrity (e.g., honesty, respect, fairness, and responsibility) in their use of material obtained through AI text-generating tools (e.g., ChatGPT, Bing, Notion AI). If an instructor prohibits the use of AI tools in a course, students may face an allegation of academic misconduct if using them to do assignments. If AI tools are permitted, students must cite them. According to the MLA (https://style.mla.org/citing-generative-ai/), writers should

- cite a generative AI tool whenever you paraphrase, quote, or incorporate into your own work any content (whether text, image, data, or other) that was created by it
- acknowledge all functional uses of the tool (like editing your prose or translating words) in a note, your text, or another suitable location
- take care to vet the secondary sources it cites

If students are not sure whether or not they can use AI tools, they should ask their professors.

Non-academic misconduct: Students are expected to conduct themselves in a respectful manner on campus and in the learning environment irrespective of platform being used. Behaviour, communication, or acts that are inconsistent with a number of UW policies could be considered "non-academic" misconduct. More detailed information can be found here:

- Respectful Working and Learning Environment Policy https://www.uwinnipeg.ca/respect/respect-policy.html,
- Acceptable Use of Information Technology Policy https://www.uwinnipeg.ca/policies/docs/policies/acceptable-use-of-information-technology-policy.pdf
- Non-Academic Misconduct Policy and Procedures: https://www.uwinnipeg.ca/policies/docs/policies/student-non-academic-misconduct-policy.pdf and

https://www.uwinnipeg.ca/policies/docs/procedures/student-non-academic-misconduct-procedures.pdf

Copyright and Intellectual Property: Course materials are the property of the instructor who developed them. Examples of such materials are course outlines, assignment descriptions, lecture notes, test questions, and presentation slides—irrespective of format. Students who upload these materials to filesharing sites, or in any other way share these materials with others outside the class without prior permission of the instructor/presenter, are in violation of copyright law and University policy. Students must also seek prior permission of the instructor/presenter before, for example, photographing, recording, or taking screenshots of slides, presentations, lectures, and notes on the board. Students found to be in violation of an instructor's intellectual property rights could face serious consequences pursuant to the Academic Misconduct or Non-Academic Misconduct Policy; such consequences could possibly involve legal sanction under the Copyright Policy:

https://copyright.uwinnipeg.ca/basics/copyright-policy.html

Privacy

Students have rights in relation of the collecting of personal data the University of Winnipeg

- Student Privacy: https://www.uwinnipeg.ca/privacy/admissions-privacy-notice.html
- Zoom Privacy: https://www.uwinnipeg.ca/privacy/zoom-privacy-notice.html

Students may choose not to attend classes or write examinations on holy days of their religion, but they must notify their instructors at least two weeks in advance. Instructors will then provide opportunity for students to make up work examinations without penalty. A list of religious holidays can be found in the 2019-20 Undergraduate Academic Calendar online at

http://uwinnipeg.ca/academics/calendar/docs/important-notes.pdf

Students with documented disabilities, temporary or chronic medical conditions, requiring academic accommodations for tests/exams (e.g., private space) or during lectures/laboratories (e.g., note-takers) are encouraged to contact Accessibility Services (AS) at 204-786-9771 or accessibilityservices@uwinnipeg.ca to discuss appropriate options. All information about a student's disability or medical condition remains confidential.

https://www.uwinnipeg.ca/accessibility-services

Required TextBook(s)/Reading List

The required textbook for this course is the following:

Operations Research: An Introduction, 11th edition, 2022

Author: Hamdy A. Taha
Publisher: Pearson
ISBN-13: 9780137625727
Supplementary scientific papers, and notices will be posted on the course website. Students are responsible for all material covered in class and posted on the website. Students are also responsible for announcements made in class and via email.

Course Outline (Tentative)

Week One

Introductory Concepts, Linear Programming Applications (LP), Convexity analysis, Graphical LP Solution, Computer Solution with Solver and AMPL, Binary Optimization.

Week Two

Semidefinite programming, Simplex Method, Simplex Tableau Computations, Artificial Starting Solutions (M-Method and Two-Phase Method), Graphical and Algebraic Sensitivity Analysis, Duality, Post-Optimal Analysis, Feasibility and Optimality.

Week Three

Transportation Model and Algorithm, Assignment Model, Hungarian Method, Advanced Linear Programming, Bounded-Variables Algorithm, Parametric Linear Programming

Week Four

Network Model, Network Flow Problems and Solutions, Minimal Spanning Tree Algorithm, Shortest-Route Problem, Dijkstra's Algorithm, Floyd's Algorithm, Maximal Flow Model and Algorithm, Critical Path Method, LP Formulation.

Week Five

Goal Programming, Weights Method, Preemptive Method, Integer Linear Programming (ILP), Branch-and-Bound Algorithm, Cutting-Plane Algorithm.

Weeks Six and Seven

Heuristic Programming, Greedy (Local Search) Heuristics, Discrete/Continuous Variable Heuristic, Metaheuristics, Tabu Search, Simulated Annealing, Genetic Algorithm, Artificial Bee Colony, Metaheuristics Fine-Tuning, Metaheuristics Application to ILP, Constraint Programming, Constrained Optimization Methods.

Week Eight

Traveling Salesperson Problem, Robust Modeling and Optimization, Nonlinear Programming Algorithms, Deterministic and Probabilistic Dynamic Programming.

Weeks Nine and Ten

Decision Analysis and Games, Analytic Hierarchy process (AHP), Decision under Uncertainty, Utilities and Payoffs, Zero-Sum Games, Minmax Theorem, Pure and Mixed Strategies, Bayesian Games, Cooperative Game Theory, Coalition Formation, Matching Games, Stochastic Games.

Week Eleven

Markov Chains, Queuing Systems, Pure Birth and Death Models, General Poisson Queuing Model, Single-Server and Multiple-Server Models.

Week Twelve

Simulation Modeling, Monte Carlo Simulation, Discrete Event Simulation, Sampling, Simulation Languages, Classical Optimization Theory.

Note that all topics listed may not be covered and may be offered in a slightly different time order. Each topic will include case studies from the areas of network management, resource optimization, multi-agent systems, and cybersecurity.